An Intelligence and Creative Computing Based Mental Health Care Framework

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Declaration

I declare that the work described in this thesis was originally carried out by me during the period of registration for the degree of Doctor of Philosophy at De Montfort University, U.K., from July 2016 to December 2020. It is submitted for the degree of Doctor of Philosophy at De Montfort University. Apart from the degree that this thesis is currently applying for, no other academic degree or award was applied for by me based on this work.

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List of Acronyms

ADC	Analogue-to-Digital Conversion
AI	Artificial Intelligence
AM	Acoustic Model
ANN	Artificial Neural Network
API	Application Programming Interface
AVP	Attribute Value Pair
BMI	Body Mass Index
CNN	Conventional Neural Network
DAC	Digital to Analogue-Conversion
DNA	Deoxyribonucleic Acid
DPOS	Delegated Proof of Stake
ERPs	Event-Related Potential
fMRI	Functional Magnetic Resonance
GPU	Graphics Processing Unit
IDE	Integrated Development Environment
KBS	Knowledge-Based Systems
KE	Knowledge Engineering
KNN	K-Nearest Neighbour
LHC	Large Hadron Collider
LM	Language Model
LPCC	Linear Predictive Cepstral Coefficient
MEMS	Micro-Electro-Mechanical System
MFCC	Mel Frequency Cepstrum Coefficient
MHCS	Mental Health Care System
NLP	Natural Language Processing
NTC	Negative Temperature Coefficient
OWL	Web Ontology Language
PDAs	Personal Digital Assistance
POS	Part of Speech

POW	Proof of Work
PTC	Positive Temperature Coefficient
PTT	Pulse Transmission Time
PWV	Pulse Transmission Speed
RDF	Resource Description Framework
RNN	Recurrent Neural Network
SNS	Sympathetic Nervous System
SVM	Support Vector Machine
URI	Uniform Resource Identifier

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Publications by the Candidate

1. D. Jing, H. Yang, L. Xu, and F. Ma, "Developing A Creative Idea Generation System for Innovative Software Reliability Research", *2015 Second International Conference on Trustworthy Systems and Their Applications*, IEEE, China, pp. 71-80, 2015.

2. L., Zou, Q. Liu, S. Ma, and F. Ma, "Eliciting Data Relations of IOT Based on Creative Computing", *International Journal of Performability Engineering,* Elsevier, London, UK, vol. 15, no. 2, pp. 559-570, 2019.

3. F. Ma, and Q. Liu, “An Approach to Machine Learning Based Health Data Analysis for Wearable Intelligent Shoes”, *12th International Conference of Interdisciplinary Design and Industrial-academic Collaboration*, Shu-Te University, Taiwan, 2019.

4. F. Ma, H. Yang, W. C. Chu, and Q. Liu, “An Intelligent Health Analysis Approach to Detecting Potential Threats with Health Data Reuse”, *44th Annual Computers, Software, and Applications Conference (COMPSAC)*, IEEE, UK, pp. 1546-1551, 2020.

5. F. Ma, S. Ma, Q. Liu, “Graphical Probability Model and Heritage Tourism Routine Design”, IEEE *International Conference on Creative Lifestyle Computing,* Macau, China, December 2020.

6. F. Ma, Q. Liu, W. C. Chu, “Loop Destroying Algorithm for Generating Creative Solutions Applying in Health Care Area”, IEEE *International Conference on Creative Lifestyle Computing*, Macau, China, December 2020.

Abstract

Artificial intelligence is being developed and applied in business, medical, tourism and other subjects. Health care can be related to artificial intelligence, serving more on protecting people's health through supervising some indexes of people and providing advice for people's normal life.

As health care is required colleting the physical data, voice data and video data, wearable products are suitable. The user is connected with wearable products through minor cameras, sensors, and chips.

In this research, an artificial intelligence-based health care framework is achieved for supervising and managing user's health conditions and being applied with intelligent shoes. The aim of this research is to serve people on mental health care in normal life based on physical data analysis and mental data analysis, to protect people from being sub-health, to advise people on different aspects of being healthy.

An applicable system can be generated with specific AI algorithms and machine learning algorithms, including body index data statistical model analysis, voice data analysis algorithm, and video data analysis. The framework can collect health related data and analyse it, generating health state reports and advice report for the user. The entire system is based on artificial intelligence theories and methods, and machine learning algorithms, completing health data processing. Abstraction method is combined with conventional nueral network and recurrent neural network are used for voice data analysis and video data analysis. Statistical model is created based on body index data categories. Three kinds of data can be processed for supervising the emotions of the user.

This research will generate a mental health care framework and a mental health supervision and management system that can be set on the wearable products for the application.

Chapter 1

Introduction and Motivation

Objectives

- To analyse the requirements for the AI based Mental Health Care system
- To discuss research questions and develop research hypotheses
- To explain research methods and define the measure of success
- To highlight original contributions
- To outline the structure of the thesis

1.1 Overview of Research Problems

Human is unique with an intelligent brain and complicated emotions expressions Tension, worry, fear, anxiety, guilt, depression, anger, etc. are different emotions in everyone's body. These emotions not only bring about psychological changes but also directly affect physical and mental changes. Some proposed research has stated that more than 70% of people would eventually suffer from emotional "attack" on their body organs. In other words: a negative mood will eventually affect the health of the body [19]. Especially in the current highly competitive society, people are suffering from pressure nearly every day, which may lead to negative emotions.

Based on some proposed research, through a large number of investigations on cancer patients, it can be found that the occurrence of cancer is related to the person's long-term resentment and depression, and the person's bad emotions [19].

Because of the depression of resentment, the blood flow of the body is not smooth, and the body is in a state of hypoxia, which makes the accumulation of toxins increase [18]. People who are anxious and stressed will affect their gastrointestinal function and get gastritis and gastric ulcer easily. Long-term anxiety, or fear of something happening, will lead to hair loss and ulceration. Many diseases are directly related to emotions.

According to the proposed research, up to 200 kinds of diseases are caused by bad emotions [19]. If the human body is compared with a computer, emotion is equivalent to software. A person often has anger, depression, or pain, which is equivalent to that too much computer junk toxin makes the computer being in low working efficiency, operate poorly, or even the system has to be reinstalled.

When a person is angry and painful, it can make the sympathetic nerve extremely excited, the heart rate is accelerated, and the myocardial oxygen consumption is greatly increased. Therefore, mental health care is imperative for people to maintain healthy. The proposed research on mental health care is based on medical theories and techniques. Psychology theories are the basis of mental health supervision as well.

Artificial intelligence-related theories and methods can be appliedfor generating novel algorithms achieving mental health care system. Based on development of wearable products and connections between software and devices, the system can help improve people’s mental health via supplying health advice.

1.2 Research Aims and Objectives

This research aims at creating an AI based framework for tackling mental health care problems and achieving mental health analysing and supervising. User’s mental health can be recognised and managed, and related advice can be provided by the proposed system.

Currently, research on AI related algorithms is limited on the aspect of supporting mental health care supervising and management, the supporting literature about this. Mental health care is based on medical related field knowledge conventionally, artificial intelligence is rarely being used in entire mental health management and supervision. Creating artificial intelligence based mental health care framework is necessary, which is useful for achieving mental health identifying and supervising. Proposed papers and research on such related topics are limited.

Therefore, artificial intelligence algorithms, including data preparation algorithm, data analysis algorithms, and data assembly and mining algorithms are applied to generate mental health supervising and report generation. To tackle this problem, an artificial intelligence based mental health care framework is established. As the health care realm and computer science (AI) are required to be combined to achieve novel frameworks and approaches, creative computing theories and methods are imperative to generate solving the interdisciplinary problems.

Creativity should be achieved by using creative computing methods on solving such issues. For being better understood, creativity definitions and new taxonomy are depicted and explained in this research. Definition of creativity assists people to comprehend what is creativity, and new taxonomy is used for assisting people in understanding creativity in distinguished aspects.

In this research, several objectives are planned, including:

- To develop mental health care framework for applying mental health care in common health detection.
- To develop novel algorithms for supervising and managing mental health based on artificial intelligence algorithms.
- To develop quantitative relationships between emotion changes and body index parameters.
- To develop knowledge graph as basis of mental health analysis and discovering logical relationships between emotions and mental health data.
- To produce mental health advice providing people specific guidance for mental health care.
- To apply creative computing methods for generating interdisciplinary methods and generating knowledge combination models for integrating mental health area and AI.

1.3 Research Questions and Hypotheses

The kernel research question of this research topic is:

How to achieve mental health supervision and management intelligently with AI based algorithms?

To answer this question, it is required to decompose kernel questions into sub-questions to achieve the eventual aim by completing addressable sub-missions.

Sub-question 1:

What kinds of factors may influence mental health care and mental health care analysis model establishment?

Sub-question 1.1 How to detect factors that may affect mental health care?

Sub-question 1.2 How to detect factors that may influence establishing mental health care analysis model?

Sub-question 1.3 How to establish mental health care analysis model for mental health supervision and management by analysing influential factors?

Sub-question 2:

What kinds of quantitative models are capable to support the research of mental health care?

Sub-question 2.1 What kinds of models can be connected with the research of mental health care?
Sub-question 2.2 What kinds of algorithms are the basis for mental health-related data analysis models?
Sub-question 2.3 What kinds of algorithms can be used for generating mental health care advice?
Sub-question 2.4 How to achieve extreme mental health problems warning mechanisms?
Sub-question 3:
What is the AI-based mental health care framework be like?
Sub-question 3.1 What kinds of modules that the AI-based mental health care framework should include?
Sub-question 3.2 How to build an intelligent Mental Health Care framework to achieve emotion recognition and emotion supervision?
Sub-question 3.3 How to connect the Mental Health Care system with wearable products?
Sub-question 4:
How to analyse mental health with wearable products?
Sub-question 4.1 How to achieve connections between mental health care framework-based software and wearable products?
Sub-question 4.2 How to make the framework be extensible for most of the wearable products?
Based on research questions and sub-questions, some assumptions should be clarified before hypotheses and the research process being illustrated. To specify these research questions to complete artificial intelligence-based mental health care framework, hypotheses are imperative to be listed. Kernel hypotheses of this research are:
Mental health care management and supervision can be more intelligent on wearable products by using artificial intelligence algorithms and applying creative computing theory to combine theories and methods from distinguished realms.
Based on cardinal hypotheses and research questions, sub research hypotheses are required:
RH1: Mental health care can be managed by using artificial intelligence-related algorithms, including deep learning, machine learning, knowledge graph, and so forth, to detect people's emotions.
RH2: Creative computing approaches can be used to achieve multidisciplinary

approaches to achieving creativity in distinguished realms. Feasible approaches will be generated to achieve interdisciplinary methods for multiple application types in different realms.

RH3: Mental health care can be quantitatively calculated by analysing collected emotion-related data.

RH4: There are connections between mental health and body health indexes and models that can be established for supervising and managing mental health.

To complete this research and answer all the research questions, data preparations, data analysis, and suggestions generation phases are required. Mental health data is different from physical health data and related indexes, which is required more intelligent algorithms. Meanwhile, mental health brief report is required for the user as the final service about emotion management.

1.4 Research Methods and Evaluation

1.4.1 Methods

In this thesis, an interdisciplinary research method is deployed. According to different perspectives, interdisciplinary research can be divided into four levels:

- method intersection,
- theory reference,
- problem pulling, and
- culture blending.

Among these four levels, crossing methods includes method comparison, transplantation, radiation, aggregation, and so on, which usually occurs between disciplines, and each aspect and link contains very rich and detailed content. Theoretical reference mainly refers to the interaction of knowledge levels, which is usually proofed in the proximity of emerging disciplines to mature disciplines or the penetration and expansion of different disciplines to emerging knowledge. Problem pulling is a multi-dimensional comprehensive process centred on large problems. It includes multi-disciplinary synthesis realised purely for the study of objective phenomena, multi-disciplinary synthesis realised for the discussion of major theoretical problems, and multi-faceted synthesis realised for the solution of major practical problems.

The interdiscipline research can be also referred as multi-disciplinary, comprehensive discipline, or complex discipline. Creative computing is used to solve crossing methods and multi-disciplinary applications for processing issues. For example, in the early

1980s, Qian [149], put forward a semi theoretical and semi economic method combining scientific theory, empirical knowledge, and expert judgment to deal with complex problems. Also, in the 1980s, a group of scientists in different fields headed by Nobel laureate Graham formed the Santa Fe Institute in the United States to carry out interdisciplinary research, known as complexity research (Complexity Science). It is not only about the complexity of nature but also the complexity of human society. Their research reflects the comprehensive trend of the development of modern scientific technology and technical subjects. "Research has shown that physics, biology, behavioural science, and even art and anthropology can connect them in a new way". According to Gelman, some progress had been made in this field, such as genetic algorithm, computer network, evolutionary economy, and artificial system.

With the implementation of the "human gene plan", bioscience has entered the era of "post-genome". In this era, bioscience involves more and more fields, involves more and more complex problems, and adopts more and more advanced technology. It is necessary to rely on the strength of the interaction between disciplines such as physics, chemistry, mathematics, engineering and computer science, and bioscience, which seems to have formed the trend of interdisciplinary.

This kind of interdisciplinary fusion has produced many achievements, the most important of which is the DNA double helix model proposed by Watson, a student of Delbruck, and F. Crick, a British crystallographer, in 1953. Since then, bioscience has been transformed from descriptive subject to experimental subject, and many new interdisciplinary subjects have been formed.

At the end of the 20th century, there was another trend of interdisciplinary research related to bioscience. But this time, it's not physics and chemistry, but biology. Its name has evolved from Bio-X to x-biology. On the one hand, this change emphasises that life is a specific research object, no longer an appendage of physics and chemistry, on the other hand, it also emphasises the importance of science to bioscience research. For example, in the past, genetic research relied on the analysis of single-gene mutations, while today's chemical genetics attempts to use the huge amount of small molecular compounds produced by combinatorial chemistry to study the function of genes.

Cultural integration is the mutual penetration and integration of the cultural backgrounds on which different subjects rely. This integration is not a separate process, because any interaction between disciplines involves cultural factors, but the real cultural integration is a deeper and broader process, which is the ultimate goal of interdisciplinary research. It is the latter situation that contemporary interdisciplinary reflection needs to explore. Free access to interdisciplinary research is not easy. In addition to the traditional interdisciplinary scientific research consciousness and cultivation, it should also have strict interdisciplinary awareness and interdisciplinary scientific research consciousness. As scientific research has entered the era of interdisciplinary action, it is imperative to have a proper understanding and correct attitude towards interdisciplinary research. In the scientific community, the main resistance to interdisciplinary research is the lack of deep consensus. Therefore, it is necessary to strengthen the interdisciplinary clean-up and publicity within science, and promote the interdisciplinary basis by promoting the transplantation of effective methods, including the transfer of objects, the promotion of theories or principles, and the integration of methodology formed by the penetration of basic concepts; and promote the interdisciplinary basis by promoting the extensive research on complex problems, complex adaptive systems, and complex science. Cross-domain problems are required interdisciplinary methods for chasing problem solutions. Basic creative computing methods can be applied for discovering such solutions.

1.4.2 Success Criteria

This research aims at establishing mental health care management and supervision framework applying in wearable products. The research can create products to improve mental management and supervision efficiency. The success criteria of this research is how to evaluate the framework that is feasible for mental health care detection. A specific system is established in the end to prove that the application of the framework is feasible. Further, a case study about mental health care management and supervision is imperative for success evaluation. This thesis will be:

- Discovering cross-domain methods for generating artificial intelligence-based mental health care management and supervision.
- Building quantitative relationships between body health indexes and mental health states.
- Generating framework of artificial intelligence-based mental health care detecting.
- Generating specific rules for evaluating mental health detecting outcomes.
- Establishing mental health care systems to prove the application of mental health care framework.

- Using a feasible case study to prove to apply mental health care systems on wearable products.

1.5 Original Contributions

Artificial intelligence-based mental health care system on wearable products are proposed and validated by using creative computing theories and methods achieving interdisciplinary methods. In this research, artificial intelligence-based mental health care system establishment is based on knowledge from the medical area and computer science (especially machine learning and artificial intelligence) area. The followings are all the expected original contributions of this research:

C1: Mental health care framework and the system is achieved by this research including mental health data preparation, mental health data analysis, and mental health report generation. The outcomes are provided for users to detect mental health. Related research has been explained in Chapter 3.

C2: Novel approach for generating mental health by using collected mental health data based on combinations of knowledge in two subjects.

C3: Quantitative relationships between mental health and body health indexes are established by using math models. Formulas can depict relationships between mental expressions and body indexes based on detecting people's behaviours, languages, and facial expressions. Four kinds of data-related sub-systems are stated in Chapter 4, Chapter 5, and Chapter 6.

C4: Novel algorithms for mental health care are created based on behaviour and facial expression analysis. Related novel algorithms are stated in Chapter 6.

C5: Outcomes evaluation is completed on evaluating output and mental health analysis process. Evaluation methods are explained in Chapter 7.

To sum up, this research can generate an artificial intelligence-based mental health care system for mental health management and supervision applying to wearable products. The system can provide mental health-related analysis results and reports for people to maintain a healthy status.

1.6 Organisation of Thesis

This research thesis includes nine chapters and three appendixes to illustrate how to generate an artificial intelligence-based mental health care system applying to wearable products.

Chapter 1: Introduction and Motivation

The introduction and Motivation of this research are presented in this chapter. Research questions, hypotheses, research methods, and research success criteria are depicted to make the theme of this research more explicit. Original contributions are declared. The thesis structure is listed at the end of Chapter 1.

Chapter 2: Background and Related Studies

Research background and related work are summarised in this chapter. Existing research on machine learning and AI for mental health care applications are explained. Specific research on mental health care is listed and moods of people are stated as well. wearable products on medical domain development are illustrated as support of system application. Creativity and creative computing theories and methods are concluded as the basis of interdisciplinary methods generation.

Chapter 3: Constructing an Artificial Intelligence-based Mental Health Care Framework

In this chapter, a general explanation for artificial intelligence-based mental health care framework is presented. The entire workflow will be depicted in three sections, which are mental health-related data preparation technique explanation, mental health analysis, and recognition technique explanation, and mental health supervision and advice techniques explanation. The structure of the framework is depicted as well. Based on data types, there are three sub-workflows in the framework, which are body index data-based mental health analysis workflow, voice data-based mental health analysis workflow, and video-based mental health analysis workflow.

Chapter 4: Body Index-Based Mental Health Analysis Technique

In this chapter, the methods for body index data collecting and pre-processing are explained. The workflow and working mechanisms are explained explicitly. Statically model is used for generating body index data analysis algorithm. As the data is structured data, multi-variable formulas are built for calculating emotion values based on body index data. The final output of this technique is the possible emotion based on body index data analysis. Details of the technique are depicted in Chapter 4.

Chapter 5: Voice-Based Mental Health Analysis Technique

In this chapter, voice data pre-processing, knowledge graph establishment, and voice data analysis, and emotion recognition are explained. Voice data transferring to text data is completed before pre-processing. Voice data collection, clearance, and classification are stated. Weighted connections between three types of data are built based on text data states. Text data analysis for emotion expectations is based on natural language processing, words cutting and accumulation theory, which is created for algorithm establishment.

Chapter 6: Video-Based Mental Health Analysis Technique

In this chapter, video data is pre-processed and analysed specifically. Video data includes facial expression data and behaviour data. Initially, facial expression data and behaviour data are separated from collected video data. Clearance and classification for two kinds of data are completed separately. Further, a knowledge graph is established for both facial expression data and behaviour data. The analysis methods for facial expression data and behaviour data are different. CNN and RNN are applied for facial image analysis and behaviour data analysis separately. Emotions are analysed to output expected emotions based on facial expression data and behaviour data in the interval.

Chapter 7: Consensus Mechanisms and Mental Health Supervision and Problems Advice Generation

In this chapter, consensus mechanisms and mental health supervision, and advice generation are explained. Consensus mechanisms and integration methods are completed to achieved output emotions analysis. Four expected emotions based on three types of data are integrated to output the final expected emotion in the time interval. Consensus mechanisms are formulated based on consensus theory in block chain area. Supervision workflow and problem advice workflow are explained in this chapter as well.

Chapter 8: Case Study

The case study illustrates the application of intelligent mental health supervision and management system with wearable products. Mental health supervision and management system are set in wearable shoes to create connections with users. Data collection, data pre-processing, data analysis, supervision warning functions, and advice generation are applied for mental health management for the user.

In this chapter, processing results are presented by figures. Specific calculation details are explained as well.

Chapter 9: Conclusions

The summary of the thesis is presented in this chapter. Answers to the research questions are depicted and evaluation of kernel approaches and original contributions are presented as well. Future work is declared at the end of Chapter 9 to discuss further research about mental health analysis and management. Future research on algorithms to be applied in the mental health area is explained as well.

Appendix A. Selected Source Code of Intelligent Mental Health Care System

Source code of intelligent mental health care system for emotion supervision and management are presented in this appendix.

Appendix B. Selected Experiment Results with Intelligent Mental Health Care System

The input data and relevant output results of emotion supervision and management are presented in this appendix.

Chapter 2

Background and Related Studies

Objectives

- To introduce the background and basic concepts of this research including AI and machine learning, Mental Health Care theories and methods, and creativity
- To illustrate Mental Health Care applications of AI and machine learning
- To review existing research on sentiment analysis and supervision.
- To introduce sentiment classification and related definition
- To explain creativity techniques and tools

2.1 Wearable Medical Related Products Development

Along with the progress, new informatics technology, computer techniques, micro-electronic techniques are developed in this era. Based on these advanced, progressed techniques, and theories about human-machine interaction are applied to support creating intelligent wearable products. People are always the kernel part in the human-machine interactions, which means machines (wearable products) are the tools for serving people well eventually.

The known wearable products mean portable equipment that can be worn by the users or be composited on cloth or accessories of the users. Massachusetts Institute of Technology proposed wearable products in the 1960s [110]. It was the first time wearable products were mentioned formally [88]. In the year 2012, Google Company innovated google glass, which was regarded as the first wearable products production [88]. That year was regarded as the first year of the era of wearable product [88]. The ideas are not novel, but Google company is regarded as the pioneer of wearable products because of combining informatics techniques with products. The combination is used to achieve creativity.

The definition of wearable products should be explained that is imperative for further combination with software applying in mental health care. The wearable products can change people's normal life and provide convenience and intelligent assistant to some extent. Wearable products can support the hardware through effective software and data interaction, cloud interaction to achieve multi-function. Meanwhile, wearable products bring novel experiences by using this kind of equipment and life could be changed [88]. The equipment mentioned above is a kind of personal mobile computer system with characteristics on wearable, personality, novel form, mobility, and so forth. Assistant and enhancement to people's natural and continuous activities and behaviours can be achieved by this equipment. Recently, mobile Internet and big data have been well developed, so wearable intelligence production can obtain brilliant development chance to change the lifestyle [82]. Wearable products, which can generate real-time, multi-circumstances communication with people, are different from previous interactive products. Furthermore, wearable products are capable to become an assistant for people's normal life, studying, and achieving working efficiency enhancement [58].

Currently, some existing functions on wearable products are useful. Based on data from the public Internet, wearable production is equipped with calculation functions, connecting with mobile facilities and other kinds of portable accessories [108]. Wearable products, like wrist-based products (including watches, wrist belts, and so forth), feet-based products (including shoes, socks, and any other products designed for legs), head-based products (including glasses, helmets, head belts, and so on), and other anti-main-stream products types including smart cloth, backpacks, assistant sticks, accessories and so forth, improve the relationships between people and Internet [108]. However, mental health care is another issue to be considered as wearable products currently can rarely supervising mental health based on collected data. Deep learning and machine learning are proofed to be the incredible technique for solving complex mental health analysis issues, but people are becoming worried about the accuracy of outcomes if the algorithm is unreliable [94]. Deep learning and machine learning (Artificial Intelligence) based mental health care framework and the applicable system are necessary.

To improve the techniques in wearable products to assist people supervising mental health care in normal life, research on combining AI and medical regarding wearable products as the carrier is imperative. Proposed research on wearable products industry and relevant field is blank before the year of 2013. Proposed papers can be rarely found. Rarely scholars have a deep research on development trend in mental health care being fused with AI and wearable products. For the wearable products industry, the mainstream opinion focuses on the whole supply chain is affected by production form, production functions, and wearable products.

According to the production form, Zhao stated sports and health become the breakpoint of wearable product development [130]. In these two fields, wearable products could become a kernel factor to improve the development of design [97]. Wearable products can break the design boundary in relevant fields. Geng, et al., stated wearable products are becoming intangible, micro-orientation [35]. In the future, wearable products form can be enhanced in three aspects, which are tiny and thin, interaction friendly, and easily connective [35]. Huang and Zhang claimed that wearable products could have similar functions with mobile phones and other portable equipment [48]. Wearable products can become the next control centre platform for managing personal information [48]. Convenience and health are regarded as the aim for developing intelligent wearable products. Based on proposed research on wearable products design, it is possible for my research to achieve connections between software and hardware.

According to the aspect of product functions, Sun and Feng claimed that wearable products had the trend on marketisation, digitised and networked, which brought changes on functions and architecture aspects of interaction [112]. Han claimed that wearable products would be developed from components to entire equipment, from volume production to customised production [43]. Most importantly, wearable products could vary from unitary hardware to artificial intelligence hardware [43].

From the perspective of the supply chain of wearable products, Xiang stated that the appearance of wearable products brought a revolution on data processing [115]. Especially complicated data processing could become a popular field [115]. Song explained that with the development of motivate Internet, connections between wearable products and different kinds of application software would be a new development trend [109]. Wearable products can be applied to combine supply chain, satisfying healthy entertainment for customers, requirements of information obtaining and delivering [109]. Wu stated that wearable products could facilitate open-source of hardware including chip providers opening the source of intellectual property and professional companies opening kernel capabilities [117].

Table 2.1 Classification of Intelligence Shoes Production

Company	Main Production	Kernel Function	Type
Lining	Intelligent Running	Counting Paces	Sports Shoes
Minhu	Intelligent Running	Counting Paces	Sports Shoes

Tebu	Intelligent Running	Counting Paces	Sports Shoes
Anta	Intelligent Running	Counting Paces	Sports Shoes
361	Intelligent Running	Counting Paces	Sports Shoes
	Intelligent Kids Shoes	Positioning	Kids Shoes
Shuangchi	Intelligent Running	Counting Paces	Sports Shoes
	Intelligent Kids Shoes	Positioning	Kids Shoes
Tencent	Kids Intelligent Shoes	Positioning	Kids Shoes
Xiaoai	Intelligent Pregnant Shoes	Counting Paces	Pregnant Shoes
Guizhibu	Intelligent Pregnant Shoes	Counting Paces	Pregnant Shoes

With rapid development, increasingly famous organisations have invested a lot in smart wearable products. In Table 2.1, some companies that have produced intelligent shoes are presented. The products mainly includes intelligent shoes for counting paces, kids intelligent shoes for positioning, and pregnant shoes for supervising women's health. Besides the newcomers, some classic intelligence brands, such as “Shuangchi”, created relevant new production step by step.

‘OF Week’ wearable products website stated that after the rapid development in 2015, more and more famous organisations, such as Tencent, Lenovo, access this field and focus on smart shoe research [119]. Most of them have already promoted their production. In the intelligence equipment market, competition is increasing.

Further, the connection hardware between the user and wearable products acts as a bridge role that can reduce the gaps. The development level on research and trading is highly improved. In 2016, the shipment of intelligence chips had been improved enormously. The main manufacturer of intelligence chips for the intelligence equipment are Huami, QQ wulian and Foxconn. Among them, Huami occupies the largest shipment, which is about 1500 thousand. Shipment of QQ wulian is about 800 thousand. Shipment of Foxconn is about 500 thousand. The previous giant on intelligence shoe chip shipment, Qiangua Technology Company has been losing the market and changed to other fields.

The shipment of Qiangua Technology Company is only 20 thousand this year. Based on the situation, the shipment of intelligence chips in China could be 6000 thousand in 2016, which means the development situation of intelligent wearable products are positive [52]. In 2016, the situation of Internet companies is still depressed. Until November of 2016, based on the statistical data, thousands of Internet companies claimed to be bankrupted. Internet companies in China stopped producing hardware to make the company in the normal situation [16]. Consumers are increasingly losing the passion for intelligence hardware, and then intelligence wearable products become the new target for the consumers in the market. Besides the companies like Tencent, Xiaomi, Lenovo, there are over ten Internet companies joining the intelligence equipment and relevant accessories research list. However, Internet companies cannot occupy satisfied portions on the market based on existing technologies and resources since the field is unfamiliar for those companies. Meanwhile, traditional shoe organisations, brand companies are joining intelligence shoes production based on Industry 4.0 and manufactured in China 2025 [122]. Besides the main sports brand mentioned above, Guirenniao, Tianchuang fashion and some other famous brands are trying to join the intelligence equipment industry.

In the traditional unintelligent sports shoe era, different manufacturers focused on low weight, high damping, wearproof material, injury prevention aspects for research and development. Some of the main technologies have been renowned by sports fans, such as air cushion damping. Marketing experts point out that apple company, google company, Nike has already focused on research and development on relevant intelligence sports shoes [99]. Nike company makes relevant research and development work for outsourcing to a team in Taiwan, China (research members are mainly from Taiwan Universities) [118].

Taking Nike company intelligence shoes as an example, the accelerometer, the gyroscope is equipped on these kinds of shoes. If some of the activities may cause injury to the individual, the intelligence sports shoes will alarm [3]. Of course, being similar to healthy wrist bands and intelligence watch, researchers have also prepared all kinds of intelligence sports shoes with supervision sensors and functions [92]. For example, in the process of running, intelligent sports shoes can supervise users' body indexes and other kinds of data to provide feedback for users about the real-time body condition.

Health wrist bands produced by Jawbone company can record users' paces, energy loss.

But as it is a wrist band instead of legs wrists band, the measurement is inaccurate in some respect. The sensors and counting utilities that are equipped in sports shoes, can record more accurate data [56]. Sensors and some other utilities in the sports shoes can record and analyse people's body heart beating rate, actions, breathing, temperature, and burning energy in running, walking, stretching process, which can at the same time presented in application software [24]. The application can recognise multiple training types and yoga movements through intelligence chips.

In Figure 2. 1, existing wearable products are presented with a human model. From head to feet, all kinds of wearable products are based on chips and sensors to collect data. Major wearable products that have been designed for people include a wearable intelligent helmet, wearable intelligent glasses, wearable intelligent watch, wearable band, wearable intelligent clothes, and wearable intelligent shoes. Chips can be used as connections in data collection media between users and wearable products. Body indexes and other related data can be collected by adding chips to wearable products, such as shoes and clothes. Micro cameras can be placed for collecting image data and video data for further analysis. Mental health is affected by multi-factors in the surrounded environment so that the analysis of people's emotions is a complicated job. Besides, human's emotions are complicated mental expressions based on proposed scientific research. Specific literature reviews about the emotions are explained in the next section. A dermal patch is a kind of advanced technique for applying sensors and chips in wearable products for data collection[137].

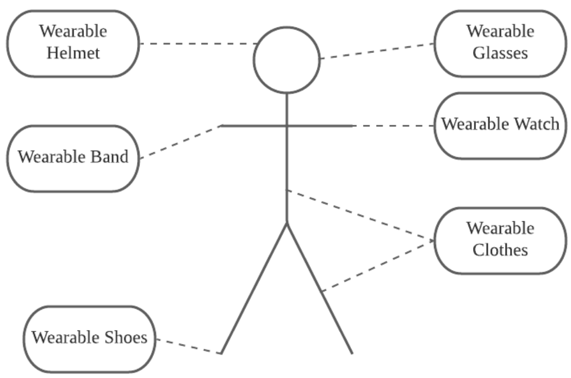

Figure 2. 1 Wearable Products Classification

2.2 Existing Research on Mental Health Care

Based on the perspectives about the emotions, it is a kind of solution for problems that is represented in time-tested manner [39]. For instance, one of the emotions of people, fear means when people are afraid, the senses are sharpened, the muscles of people are primed to make people moving faster away from the place that makes people fear [40]. The emotional reactions are typically short-lived and included in subjective experience. Further, different emotions of people are used for dealing with different problems [39].

Emotion refers to the experience of the attitude towards the external things produced with influences of cognition and consciousness [11]. It is the response of the human brain to the relationship between the external things and the needs of the subject. It is a kind of psychological activity mediated by individual needs [11]. Therefore, the response to external things from the brain has influences on emotions.

According to Daniel Goleman, a psychology professor at Harvard University, emotion is a kind of unique thought with psychological and physiological states, as well as a series of tendencies of action [37]. According to the Oxford English dictionary, the literal meaning of "emotion" is "the excitement or agitation of psychology, feeling, passion, any intense or excited mental state" [89]. Functionalism defines emotion as a psychological phenomenon of the relationship between individuals and environmental events [55]. Arnold's definition is a kind of experience tendency which is beneficial to trend perception and harmful to leave perception [50]. This experience tendency is accompanied by a corresponding physiological pattern of approaching or retreating [4]. Lazarus proposed the definition that emotion is the organisation of physiological and psychological responses from positive or negative information in the dynamic environment, which depends on short-term or continuous evaluation [57].

There are more than 20 definitions of emotion. Although they are different, they all admit that emotion is composed of the following three components, which is presented in Figure 2. 2:

- Emotion involves changes in the body, which are expressions of emotion.
- Emotion involves conscious experience.
- Emotion contains cognitive components, involving the evaluation of external things.

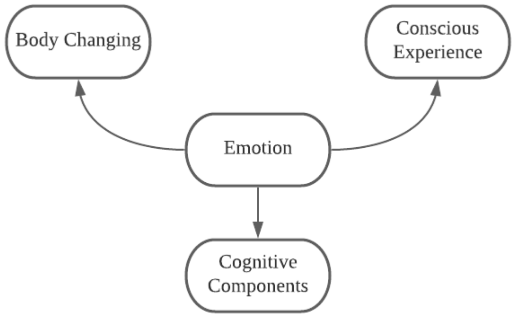

Figure 2. 2 Emotion Components

Because emotion and emotional expression are easily confused, for example, the satisfaction of love is always accompanied by happiness [33]. Emotion is a state that is constantly aroused and experienced by individuals. Emotional expression includes the actions of people in a specific emotion. Language (voice), facial expressions, and behaviours are all emotional expression forms. Mental health is defined as the psychology state of the people. Mental health can be divided into three categories, which are positive mental health, negative mental health, and natural mental health [33]. Mental health can be expressed by people by emotions, behaviours languages(voice), or some other forms. Some people are influenced so deeply by mental health issues that they would not express the mental issues to anyone [11]. It is difficult for the researchers to detect mental states. In this research, I focused on the mental issues that are expressed by the emotions in normal life. It is the expression form that can be detected and calculated by algorithms for further analysis. Mental health can be supervised in this way.

Different types of emotions have impacts on normal interaction with others. People are usually ruled by these emotions in normal life. The choices, behaviours, perspectives are partly influenced by emotions. A few different research theories on emotions are proposed to define and categorise emotions from people.

Emotions have been researched for years. A list of scholars has proposed theories based on literature for teaching people about human emotions principles and classification. Some more scholars have discussed the combination between health care and emotion control. Mental health problems appearance has influences on health, which can be presented by the health index [11].

Robert Plutchik proposed the theory for defining eight basic emotions, which are fear, anger, sadness, joy, disgust, surprise, trust, and anticipation [96]. For each basic emotion, specific definitions and classification are explained. Fear means the feeling of being afraid, frightened, or scared [96]. Anger means the feeling of angry, which is a weak emotion [96]. The strong emotion of anger is rage. Sadness refers to the feeling of sadness, which is similar to sorrow, grief. Joy is regarded as the feeling of happiness or gladness [96]. Disgust is that the feeling something is wrong or nasty. Surprise refers to a mood of being unprepared for something [96]. Trust is regarded as a positive emotion [96]. In the specific label of this emotion, the admiration is stronger, the acceptance is weaker. Anticipation is usually regarded as an action [25]. In the emotion aspect, anticipation refers to the sense of looking forward in a positive way to something that may nearly happen [96]. Especially, the expectation is more neutral [25]. To be more explicit to express emotion classification and scope, Plutchik designed an emotion wheel based on eight emotion labels. As can be seen in Figure 2.3, different emotions are represented by different colours in the structure of the wheel.

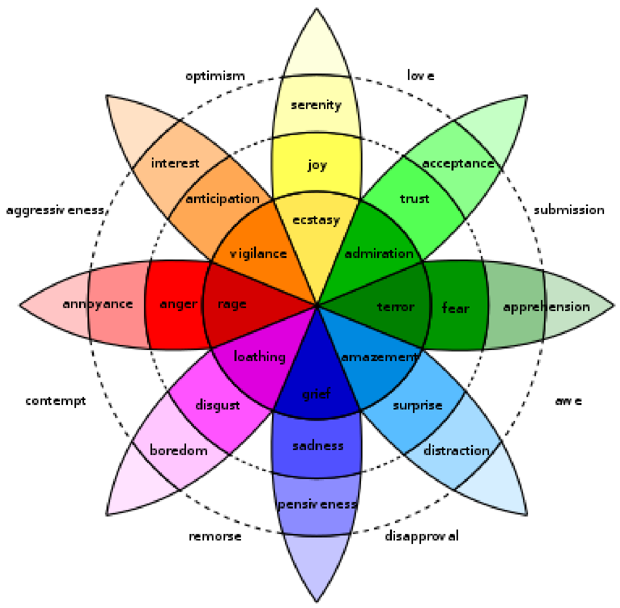

Figure 2.3 Emotion Wheel

Based on the primary explanation of the emotion wheel, eight emotion aspects have mapping relationships oppositely. Joy is mapped with sadness as the opposite side [25]. Fear is mapped with anger. Anticipation is mapped with surprise. Disgust is mapped with trust [13].

Further, the emotion wheel has achieved a combination depiction between distinguished labels, such as optimism is the composition of joy and anticipation [133]. Love is composed of joy and trust. Submission is composed of trust and fear [83]. Fear and surprise are combined to be awe emotion [83]. Surprise and sadness are combined to be disapproval [96]. Sadness and disgust are mingled to be remorse [96]. Disgust and anger are the basis of contempt [96]. Lastly, anger and anticipation are composed of aggressiveness [25].

The vertical dimension of the emotion wheel represents the intensity of each emotion label [10]. From outside to the centre of the wheel, emotions are intensified. The colours in the wheel are used for representing the intension of emotions. For instance, annoyance is the least level intention of anger emotion. Rage is regarded as the highest level of anger's intensity. Anticipation's highest-level emotion is vigilance. Joy's highest-level emotion is ecstasy. The administration is the highest-level emotion of trust. Fear's highest-level emotion is terror and so forth. Such emotions contain hard-to-detect changes of emotions in normal life [10]. Dark colours and light colours around the basic eight emotion in the emotion wheel can be used for emotion analysing for individuals [25].

Furthermore, some scholars stated that the emotion of humans included anger, friendship, fear, shame, shamelessness, kindness, pity, indignation, envy, and love [81]. Ten emotion classification method has some similar points with emotion wheel method. For example, anger, fear, and love have the same with emotion labels in the emotion wheel [95]. However, others are rarely being connected with labels in the emotion wheel. Some of the labels in the ten-label-emotion-model such as friendship are where people feel joy and may have fun together [34]. The definition of each emotion and words for representing related emotion is inaccurate.

Charles Darwin had researched on emotion as well. The expressions of the emotions in man and animals were the kernel work of Darwin in emotion subject, which is an imperative source for emotion research [81]. The chapter headings of the research achievement are basic emotions' labels, which are:

- Suffering and weeping
- Low spirits, anxiety, grief, dejection, despair
- High spirits, Joy, love, tender feelings, devotion
- Reflection, meditation, ill-temper, sulkiness, determination
- Anger and hatred
- Disgust, disdain, contempt, guilt, pride, helplessness, patience, affirmation and

negation

- Surprise, astonishment, fear, horror
- Self-attention, shame, shyness, modesty blushing [81]

Table 2. 2 Darwin Emotion Classification Categories

Emotion Label	Related Emotions	Positive (P) or Negative (N)
Suffering	Weeping	N
Low Spirits	Anxiety, grief, dejection, despair	N
High Spirits	Joy, love, tender feelings, devotion	P
Reflection	Meditation, ill-temper, sulkiness, determination	N
Anger	Hatred	N
Disgust	Disdain, contempt, guilt, pride, helplessness, patience, affirmation, and negation	N
Surprise	Astonishment, fear, horror	N
Self-attention	Shame, shyness, modesty, blushing	N

The list of the headings of Darwin's research are basic emotions of people[46]. Eight aspects of emotions are specific classifications [81]. Each category has its definition direction. For example, the third category of emotions, i.e., joy, high spirit, love, tender feelings and devotion are positive feelings for life [101]. However, the order in of them can be recognised difficultly, which is not as explicit as the emotion wheel.

Darwin detected people, as special mammals, who knows how to use muscles to express different emotions [101]. The face of people has muscle movements that can adapt requirements of emotional expression [101].

Ekman stated the theory further through researching on emotion hiding of people [23]. Ekman focused on filming glimpses of people's emotional expressions [23].

Some scholars proposed an academic study depicting 27 emotion labels which are Admiration, Adoration, Aesthetic Appreciation, Amusement, Anxiety, Awe, Awkwardness, Boredom, Calmness, Confusion, Craving, Disgust, Empathetic pain, Entrancement, Envy, Excitement, Fear, Horror, Interest, Joy, Nostalgia, Romance, Sadness, Satisfaction, Sexual desire, Sympathy, Triumph. The 27 emotions include most of the general emotions of people. However, the classification is not achieved [21].

Based on these theories, the basic emotions are accepted by most scholars, which are six basic emotions including happiness, sadness, disgust, fear, surprise, and anger. Six basic emotions theory was identified by Paul Eckman. He expanded the emotions to include pride, shame, embarrassment, and excitement.

Psychologists have attempted to identify different types of emotions in normal life after people experienced them. Some of the emotions are combined to be classified into the same category that can explain similar emotions.

Table 2. 3 Selected Proposed Classification of Emotions

Scholar(s)	Classification of Emotions
Paul Eckman	happiness, sadness, disgust, fear, surprise, and anger
Michael Lewis, Jeannette M. Haviland-Jones, Lisa Feldman Barrett	Admiration, Adoration, Aesthetic Appreciation, Amusement, Anxiety, Awe, Awkwardness, Boredom, Calmness, Confusion, Craving, Disgust, Empathetic pain, Entrancement, Envy, Excitement, Fear, Horror, Interest, Joy, Nostalgia, Romance, Sadness, Satisfaction, Sexual desire, Sympathy, Triumph
Charles Darwin	Suffering and weeping; Low spirits, anxiety, grief, dejection, despair; Joy, high spirits, love, tender feelings, devotion; Reflection, meditation, ill-temper, sulkiness, determination;

	Anger and hatred; Disgust, disdain, contempt, guilt, pride, helplessness, patience, affirmation and negation; Surprise, astonishment, fear, horror; Self-attention, shame, shyness, modesty, blushing.
Robert Plutchik	fear, anger, sadness, joy, disgust, surprise, trust, and anticipation

For happiness, sadness, and fear, each emotion can bring different feelings, different facial and physical reactions, as well as psychological feelings [33].

From the perspective of biological evolution, emotions can be divided into basic emotions and compound emotions [38]. Basic emotions are shared by people and animals and can be learned without learning [59]. They can also be called primitive emotions. Each basic emotion has its neurophysiological mechanism, internal experience, external performance, and different adaptive functions [84]. Although there are many different kinds of emotions, it is more common to regard happiness, anger, sadness, and fear as the basic forms of emotions [84]. In human society, these basic emotions are generally understood through races.

Happiness is a kind of pleasure in the individual spirit, a satisfaction in the soul, and a very comfortable feeling that the individual receives from the inside to the outside [87]. Tasting delicious food, appreciating art, participating in games, and interpersonal communication can make individuals have happy emotional experiences. The common expression of happiness is laughter [91]. When people laugh, they will always be accompanied by the pleasure in their hearts and the openness in their bodies [2].

Anger not only refers to a kind of tense and unpleasant emotion caused when the desire cannot be achieved or the action to achieve the goal is frustrated but also exists in the extreme antipathy to the social phenomenon and other people's encounter or even unrelated matters [116]. Anger is a kind of negative feeling state, which generally includes hostile thoughts, physiological reactions, and maladaptive behaviours [29].

Anger appears earlier in the process of human growth. Infants born three months have the expression of anger. Restricting their exploration of the external environment can cause anger. For example, restricting their physical activities, forcing them to sleep, limiting their range of activities, not playing with toys, etc. can cause their anger [37].

Sad, as a negative basic emotion, usually refers to the emotional response caused by separation, loss, and failure, including depression, disappointment, discouragement, depression, loneliness, and isolation [91]. The degree of sadness depends on the importance and value of what is lost; it also depends on the consciousness tendency and individual characteristics of the subject [2].

Fear is a kind of intense depressive emotional experience that people are afraid when facing a certain dangerous issue, trying to get rid of it but unable to do anything [116]. Fear is usually the most harmful to people's physical and mental health.

For many times, emotions are not simply happiness or anger, but a combination of different emotions, such as sadness and joy, anxiety, hostility, and other emotions [116]. The combination of these emotions is called compound emotions. Different emotions will produce a variety of compound emotions [29]. Human emotions are very complex and colourful. The study of emotion has always been a hot topic in the field of psychological cognition [29].

Emotions are different from the term mental health. Emotions are the expressions of mental health. Some deep mental health problems cannot be recognised in our normal life. However, emotion is one of the expression methods of the mental health. It is the chance for discovering mental health by evaluating emotions of the users.

Emotions accompany people's life, which is not only a response but also a kind of mean. In life and work, lots of issues are required to be dealt with, and emotions are produced at the same time. Emotions sometimes inevitably affect our daily life, so the effective management of emotions is very important. Being the master of emotions, rather than being controlled by emotions, is an important course people need to practice [37].

Connections between emotions and body change. From the emotional aspects, body indexes could change, such as body temperature, heartbeat, respiration, blood sugar, and others.

In the long-term negative mood, the nerve centre continues to release impulses to regulate homeostasis, which leads to the habituation of receptors and receptors to nerve impulses and hormones, and homeostasis will start migration [54]. At the same time, high load operation of organs, long-term fatigue, will also affect the health of the body [61].

Scholars feel that increasing changes in the mental state will cause different emotions of the body to react in different parts of the body.

The Finnish researchers, who published research papers in the proceedings of the American Academy of Sciences, stated that emotions did consistently affect our bodies [54]. In five experiments, 701 participants "showed two tendencies in response to hearing or seeing stimulating words, stories, movies or certain facial expressions" [54]. As required, when they are stimulated, they will increase or decrease the body response and colour the corresponding parts of the body diagram [61]. Their mood changes are caused by listening to stories or watching movies. On the blank chart made by computer, colour is shown according to the feeling of the body, red or yellow for the parts with a strong reaction, blue or black for the parts with lighter reaction [54].

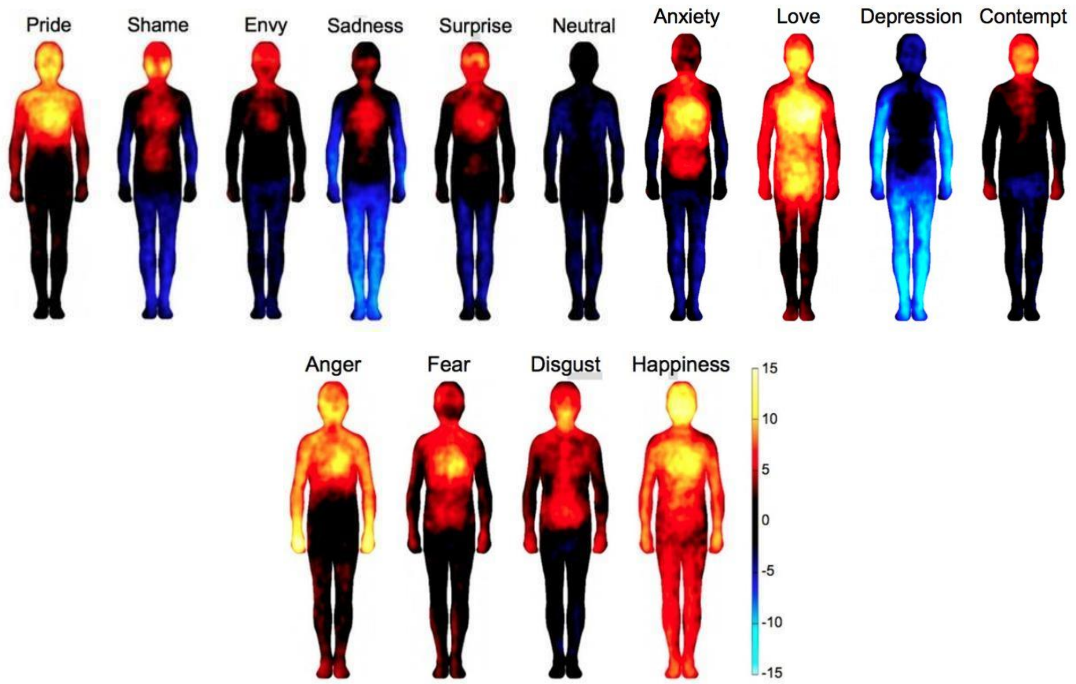

Figure 2. 4 Body Reaction for Different Emotions

Figure 2. 4 can express the expected effect: the head is hot when angry; the head, hands and feet of happy people will be hot; the people who feel depressed are painted blue (that is, the feeling of limbs) [22]. Almost all emotions cause head changes, such as smile, frown, skin temperature, and other body changes, perhaps because one is preparing and talking to hug, or one wants to extend his fist to knock down the other party [30]. At the same time, "reactions also occur around the digestive system and throat, mainly in the

stomach", it's important to note that limb responses are not like blood flow, body temperature, or other objective measurements [54]. According to their own experience, the main performance is body tingling. In the above illustration, there is a close relationship between the colour of different body parts and 71 kinds of stimulation (speech, story, movie, etc.) each person receives [54]. From a physiological point of view, most emotions can only cause very small fluctuations in heart rate or changes in body surface temperature, and the body will not become hot because of surprise [61]. However, the results seem to reveal the human body's subjective feelings of mental state, the influence of muscles and viscera, and the indistinguishable nervous system response [54]. For example, the feeling of jealousy will not make face red, but people feel that the upper part is red. Therefore, the classification of the emotion can be confirmed in this research, including six basic emotions. Related emotions are the supports of the research process. Emotion values can be calculated and a related model can be developed based on the structure of the emotions.

2.3 Proposed Research on Artificial Intelligence for Mental Health Analysis Application

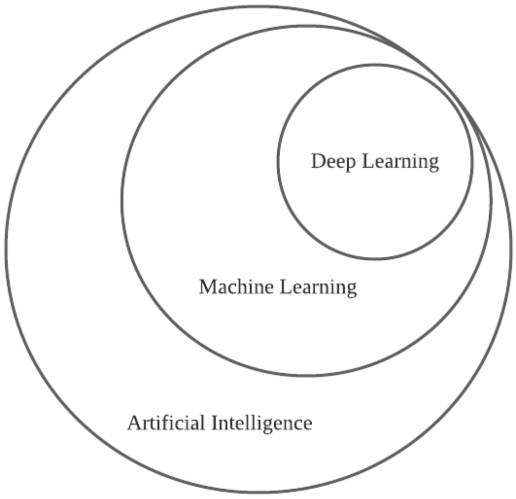

Figure 2. 5 Relationships Among Artificial Intelligence, Machine Learning, and Deep Learning

Artificial intelligence was born in the 1950s when a few pioneers in computer science began to question: can computers "think"? The answers are still being explored to this question today. The simple definition of artificial intelligence is as follows: to make computers attempt to automate the intelligence tasks that are usually completed by human beings [7]. Therefore, artificial intelligence is a comprehensive field, including not only machine learning, but also more methods that do not involve learning. For example, early chess programs contained only hard-coding rules carefully written by programmers, which is not machine learning automatically [7]. For quite a long time, many experts believe that as long as programmers carefully write enough clear rules to deal with knowledge, they can achieve artificial intelligence equivalent to human-level [85]. This method is called symbolic AI, which is the mainstream paradigm of AI from the 1950s to the end of the 1980s. In the upsurge of the expert system in the 1980s, the popularity of this method reached its peak [79]. Although symbolic AI is suitable for solving well-defined logic problems, it is more difficult to give clear rules to solve more complex and fuzzy problems, such as image classification, speech recognition, and language translation [80]. Therefore, a new method to replace symbolic artificial intelligence appears, which is machine learning [53]. Among all the above application areas, image classification, language translation, or language processing are essential algorithm bases for mental health analysis.

Although machine learning has rapidly become the most popular and successful branch of artificial intelligence in the 1990s [80]. This development is driven by advanced hardware and a large volume of data sets. Machine learning and mathematical statistics are closely related, but they are different in several important aspects. Being different from statistics, machine learning is often used to process complex large data sets (such as data sets containing millions of images, each image contains tens of thousands of pixels). It is impractical to use classical statistical analysis (such as Bayesian analysis) to process such data sets [1]. Therefore, machine learning (especially deep learning) presents relatively few mathematical theories (probably too few) and is engineering-oriented [74]. Classification algorithms in machine learning can be applied for mental health data classification. General mental health-related data is of different types, including structured data and unstructured data. Body indexes are the basis for the mental health analysis. Image and behaviour analysis is used for making the analysis outcomes more accurate.

Usually, it is rarely being realised in advance which algorithm is best for the current dataset. An experiment has to be generated again and again to find the algorithm that works well on the dataset and then further adjust the corresponding algorithm model parameters.

First of all, it can be guessed which algorithms may have better effects on the current data set, and then select several algorithms to be tested, then it can be started to experiment with these algorithms on the data set [44].

It is better to choose different algorithms to be tested, for example, to select linear model and nonlinear model, and then to observe the learning ability of different types of models to data sets [53].

Basic classification algorithms include KNN, SVM, logistic regression, decision tree, neural network-related algorithm, and so forth [80]. In this research, a decision tree is more suitable for mental health data classification.

Machine learning methods often focus on learning with only one or two layers of data representation, so they are sometimes called shallow learning. These hierarchical representations are almost always learned through a model called a neural network [106]. The structure of the neural network is layer by layer. The term neural network comes from neurobiology. However, although some core concepts of deep learning are derived from people's understanding of the brain, the machine learning model is not a brain model [100]. There is no evidence that the brain's learning mechanism is the same as that used in modern machine learning models. For newcomers in this field, if there is any relationship between AI and neurobiology, it will be confusing and only counterproductive [124]. The mysterious packaging of "just like our mind" is not required, and it is better to forget the imaginary connection between AI and biology. As far as our purpose is concerned, AI is a mathematical framework to learn from and express data.

In 2011, Ciresan from IDSIA began to win the academic image classification competition by using the deep neural network trained with GPU [132]. This is the first time that modern deep learning has been successful in practice. But the real turning point came in 2012, when the Hinton team took part in the annual large-scale image classification challenge, ImageNet [64]. The ImageNet challenge was known for its difficulties at the time, and participants needed to train 1.4 million high-resolution colour images and then divide them into 1000 different categories [121]. Since 2012, deep convolution neural network (Convnet) has become the preferred algorithm for all computer vision tasks [60]. More generally, it works on all perceptual tasks. At major computer vision conferences in 2015 and 2016, almost all presentations were related to

Convnet [60]. At the same time, AI is also applied to many other types of problems, such as natural language processing [63]. Some creative algorithms have completely replaced SVM and decision tree in many applications.

Natural language processing (NLP) is a technology for the study of computer processing of human language, including:

Syntactic semantic analysis: for a given sentence, segmentation, part of speech tagging, named entity recognition and linking, syntactic analysis, semantic role recognition, and polysemous word disambiguation are carried out [73].

Information extraction: extract important information from a given text, such as time, place, person, event, cause, result, number, etc [20]. It involves key technologies such as entity recognition, time extraction, causality extraction, and so on [20].

Text mining (or text data mining): including text clustering, classification, information extraction, summary, emotional analysis, as well as visual and interactive expression interface for the information and knowledge mined [8]. At present, the mainstream technology is based on statistical machine learning.

Machine translation: the input source language text is automatically translated to obtain the text of another language [17]. According to different input media, it can be divided into text translation, voice translation, sign language translation, graphic translation, etc [17]. From the earliest rule-based method to the statistical method twenty years ago, and then to the neural network (encoding decoding) method today, machine translation has gradually formed a more rigorous method system [17].

Information retrieval: index large-scale documents. It can simply index the words in the document with different weights, or use the technology of 1, 2, 3 to build a deeper index [20]. During the query, the input query expression such as a search term or a sentence is analysed, then the matching candidate documents are searched in the index, and then the candidate documents are sorted according to a sorting mechanism, and finally, the documents with the highest-ranking score are output [20].

Question and answer system: for a question expressed in natural language, the question and answer system gives an accurate answer [17]. It is necessary to carry out some semantic analysis of natural language query statements, including entity link and relationship recognition, to form logical expressions, and then find possible candidate answers in the knowledge base and find the best answers through a sorting mechanism [17].

Dialogue system: through a series of dialogues, the system can chat, answer, and complete a certain task with users [73]. It involves user intention understanding, general chat engine, question answering engine, dialogue management, and other technologies [73]. Besides, to reflect the context, it is necessary to have the ability of multiple rounds of dialogue. At the same time, to reflect the personalisation, it is required to develop user portrait and personalised response based on user portrait.

The existing combination of mental health analysis and machine learning is started from natural language processing. Giant companies like Twitter, information from comments, or twits are used for analysing user's emotions. Mental health can be expressed by using such natural language processing. Several proposed kinds of research have been done about analysing sentiment based on comments on Twitter.

Pak and Paroubek built a model to explain the tweets as objective, positive, and negative. By using Twitter API and automatically, the model can evaluate emotions. The corpus can be used for developing an emotion classifier based on the Naïve Bayes method by using features N-gram and POS-tags [90].

Go and Huang proposed distant supervision for emotion detection in twitter texts, in which their training data consisted of tweets with emoticons that served as noisy labels. The theories like Naive Bayes, MaxEnt, and Support Vector Machines (SVM) are applied for establishing models [36].

Barbosa et al. designed a two-phase automatic sentiment analysis method for classifying tweets texts for emotion analysis. They classified tweets as objective or subjective and then in the second phase, the subjective tweets were classified as positive or negative [5].

The techniques that are going to be used in this research are stated in this section. Computing can be completed by using these methods for supporting building-related frameworks and systems.

2.4 Knowledge Graph and Blockchain Consensus Mechanisms

The goal of Internet knowledge is to build a world wide web that can be understood by both humans and machines and make people's networks more intelligent [62]. However, due to the multi-source content and loose organisational structure of the world wide web, knowledge interconnection in the big data environment has brought great challenges [98]. Therefore, people need to explore the knowledge interconnection methods that not only meet the development and change of network information resources but also meet the needs of users and people from a new perspective according to the principles of knowledge organisation in the big data environment, to reveal the overall relevance of human cognition in a deeper level [98]. Knowledge graph, with its powerful semantic processing ability and open interconnection ability, makes the vision of the "knowledge network" proposed by Web 3.0 possible [27].

With the rapid development of the Internet and the explosive growth of knowledge, search engines are widely used [27]. The traditional search engine technology can quickly sort the web pages according to the users' queries and improve the efficiency of information retrieval [27]. However, this efficiency does not mean that users can quickly and accurately obtain information and knowledge. For a large number of results being collected by search engines, manual screening and screening are also required [15]. Facing the increasing mass of information on the Internet, web search methods (only including the traditional documents linked between web pages and web pages) cannot meet the needs of people to quickly obtain the information they need and master the information resources comprehensively [32]. In order to meet this demand, knowledge graphing technology came into being [32]. The users can access the knowledge information they need more quickly and accurately and make certain knowledge mining and intelligent decision-making [32]. From the institutional knowledge base to the Internet search engine, scholars and institutions have made in-depth research on knowledge graph, hoping to show the connection between various concepts in this clearer and dynamic way [32].

The knowledge base system represented by the expert system began to be widely studied and applied [62]. The research on knowledge representation and knowledge organisation began to be carried out in-depth [111]. The institutional knowledge base system is widely used in the internal data integration and external publicity of scientific research institutions and units [72]. In November 2012, Google took the lead in proposing the concept of knowledge graph (kg), indicating that it will add the function of knowledge graph to its search results[111]. Its original intention is to improve the ability of search engines, enhance the search quality and search experience of users [111]. According to the statistics in January 2015, KG built by Google has 500 million entities and about 3.5 billion entity-relationship information, which has been widely used to improve the search quality of search engines [111]. Although the concept of knowledge graph is relatively new, it is not a new research field. As early as 2006, Berners Lee put forward the idea of linked data, calling for the promotion and improvement of relevant technical standards such as URI (Uniform Resource Identifier), RDF (Resource Description Framework), Owl (Web Ontology Language) is ready for the coming of the semantic network [9]. Then there is an upsurge of semantic network research. Knowledge graph technology is based on related research results, and it is a sublimation of existing semantic network technology [9].

The knowledge graph is a kind of semantic network that represents the relationship between entities [93]. It can formally describe the things in the real world and their relationships.

The knowledge graph is a structured semantic knowledge base, which is used to describe concepts and nodes, and their relationships in the physical world by using the form of symbols [47]. Its basic unit is the "entity relation entity" triplet, as well as an entity and its related attribute-value pairs. Entities are connected through relationships to form a network knowledge structure [107].

Triple is a general expression of the knowledge graph, that is, $G \in (\mathrm{E}, \mathrm{R}, \mathrm{s})$, the entity set in the knowledge graph is $E = \{e_1, e_2, \dots, e_{|E|}\}$. $R = \{r_1, r_2, \dots, r_{|E|}\}$ represents relationships set in the knowledge graph, including R types of different relationships. $S \subseteq E \times R \times E$ represents Triplet set in the knowledge graph[15]. The basic form of triple mainly includes Entity 1, relationship, Entity 2 and concept, attribute, attribute value, etc. Entity is the most basic element in the knowledge map, and different entities have different relationships [111]. The concept mainly refers to the set, category, object type, type of things, such as people, geography, etc.; the attribute mainly refers to the attributes, characteristics, characteristics, and parameters that the object may have. Each entity (the extension of concept) can be identified by a globally unique ID. Each attribute-value pair (AVP) can be used to describe the internal characteristics of an entity, while the relationship can be used to connect two entities and describe the relationship between them.

The structure of the knowledge graph can be presented as:

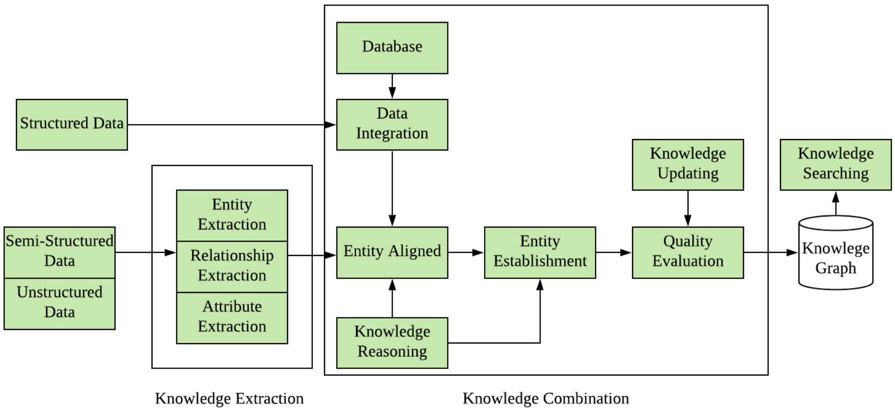

Figure 2. 6 Knowledge Graph Structure

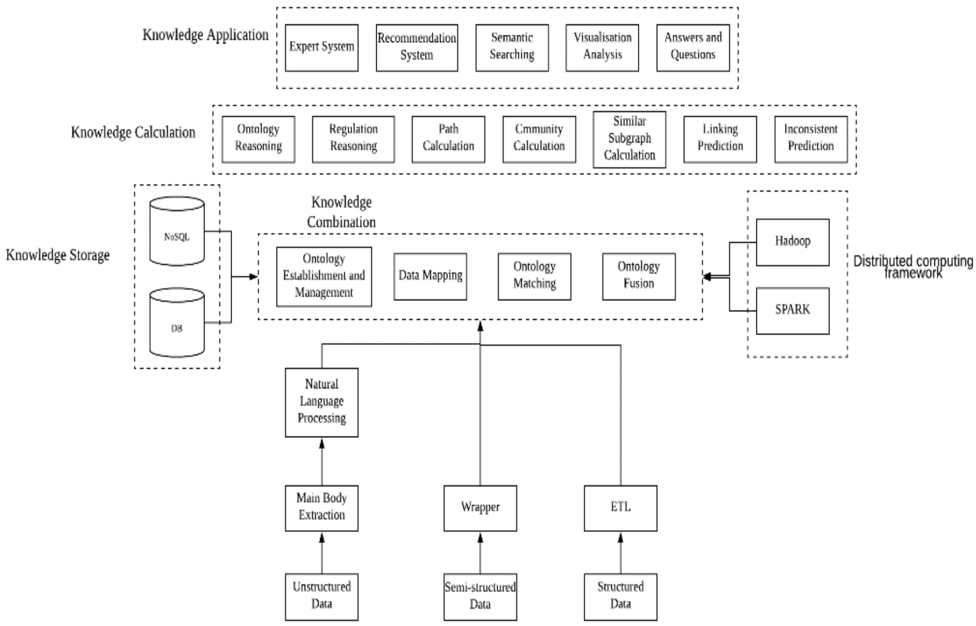

Figure 2. 7 Knowledge Graph Technical Structure

The techniques that are used in knowledge graph includes expert system, semantic web techniques, ontology reasoning, natural language processing, and big data techniques [103].

The key techniques of the knowledge graph include: Knowledge extraction (or information extraction), containing entity extraction, relationship extraction, attribute extraction (in essence, attribute extraction can also be regarded as relation extraction) [78].

Knowledge fusion contains entity connection, which includes entity disambiguation - a technique designed to solve the problem of ambiguous entities with the same name [45]. The main method of entity disambiguation is clustering [105]. The key problem of cluster disambiguation is how to define the similarity between entity object and reference item [105]. The common methods are,

- Space vector model.
- Semantic model (similar to space vector model, the difference is that the semantic model not only contains word bag vector but also some semantic features).
- Social network model (the basic assumption of this model is that objects are grouped, and people are grouped. In a socialised environment, the meaning of entity references is largely determined by the entities associated with them).
- Encyclopedia knowledge model (Encyclopaedia websites usually allocate a separate page for each entity, including the connection to other entity pages, encyclopedia knowledge model It is using this link relationship to calculate the similarity between entity references.) [102].

Entity alignment is mainly used to eliminate entity conflicts, unclear directions, and other inconsistencies in heterogeneous data [102]. It can create a large-scale unified knowledge base from the top level, to help the machine understand multi-source heterogeneous data and form a high-quality knowledge base [102]. The alignment algorithm can be divided into pair entity alignment and group entity alignment, while group entity alignment can be divided into local group entity alignment and global group entity alignment [113]. Pairwise entity alignment,

- Entity alignment method based on a traditional probability model.
- Entity alignment method based on machine learning.

Local entity alignment method: the local entity alignment method sets different weights for the attributes of the entity itself and the attributes of the entities associated with it and calculates the overall similarity by weighted sum [114]. It can also use the vector space model and cosine similarity to determine the similarity degree of entities in a large-scale knowledge base [123]. The algorithm establishes name vector and cosine similarity for each entity the virtual document vector and the name vector are used to identify the attributes of the entity, while the virtual document vector is used to represent the attribute values of the entity and the weighted sum values of the attribute values of its neighbour nodes [123]. Global collective entity alignment method,

- Collective entity alignment method based on similarity propagation.

- A method of group entity alignment based on probability model;

Knowledge processing is another kernel technique of a knowledge graph. Specific techniques include ontology construction, knowledge reasoning, quality assessment[93]. Ontology construction - the biggest characteristic of ontology is that it is shared, and the knowledge reflected in ontology is a well-defined consensus [93]. Ontology is the semantic basis of communication between different subjects in the same field [123]. Ontology is a tree structure. There is a strict "is a" relationship between nodes (Concepts) in the adjacent level [123]. This simple relationship is conducive to knowledge reasoning but not conducive to the expression of concept diversity. Ontology can be built manually (with the help of ontology editing software) or automatically by a data-driven way with the help of a computer, and then modified and confirmed by the combination of algorithm evaluation and manual audit [93]. In addition to the data-driven method, the cross-language knowledge link method can be used to build an ontology library [123]. At present, the main research work of ontology generation mainly focuses on the entity clustering method. The main challenge is that the entity description obtained by information extraction is very short, and the lack of necessary context information leads to the unavailability of most statistical models[93].

Knowledge reasoning refers to starting from the existing entity-relationship data in the knowledge base, building a new association between entities through computer reasoning, to expand and enrich the knowledge network [131]. Knowledge reasoning is an important mean and key link in the construction of a knowledge map. Through knowledge reasoning, new knowledge can be created based on existing knowledge [131]. The method of knowledge reasoning is as follows.

Quality assessment refers to the task of quality assessment for the knowledge base is usually carried out together with entity alignment task [102]. Its significance lies in that the credibility of knowledge can be quantified, the one with high retention reliability and the one with low rejection reliability can effectively guarantee the quality of knowledge [102].

The amount of information and knowledge that human beings have is a monotonously increasing function of time, so the content of the knowledge map also needs to keep pace with the times, and its construction process is iterative [6]. Logically speaking, the only crying update includes concept level update and data level update [6]. There are two ways to update the content of the knowledge map: comprehensive update and incremental update driven by data [102].

Although the knowledge representation of triples has been widely recognised, it faces many problems in computing efficiency, data sparsity, and so on [6]. In recent years, the learning technology represented by deep learning has made important progress [102]. It can express the semantic information of entities as dense and low-dimensional real value vectors, and then efficiently calculate entities, relationships, and their complex semantic relationships in low-dimensional space, which is of great significance to the construction, reasoning, fusion, and application of knowledge base [131].

In this research, techniques of knowledge graph are applied for generating mental health data relationships to assist in generating emotion supervision more accurately.

Blockchain is regarded as a novel research area being combined with artificial intelligence.

This new consensus mechanism of blockchain enables it to complete its operation in large-scale and efficient cooperation without relying on centralised organisations.

In addition to cryptography technology, a consensus mechanism is also a necessary element and core part of the blockchain, which is the key to ensure the continuous operation of the blockchain system.

Due to the different application scenarios, different consensus algorithms are adopted. At present, there are four types of consensus mechanisms in blockchain,

- Workload proof mechanism POW.
- Rights and interests proof mechanism POS.
- Entrusted rights and interests' proof DPOS.
- Reification pool consensus mechanism pool.

For proof of work mechanism, it can be simply understood as proof that you have done a certain amount of work. By looking at the results of the work, you can know that you have completed the specified amount of work. POW is the most commonly used blockchain consensus algorithm. Both bitcoin and Ethereum are consensus mechanisms based on pow.

The advantages of POW are,

- The cost of establishing and maintaining a centralised credit institution is avoided by completely decentralising and nodes entering and leaving freely.
- As long as the network destroyer's computing power does not exceed 50% of the total network power, the transaction status of the network can be agreed, and the historical

records cannot be tampered with.

- The more computing power is invested, the greater the probability of obtaining bookkeeping right, and the more likely it is to generate new block rewards.

For proof of stake mechanism, the number and duration of holding tokens determines the probability of your bookkeeping. Similar to the dividend system of stocks, the more shares you hold, the more dividends you get. The token is equivalent to the rights and interests of blockchain system. At present, many digital assets are issued in new currency with POW.

The advantages of this mechanism are,

- It reduces the resource waste of the POW mechanism.
- It can also be regarded as the upgraded version of workload proof.

For delegated proof of stake, it is a more professional solution based on POS, which is similar to the voting of the board of directors. It means that the person who owns the token votes to a fixed node, elects several agents, and the agent is responsible for verification and bookkeeping. Different from POW and POS, the whole network can participate in the accounting competition, and the accounting node of DPOS is determined in a certain period.

To encourage more people to participate in the election, the system will generate a small number of tokens as rewards.

The advantages of this mechanism are that DPOS greatly improves the ability of the blockchain to process data, and can even realise the payment in seconds. At the same time, it also greatly reduces the cost of maintaining the blockchain network security.

Each consensus mechanism can rarely meet security, efficiency and fairness at the same time. The weaker the degree of decentralisation is, the lower the security is, and the faster the speed of the blockchain achieves. POW is completely decentralised, but its operation efficiency is too low. POS improves efficiency but reduces fairness and security. DPOS has strong centralisation characteristics, but it has the highest efficiency in the short term. At present, pool consensus is widely used in industry blockchain.

Knowledge graph is used for completing connections between health indexes and other related data. Block Chain is used for completing a consensus mechanism for integrating the emotion evaluation.

2.5 Creative Computing Techniques and Tools

Creative computing is a new discipline, which is in the software engineering paradigm, has been defined by several proposed research papers [26][41].

Creative computing is a novel theory describing a computing method, which is new, surprising, and useful, and can be implemented to solve issues creatively [41][128]. Each characteristic is imperative. Creative computing includes two terms in the semantic paradigm, which are creativity and computing [41][134][127]. To comprehend creative computing in literal interpretation hierarchy, creativity is an ability to achieve creative ideas; computing is to complete calculations with or without tools [26]. The computer that is a stable computer with unambiguous constraints is well documented to be an indispensable tool accompanied by people facing challenges [127]. The function of computing can be completed by using the software on computers [127]. A computer is a sort of carrier to link creative computing theory, methods, and people [127]. Meanwhile, creative computing theories and methods, and computers with software are imperative tools and techniques for people in addressing issues [26].

Therefore, creative computing means the ability to create novel, surprising, and useful solutions for addressing issues. The cardinal purpose of using creative computing is weaving and integrating proposed theories or methods to create new methods for addressing issues [26].

Creative computing needs to be fresh and valuable to create a kind of system or approach, which can be applied to navigate people to achieve knowledge combination and multidisciplinary creation [51][126][128]. It can rarely be considered as a sort of approach but a navigation guiding individuals being more creative in specific realms [135][136].

The computer system can be reconciled with creative computing with knowledge from other subjects achieving creative approaches to address issues, which has positive impacts on generating creative solutions [68]. The term creativity is ambiguous and uncontrollable [68].

The requirement for creative computing is urgent. Sophisticated issues have appeared, which are too hard for people to solve individually or with traditional tools and techniques [67], such as business model deployment, investment portfolio in the stock market, physics problems [66] [70]. Creative computing aims to guide the user to establish a business model creatively by combining knowledge of business and that of other fields [67]. Natural science, arts, and humanities may face dramatic and complicated questions and constraints which single subject is insufficient [66]. Complex problems are intractable because knowledge from the separate realm is limited in tackling such issues [65]. Even computer systems also have intrinsic constraints to limit their capability to challenge complicated issues and achieve creativity [12]. Thus, creative computing is proposed to provide satisfied creative approaches in many fields [12].

Creative computing is a challenge of software engineering, for it is an essential component in three paradigms of computing. Three paradigms are rationalist paradigm (computing is a branch of mathematics), technocratic paradigm (computing is a branch of engineering), scientific paradigm (computing is a branch of natural science) [27]. Thus, creative computing has conjunction with software engineering. The application scope of creative computing is broad [41]. As is shown in Figure 2.5, the creative computing subject is one of the subjects of the computing realm. Computing has conjunctions with software engineering, which means computers can be used for complicated computing [41]. As is illustrated, computing has been proofed as a part of software engineering, math, and natural science; creative computing is connected with these three disciplines as well [41]. Further, as one of the essential tools of creative computing in knowledge combination, creative computing can bridge computing with other disciplines [42].

Computing with useful information can be chosen to be a fundamental basis for generating creative guidance for users. Such computing modality is proposed to be creative computing [71].

Emerging techniques such as cloud computing, wearable products computing, and so forth may have connections with creative computing as useful underlying techniques.

Human-computer interaction is in the research scope of creative computing. Creative computing aims at detecting guidance and assistant for human life to make it convenient and comfortable [42].

Creative computing features and research structure is imperative for research in this discipline. Related studying structures could affect the implementation of this subject.

To detect creativity with creative computing is one of the most important research topics, which is one of the purposes of this research. Based on its interdisciplinary and multi-disciplinary feature, creativity is possible to be achieved on the computer through creative computing approaches [67].

The research scope of creative computing includes an evaluation. There should be a criterion to evaluate creative computing processing results. Assessed aspects should be listed.

Research methods in creative computing make another studying topic. Existing research methods include knowledge combination, knowledge engineering, knowledge transformational method, and so forth. Specific descriptions are illustrated in the next sub-section.

Creative computing subject has abundant methods of achieving creativity. There are four cardinal approaches of creative computing based on the proposed research (Figure 2. 8), which are:

- Knowledge combination
- Enhancement of human creativity
- Encouragement of tacit knowledge and its movement into procedural knowledge
- Crossing levels of abstraction [31][75][86].

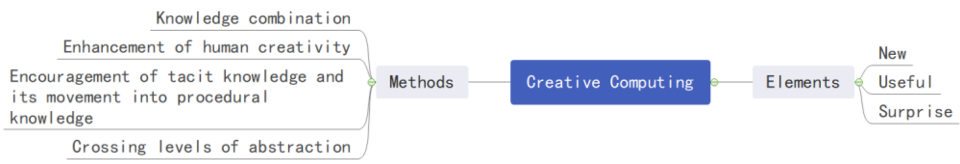

Figure 2. 8 Creative Kernel Elements and Main Methods

In existing research, an essential method of creative computing in knowledge combination. There is a consensus that creativity is derived from knowledge, and knowledge combination can be used for blending knowledge from distinct subjects generating multi-sort combinations that may include creative ideas [31].

To make enormous data useful, knowledge combination can be used to generate effective and suitable approaches for processing problems that can rarely be solved with knowledge from a single discipline. Knowledge combination is used for blending knowledge from distinct subjects. Knowledge combination can be used in three aspects,

Building connections between different categories of theories.

Building connections between theories and methods.

Building connections between methods.

In this research, theories that can be used for guiding the research process for developing mental health care framework and systems are sufficient from the support literature. Methods that are used in the research for achieving interdisciplinary combinations should contain elements from two disciplines to make the model feasible. Further, connections between theories and methods from two disciplines are necessary for this research as well. Theories from computing and mental health area can be used to navigating model development.

Creativity detecting and creative computing are positively influenced by knowledge combination. The production and processing of creativity are affected by knowledge (illustrated by some empirical scholars) [75]. Creativity can be cultivated by using the knowledge combination method, which has been regarded as an essential element of this process. Therefore, multi-disciplinary boundaries can be broken by using knowledge combination and new knowledge intermingle problem solution could be achieved eventually. If knowledge from a single subject can be used to solve problems in the related field and achieve creativity, multidisciplinary knowledge could address issues from two or more distinct domains, which is a kind of creativity. As being illustrated in the research scope of creative computing, weaving different disciplines, and provide potential progress through knowledge combination into multidisciplinary methods is useful [68].

Knowledge engineering is the assistant tool of the knowledge combination method. Knowledge Engineering (KE) was proposed by Prof. Feigenbaum to illustrate how to construct a knowledge-based system in a relevant subject [68]. KE contains aspects such as technical, scientific, and social for building and maintaining the process of knowledge-based systems (KBS) (expert system). Knowledge Engineering integrates context, knowledge base, and an inference engine to support the development of computer-aid design or expert system that inappropriate method or languages [126], and it has been summarised into five software phases to construct an expert system [70]:

- Requirements analysis
- Knowledgebase construction
- Conceptual modelling
- Operationalisation and validation, and
- Refinement and maintenance.

Enhancement of human creativity is rather than just the development of computational creativity. Computers are competent assistants for enhancing people’s creativity by using appropriate approaches [76]. General approaches for improving human creativity are illustrated in the next section.

Encouragement of tacit knowledge and its movement into procedural knowledge aim at transferring human-level knowledge into a programmed software to be processed [86]. Heuristic algorithms are used for imitating human brain working mechanisms to addressing issues, which can be implemented to detect creativity [77].

Crossing levels of abstraction is another essential tool of creative computing [120]. Abstraction levels are defined by Jing to identify idea creation by establishing a system [51][128]. In computer science, abstraction is set to be a process of data and programs that are defined in a similar semantic modality and hiding specific implementations [128]. Details of the application can be factored out to make a few norms being focused on by programmers through abstraction. Creativity can be achieved by using abstraction rules.

Surprising elements are included as crucial elements of creativity. A sense of play or fun may create unexpected items by a human, which has the possibility of producing creativity.

A mix of divergent and convergent thinking is a combination of the logical and non-logical methods [69]. Divergent thinking can be used for imagining relevant information about target topics by people [69]. The thoughts are non-logical, which is for improving the possibilities of creativity detection. Convergent thinking generally means the ability of thinking of answers to standard questions, which may rarely require creativity [69]. Most of the convergent thinking answers are produced by logical thinking.

The six basic methods of creative computing are all useful in solving problems. In this study, the method of knowledge combination is used to realise the integration and evaluation of medical observation and monitoring methods and related recommended diagnosis methods. The enhancement of human creativity is used to test the creativity of psychological theory and computers. It can stimulate tacit knowledge and related movement into procedural knowledge to produce cycle-breaking method. The combination of divergent thinking and convergent thinking is one of the bases of realising creative guidance methods. Based on the knowledge combination method and abstract theory, combined with the improvement of human creativity, a new classification of creativity is completed. The next section is used to emphasise how to apply creative computing and multidisciplinary approaches to approach artificial creativity in this study. A new creative calculation method is designed.

As mentioned above, the creative computing methods used in this study include knowledge combination (from two or more disciplines), enhancement of human creativity (not just the development of computational creativity), encouragement of tacit knowledge and its transformation into procedural knowledge, spanning the abstract level, and being a mixture of divergent thinking and convergent thinking.

Knowledge combination is used to detect the path of creativity generation, especially the fusion of knowledge and models of different disciplines based on computers. The knowledge of other subjects is connected with computer science knowledge to form mixed tacit knowledge. Then, knowledge movement is realised by programming, from tacit knowledge to procedural knowledge, the theoretical model is transformed into a computer operation model, and the artificial creation system is realised.

The intersection of abstract levels is the basis of new creative taxonomy. Due to the traditional creativity in human society, it is necessary to establish a new classification method to improve the possibility of computer detection of creativity.

The creative guidance method is based on the combination of convergent thinking and divergent thinking and Boden's three creative methods. This method realises the creative theory weaving with artificial intelligence algorithm.

Based on creative computing, the knowledge combination method can be used for generating data connecting. The weighted data and connections are useful for creating emotion calculating models. Therefore, creative computing is the basic theory for guiding knowledge combination and data connecting.

2.6 Summary

In this chapter, five main literature areas are explained specifically, including basic development state, connections with this research, and applications in the target area. Wearable medical-related equipment development is explained initially. The information of this area is stated clearly as the background of the research.

Existing research on mental health care is depicted in the Section 2.2. Some proposed research methods and theories are stated in this section. Emotion’s definition is concluded in this section with a list of classification methods by psychologists or medical researchers. As emotions, especially extreme emotions have negative influences on human body, the body changing with extreme emotions are concluded by citing proposed research. All the mental health-related literature is the basis of the research questions and research contributions. Solving existing mental health-related problems and generating accurate supervision are useful for the users.

The inter-disciplinary method can be completed based on machine learning theories and methods. As the entire workflow of the mental health supervision and management system includes four kinds of data analysis, structured data, voice data, facial image data, and behaviour actions data, machine learning is the kernel basis for generating algorithms for completing analysis. Machine learning and deep learning development and theories are both depicted in this section.

Knowledge graph and block chain consensus mechanisms are explained for being applied in this research thesis. Basic knowledge graph theory and blockchain consensus mechanisms are explained, which are the basis for establishing consensus algorithms to integrate different emotions.

Creative computing is being regarded as support for generating interdisciplinary methods for solving problems in the mental health area. In this section, creative computing definition, research scope, and some of the methods are explained for further use.

Chapter 3
Constructing an Artificial Intelligence based Mental Health Care Framework

Objectives

- To present an overview of the proposed artificial intelligence-based mental health care framework.
- To state mental health-related data collection and pre-processing workflow.
- To depict body index data, voice data, and video data analysis algorithm workflow.
- To explain consensus mechanisms and mental health supervision workflow.
- To identify mental health care advice generator workflow.

An artificial intelligence-based mental health care framework is established in this research. The framework is used for constructing mental health-related data preparation, processing data analysis, generating mental health supervising and advice. The mental health care framework includes several related techniques and algorithms, which are mental health-related data preparation techniques, mental health data analysis and recognition technique, consensus mechanisms, and mental health supervision and advice generation technique. Each technique includes specific algorithms to reach the final aim for achieving mental health supervision and management for users. Specific techniques can be applied for establishing subsystems for three types of collected data and the entire framework can be used to establish a system being set on wearable products.

3.1 System Overview

Psychological research only pays attention to emotion. In the middle of the 20th century, behaviourism dominated experimental psychology completely, and few research were focusing on emotion. When the laboratory research appears, it is mainly limited to the "conditioned emotional response". The researchers use the classic conditioned way to achieve study propulsion, rather than simply use the emotional research method. Behaviourism regards emotion as private and unobservable, so it is only suitable to study it through "serious conversation". Since the 1970s, the study of emotion has grown rapidly in both quantity and quality. Researchers from the domain of social psychology, developmental psychology, and neuroscience all have attractive discoveries to present. This is not to say that behaviourists are wrong. To a large extent, they are right: emotions are intrinsic and difficult to measure. Despite these challenges, researchers have invented new and intelligent methods to induce and measure emotions in the laboratory and the real world.

Although at the beginning of the birth of psychology, the study of emotion has been paid attention to, the neglect of the research method of emotion is an important reason for the low development rate. At the end of the 20th century, with the rise of cognitive neuroscience, researchers' interest in emotion was aroused again. One important reason is the promotion of new research methods and new technologies. Functional magnetic resonance (fMRI), event-related potential (ERPs), multi-channel physiological recording, biofeedback, eye movement recording, cognitive behaviour experiment, and hormone measurement is widely used in the research fields of emotion assessment, emotional disorder diagnosis, and emotion regulation.

However, even though emotions can be detected by using advanced medical techniques, supervision cannot be achieved continuously. Along with the development of wearable products, including shoes, clothes, watches, and so forth, the interactions between users and software can be real-time achieved. Advanced algorithms in artificial intelligence including deep learning and machine learning are kernel processing functions in the software. Therefore, the framework of mental health care can be used for generating mental health care system being acted as emotion supervisor and manager. Advice is created for warning emotions of the user.

The mental health care framework includes three phases, which are mental health-related data preparation phase, mental health analysis, and recognition phase, and mental health supervision and advice generation phase. The framework has three subsystems for processing different data types based on three main phases. Specific steps and working principles are explained in the following contents.

Framework starts from the interactions between users and wearable products. Users can be connected with wearable products by chips and sensors, that could be embedded in wearable products. Related body data can be collected in this way. The data has two types, which are structured data and unstructured data. Structured data is the body data in different aspects that are related to physical health, including body temperature, BMI, fat ratio, body moisture, and so forth. Unstructured data includes natural language data, image data, and behaviour video data. Such unstructured data is required to be transferred to data that can be processed by AI algorithms. Mental health data of the users is the initial data of the entire framework. Data pre-processing can be applied before data mining, the quality of data mining patterns is greatly improved, and the efficiency of actual mining is increased. Data pre-processing refers to the necessary processing such as auditing, filtering, and sorting before classifying the collected data. The second step of the data preparation phase is the classification of mental health-related data. Based on classification regulations, collected data can be classified into structured data and unstructured data. Further, structured data is the body condition data, which may have an association with unstructured data and mental health aspects. Unstructured data includes voice data and image data. Voice data can be collected by sensors (microphone) that are embedded in wearable products. Image data includes facial image data and user's behaviour data. Each kind of data is processed by specific algorithms to evaluate emotions from the data. The output of the mental health analysis and recognition phase is the possible mood of the user. The last step of the framework is the mental supervision and advice generation phase. The output possible mood is evaluated, and related advice is output for users to change extreme emotions that are identified and warned by the framework. The structure of mental health care framework with three phases is depicted in Figure 3. 1.

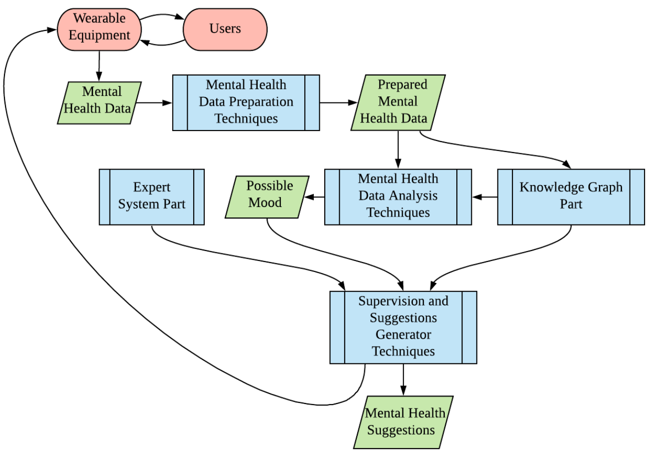

Figure 3. 1 Structure of Mental Health Care Supervision and Management Framework

In the framework, AI and machine learning algorithms are applied for data processing and analysis. Machine learning classification algorithm is used for mental health data classification. Complicated data should be classified for further processing, which would make analysing process more effective. The knowledge graph technique is used to store classified mental health data and generating connections between different nodes. Logical representations between nodes can boost more accurate outcomes being generated. Deep learning algorithms are applied in the process as well. Natural language processing techniques are used for transferring voice data into texts. Emotions can be analysed from user's expressions that are collected by using wearable products. Neural network-related algorithms are used for detecting emotional expressions from image and behaviour videos. Four possible moods from four kinds of data analysis, including body index data based mood, voice data based mood, facial expression data based mood, and behaviour data based mood, are output for integration and evaluation. Consensus mechanisms in the blockchain area are used as the basis for integration techniques. By analysing four possible moods, integrated possible moods can be detected. The evaluation algorithm based on medical knowledge is created. If the warning threshold is reached, warning from the specific system that is established in wearable products are activated, which means extreme mood may appear and the user should be careful. Eventually, if the detected possible emotion is not an extreme emotion, the system will return to activate wearable products to keep collecting data and complete the entire data processing.

For there are three types of data that will be processed in this research, including body index data, voice data, and video data, specific data processing workflow and principles are different. To secure the accuracy of mental health analysis results and efficiency of the processing procedure, three techniques are created based on data types. Body index-based mental health analysis technique, voice-based mental health analysis technique, and video-based mental health analysis technique include three data processing steps, which are data pre-processing, graph theory-based knowledge connection, and data analysis and emotion recognition for each technique. The three techniques for three kinds of collected meta data include the initial two phases of the framework, data pre-processing, and data analysis. The last phase, the supervision and advice generation phase is completed after three techniques are completed. Consensus mechanisms are used for integrating output results of three techniques, which are possible emotions based on the data analysis.

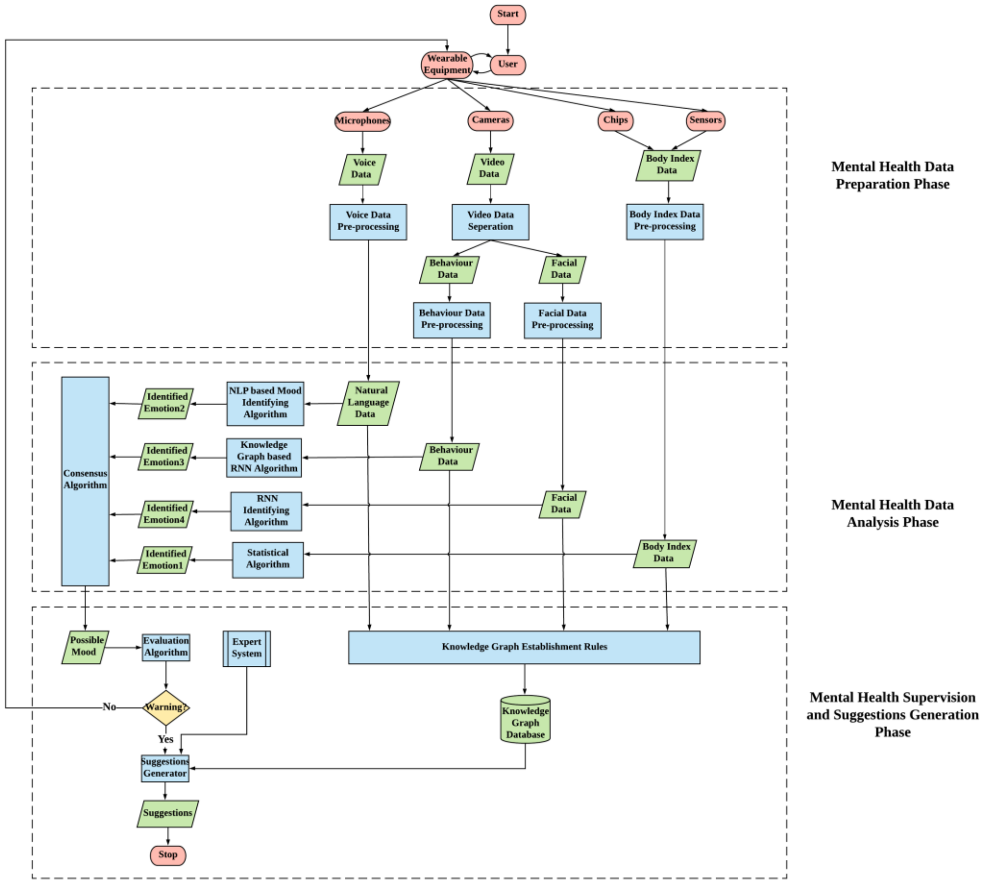

Figure 3. 2 Entire Workflow of Mental Health Care Supervision and Management Framework with Three Phases

Body index data is classified into different categories of body indexes and being processed based on statistical models. Traditional analyses for body index data are based on medical research to evaluate body conditions. The statistical model is established with eight aspects for evaluating body conditions, which can be collected by using sensors and chips in a time interval.

Voice data has a distinct data structure compared with body indexes data. The process of digital voice is the process of analogue-to-digital conversion (ADC) to obtain audio data from continuous analogue-to-digital (ADC) signals from microphones that are set in wearable products. Digital voice playback is to convert audio data into analogue-audio signal output by digital to analogue-conversion (DAC). There are two important indicators in digital sound, namely sampling rate, and sampling size. In the voice data emotion detecting process, data type transferring is required. In the pre-processing step, voice data is transferred into text data, which is fit natural language processing related algorithm. Data type transferring is based on the language model, the decoding model for output text contents. Natural language processing algorithm-based text data analysis is applied for emotion detection from the text data, which is also the emotion that is expressed by voice data.

Video data is special compared with the two data types above. Video data can be collected by using cameras that are set in wearable products. Behaviours and facial expressions are recorded by the camera. Therefore, behaviour parts and facial images with expressions should be separated from the collected dataset for further analysis respectively. Separation mechanisms are formulated for classification into two categories. Then, facial expression images are pre-processed and being analysed by using CNN-based algorithms to detect emotional changes from the facial expressions. For behaviour data, after being pre-processed, RNN is used for emotion detecting. Expected emotions based on facial expression analysis and behaviour analysis will be output.

Consensus mechanisms are used for integrating four possible emotions from three techniques to generate expected emotion. The verification model and validation model are established in this step. Emotion values for different emotion levels are calculated based on consensus mechanisms. Output expected emotions are verified by compared with emotion values that are calculated by the verification model.

Emotion can be confirmed after the consensus mechanisms step, supervision decisions can be made based on the emotional level. Threshold values of the extreme emotion value are confirmed in the supervision step. Extreme emotions include negative extreme emotions and positive extreme emotions. Warnings will be made when emotion value reaches the threshold. Related advice is generated by using an expert system. The eventual output of the framework is the advice for extreme emotions with a warning for the user of wearable products.

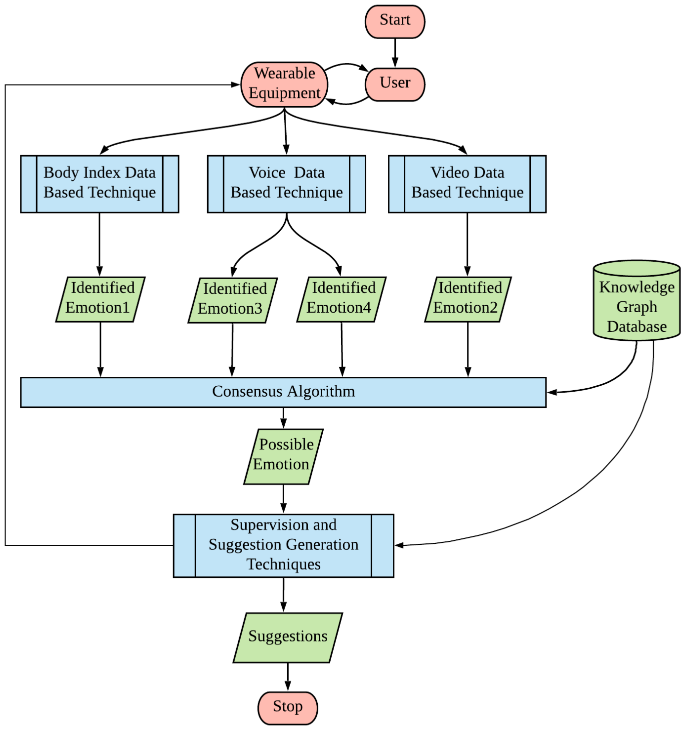

Figure 3. 3 Structure of Mental Health Care Framework with Three Techniques Based on Three Data Types

Specific workflow and techniques that are used in the framework will be illustrated in Chapter 4, Chapter 5 and Chapter 6. Section 3.2, 3.3 and 3.4 are used for clarifying the workflow of each phase and three kernel techniques that are structured in the framework.

3.2 Mental Health-Related Data Preparation Technique

In this phase, the kernel part is how to classify collected data and establishing a knowledge graph with different types of data. Logic relationships between data from different categories can be established based on knowledge graph techniques. This phase is the basis for mental health data analysis and recognition phase for identifying emotions.

There are four steps in this phase, which are data collection, data pre-processing, data classification, and knowledge graph establishment for body index data pre-processing and voice data pre-processing. For video data pre-processing, there one more step before the pre-processing procedure, which is data separation. Behaviour data and facial expression data are separated by related mechanisms into different categories. Pre-processing for facial data and behaviour data are in the same steps as body index data and voice data.

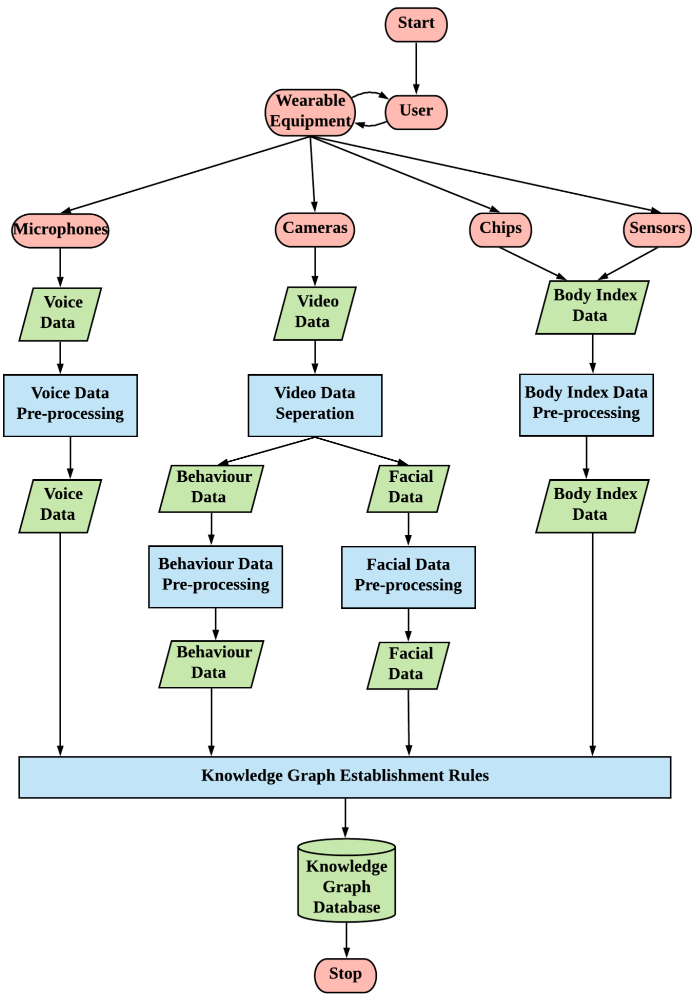

Figure 3. 4 Mental Health Data Preparation Phase Workflow

Data collections are based on three types, which are chips and sensors collection, voice collection, and video collection. With three aspects of the collection, the data system that can represent people's emotional expression is integrated. Based on medical research on people's emotions, behaviours and voices are the most expressive way of presenting emotions. Meanwhile, the body indexes are changed with emotional changes. Therefore, behaviour analysis is necessary, including facial recognition and behaviour analysis. Based on medical research, people usually express extreme emotions with unexpected behaviours or exaggerated actions along with related facial expressions. Facial expression refers to the expression of various emotional states through the changes of eye muscles, facial muscles, and mouth muscles. People's eyes are the best at communicating. Different eye behaviours can express people's different emotions. For example, when one is happy or excited, the smile is expressed; when one is angry, glare is expressed; when one is afraid, gape is expressed; when one is sad, the stare is expressed. Eyes can not only convey feelings but also communicating. There is much information between people that can only be understood through eye contact or facial expression reading. In this case, through observing people's eyes, their inner thoughts and wishes can be understood, and their attitudes are deduced: approve or oppose, accept or reject, like or dislike, sincere or false, and so forth. Relevant experiments show that different parts of the face have different expressive functions. For example, the eyes are the most important to express sadness, the mouth is the most important to express happiness and disgust, while the forehead can provide surprise signals, and the eyes, mouth, and forehead are very important to express anger. There are also experimental studies that show that mouth muscles are more important than eye muscles in expressing emotions such as joy and resentment, while eye muscles are more important than mouth muscles in expressing emotions like sadness and fear. Moreover, body indexes and emotions have relationships. Body indexes are changed when the emotion of people fluctuates. The physiological measurement of emotions looks at the way the body prepares for these behaviours. Many emotional conditions are a state of arousal of tension - a rapid heartbeat, a tightening of the abdomen, and the beginning of the opening of the hand. The increased activity of the sympathetic nervous system (SNS) is important for waking up and preparing the body for "fight or flight" actions. It promotes physiological changes, increases blood flow and muscle oxygen supply, and enables individuals to prepare for more complex physical activities. Therefore, the classification of the collected data is imperative. Structured data and unstructured data are processed with different kinds of algorithms for detecting potential emotions. Specific classification processes for different data types are illustrated in Chapter 4, Chapter 5, and Chapter 6 respectively.

Knowledge graph basic mechanisms are explained in Chapter 2. In this phase, a knowledge graph is used for building relationships between mental health-related data. With a knowledge graph, logical relationships can be quantitative and analysis results could be more accurate. The construction and application of a large-scale knowledge base need the support of many kinds of intelligent information processing technology. Through knowledge extraction technology, entity, relationship, attribute, and other knowledge elements can be extracted from some open semi-structured and unstructured data. Through knowledge fusion, the ambiguity can be eliminated between reference items such as entity, relation, attribute, and fact object, and form a high-quality knowledge base. Knowledge reasoning is based on the existing knowledge base to further mine the hidden knowledge and relationships between mental health data, to enrich and expand the knowledge base. The synthesis vector that is formed by distributed knowledge representation is of great importance to the construction, reasoning, fusion, and application of the knowledge base. Knowledge graph enhances the accuracy of mental health data analysis. Specific techniques and applications for three data types will be illustrated in Chapter 4, Chapter 5, and Chapter 6 respectively.

The output of the mental health related data preparation phase is four kinds of mental health related data and a built knowledge graph for four kinds of data.

3.3 Mental Health Analysis and Recognition Technique

Four types of algorithms are applied in this phase, including statistical algorithm, natural language processing, knowledge graph-based neural network algorithm, and physical model-based neural network algorithm. Matching the output data of data preparation phase, statistical data, voice data, facial data and behaviour data are used for further processing to mine related information for emotion detection. Four possible moods are output into a consensus algorithm for emotion integration analysis.

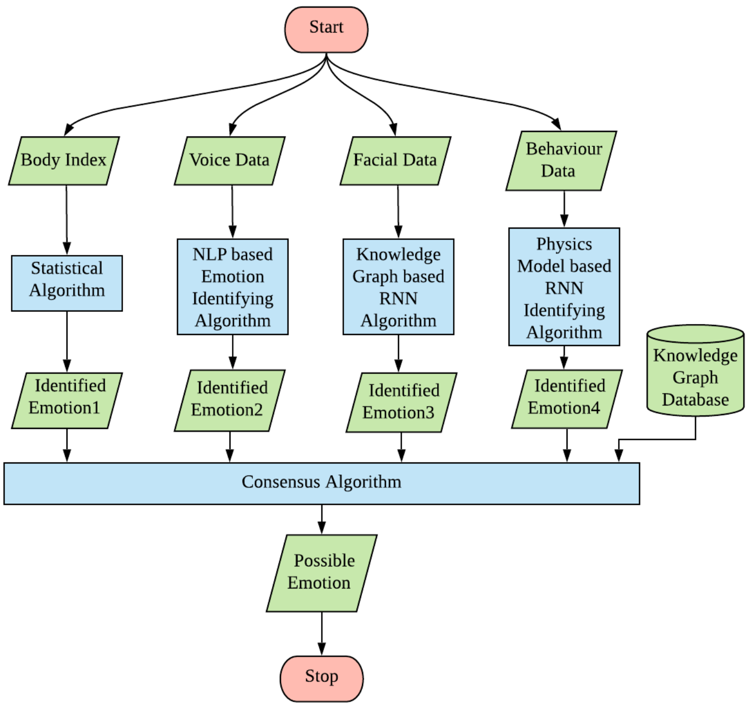

Figure 3. 5 Mental Health Data Analysis Phase

A statistical model is established in this phase for body data processing. Body indexes that are related to mental health are collected. Based on real-time collected data, possible emotions can be predicted. Statistical model refers to a model based on probability theory and established by mathematical and statistical methods. Some processes cannot be derived by theoretical analysis, but the functional relationship between variables can be obtained by experimental data and mathematical statistics, which is called the statistical model. The commonly used mathematical-statistical analysis methods include the maximum post probability estimation method, the maximum likelihood rate identification method and so on. Common statistical models include the general linear model, generalised linear model and mixed model. The significance of statistical model is still statistical when inferring the regularity of a large number of random events, so it is called statistical inference. For medical health data, the aim of this model is used for detecting related emotions that are expressed by such dataset.

Voice data is collected for analysing language emotion expressions. Voice data is transferred into text data for natural language processing. Some methods are used for analysing emotions in the texts with natural language processing.

In this research, natural language processing is used with knowledge graph to detect logic in texts that are transferred from voice data. Language is one of the most intuitionistic emotional expression ways, which usually contains sufficient information. Moreover, the knowledge graph-based neural network algorithm is used for processing facial data. Connections between facial data and other types of data are imperative to assist neural network algorithm in discovering emotions. Similarly, physical model-based neural network model is used for analysing behaviour of people to predict emotions. Behaviour analysis is based on neural network algorithm and behaviour disassembling. People’s behaviours are determined by emotions and can be disassembled into several steps. The moving range of behaviours can be detected by using a physical model in a time interval and each moving range can be analysed by using neural network related algorithm. In machine learning and related fields, the computational model of artificial neural network (ANN) is inspired by the central nervous system (especially the brain) of animals, and it can be used to estimate or rely on a large number of inputs and general unknown approximate functions. Artificial neural networks are usually presented as interconnected "neurons", which can calculate values from inputs.

Neural network is an artificial system with the functions of learning, association, memory, pattern recognition and other intelligent information processing. An important feature of neural network is that it can learn from the environment and store the learning results in the synaptic connection of the network. The learning of neural network is a training and model optimising process. Under the stimulation of its environment, some sample patterns are input to the data processing, and the weight matrix of each layer of the network is adjusted according to principles (learning algorithm). When the weight of each layer of the network converges to a certain value, the learning process is stopped. Then, the generated neural network can be used to classify the real data. Artificial neural network also has the ability of self-adaptive and self-organisation. In the process of learning or training, the synaptic weight value is changed to adapt to the requirements of the surrounding environment. The same network can have different functions due to different learning methods and contents. Artificial neural network is a system with learning ability, which can develop knowledge to exceed the original knowledge level of designers. In general, its learning and training methods can be divided into two types: one is supervised or supervised learning, which is classified or imitated by using the given sample standard; the other is unsupervised learning or unsupervised learning, which only specifies the learning methods or some rules, and the specific learning contents follow the system environment is different. Mental health-related data can be used as a training dataset for neural network related algorithms. The testing dataset is used for examining the output mood is accurate or not compared with exact outcomes. Therefore, generating four specific models for four types of data, training models and adjusting parameters is essential, which may influence on outcomes of the entire system. The output of this phase is the possible emotion of the user, which will be processed further for evaluation and warning management. To confirm the eventual emotion of the real-time state of the user, a consensus mechanism is applied in this research as an integration algorithm.

3.4 Mental Health Supervision and Advice Generation Technique

In this section, mental health supervision and advice generation phase workflow and related information explanation are presented. The workflow includes an emotion evaluation algorithm, warning decision making, and advice generation.

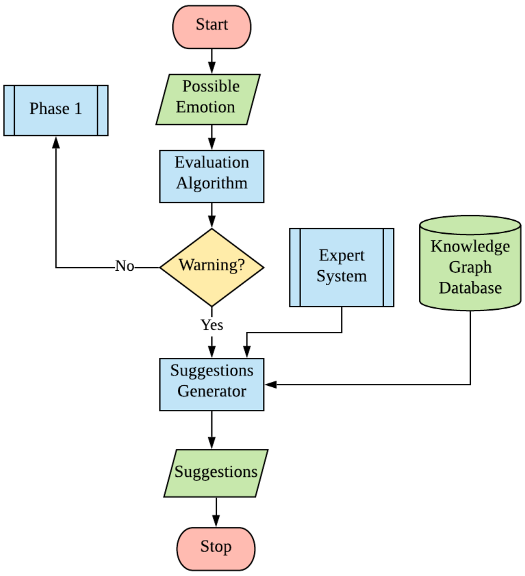

Figure 3. 6 Mood Evaluation and Advice Generation Phase

Emotion evaluation has completed the emotion value calculation in a different method compared with mental health analysis and recognition step. Each basic emotion has a threshold value which is the baseline for supervising extreme emotions, both positive extreme emotion and negative extreme emotion. Warning decision-making can be completed with this comparison. When the emotion value reaches the threshold, warnings of the framework (or applied system) are activated. When the emotion value does not reach the threshold, the framework will return to the wearable products for new iteration from data collection. The expert system can be used for advice generation for mental health care problems. Specific advice generation will be illustrated in Chapter 6. The output of this step is advice for mental health problems and warnings for extreme emotions. Iteration will be continued for real-time supervision when emotion does not reach the extreme value.

3.5 Summary

In this chapter, artificial intelligence based mental health care system is proposed and workflows are explained briefly. A specific summary of this chapter is:

Artificial intelligence-based mental health care framework includes three steps for addressing the input data, which are data preparation, mental health data analysis, and mental health supervision. For the input data, there are three types, structured data for body index, voice data, and video data. For each type of data, three steps are set to fit the processing procedure.

The data preparation technique is explained in Section 3.2, which includes data collecting, data transferring, and data classification. Generally, for three types of data, preparation techniques are different. Body index data can be collected and classified based on basic body index categories. Voice data can be transferred into text data and is classified into different categories in different time intervals. Video data can be divided into two kinds of data, which are facial expression data and behaviour data in the time interval. Further data classification is completed based on the time interval.

Data analysis for mental health analysis and recognition is explained in Section 3.3. Different algorithms are applied for mental health data analysis to output expected emotions. Body index data is analysed by statistical models. Voice data is processed by using a natural language processing algorithm-based model. Facial expression data is processed by using CNN based algorithm. Behaviour data is processed by using RNN algorithm. Knowledge graph is added as the additional technique to counting impacts for emotions between four kinds of data. Eventually, consensus mechanisms are used for integrating expected emotions to be the final output.

Mental health supervision and advice generation techniques are used for warning extreme emotions based on the output of mental health data analysis. The expert system is applied in the advice generation.

Details of these three steps in four kinds of data analysis are explained in Chapter 4, Chapter 5, Chapter 6, and Chapter 7.

Chapter 4

Body Index-Based Mental Health Analysis Technique

Objectives

- To employ body index related data collection techniques and pre-processing techniques.
- To discover graphical relationships between body index data and other mental health related data.
- To depict quantitative relationships between emotion value and body indexes.
- To explain entire workflow of body index data analysis.

In this chapter, body index based mental health analysis technique is illustrated in three steps, which are body index data pre-processing step, graph theory-based knowledge connection with body index data, body index data analysis and emotion recognition, and a summary for the technique. The creative point of this technique is the graph theory-based knowledge connections between body index data and other two types of data, and the formula establishment between body indexes categories and emotional value of the user. Specific workflow of body index data pre-processing includes data collection, data clearance, and data classification. Collected data from the wearable products are cleared and classified into different categories, which are ready for further data connections and data analysis. The knowledge graph is established with other related data categories as well. The weighted connections have influences on the possible emotion analysis. The knowledge graph can be used to improve the accuracy of emotion analysis. In the third step, the body index data analysis workflow is explained with statistical formulas. Creative computing is used as the guidance for developing this body index-based mental health analysis techniques to generate the sub-system. Theories and methods from the statistical area and physical and mental health area are combined to develop models. Related elements are considered in the model and data processing workflow to make sure output results are accurate.

4.1 Body Index Data Pre-Processing

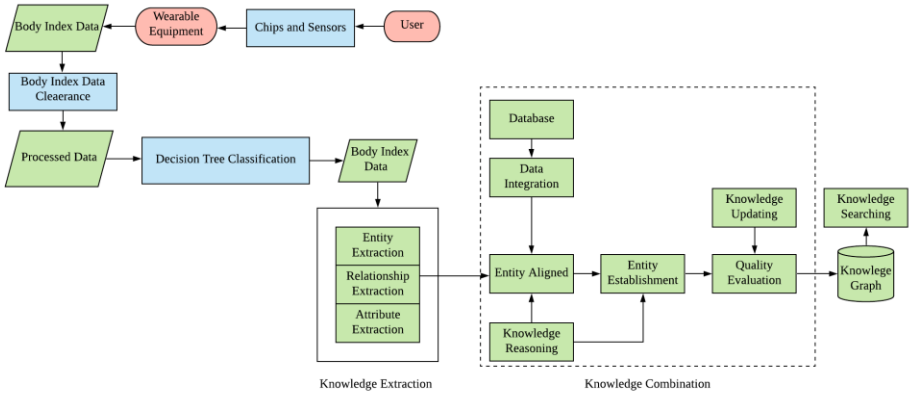

Figure 4. 1 Body Index Data Pre-processing Workflow

Wearable product is a major kind of product in the intelligent era. It has been researched for a long period of time in several aspects, such as in the aspect of user and wearable devices interaction design, medical treatment and so forth. With the creativity development in AI theory and techniques, wearable computing technology has been greatly improved and has made breakthrough progress in the interaction aspect. At present, in addition to Google's augmented reality glasses, Apple's iWatch and Huawei's sports bracelet, which can be made to achieve recognised results on the market. There are also children's phone watches, necklaces to track the activities of the elderly and smart watches to enhance interaction experiences.

The development of wearable products and related advanced AI techniques evolves new business models, which users in a new round of developing opportunities for academia and industry. Interactions between wearable products play an important role in improving the quality of people's lives and promoting economic and social development for the society. However, considering the perspective of convenience, wearable technology seems to have a positive development margin. Based on some proposed research, it shows that spreading wearable products broadly is still facing huge challenges, such as manufacturers are affected by inconstant changes of intelligent devices and lack of innovative thoughts with the growing maturity of big data, cloud computing, wireless communication and social networks.

Therefore, the interaction between wearable products, including intelligent shoes and clothes, is based on existing mature techniques with creativity and imagination to some extent.

Interaction relationships between user body index data collection and wearable products can be depicted in Figure 4. 1. In this research, wearable products are made to be the carriers for the intelligent software for supervising and managing the mental health of people. Mental health supervision and management should be based on sufficient data collection and analysis. Data collection is based on interactions between the user and wearable products. Compared with other wearable devices, such as watches, bracelets, and glasses, shoes and clothes are convenient for body index data collection.

Starting with the industrial design aspect, intelligent shoes for mental health body index data collection and interaction with the user should be explained. Existing wearable intelligent shoes contain chips and sensors at the bottom inside the shoes, which are used for identifying body indexes from the user's feet. Body indexes include blood pressure, temperature, BMI (body mass index), heart rate, weight, blood oxygen, and so forth. Wearable products should be able to detect changes in the user's body index data that can be connected with the health condition. Meanwhile, the indexes can be collected and detected by techniques that can be applied in wearable products. In intelligent shoes, chips and sensors can be connected directly with the feet of the user. Collected data is related to or can be used to calculate blood pressure, body temperature, heart rate, weight, blood oxygen, and BMI.

When the wearable products contact the skin, the sensor will send out a beam of light to hit the skin during the test, collect the pulse waveform, and analyse the heart rate, blood pressure, blood oxygen, through analysing the waveform.

For detecting body temperature, some techniques have already been developed. The temperature sensor is an important part of the design of wearable body temperature monitoring system. Thermal sensor is commonly used, and the flexible temperature sensor is one of its development directions. Thermistor is a kind of resistance whose resistivity changes obviously with temperature. It can be divided into positive temperature coefficient (PTC) thermistor and negative temperature coefficient (NTC) thermistor. NTC thermistor is widely used because of its high measurement accuracy, high interchangeability and good reliability. The 103at-4 NTC thermistor temperature sensor, produced by the Japan Shimitec company, has a temperature measuring range of - 60 ~ 150 °C and maximum power consumption of 6 MW. It has a very small value error and resistance. It has a high response rate. The thermal time constant in the air can reach 2s and the accuracy can reach ± 0.3 ℃. It is suitable for temperature detection with wearable products.

To collect the weight data of the user, the mechanism is similar to weight scale. Advanced techniques can make the weight scale to be small so that can be combined with wearable intelligent shoes.

BMI equals the division between the square of body weight and height (international unit: 2113kg/m2). BMI is an important standard commonly used in the world to measure the degree of obesity and health. BMI is mainly used for statistical body health analysis. The absolute value of body weight cannot be used to judge the degree of obesity, which is naturally related to height. Therefore, BMI obtains relatively objective parameters through body weight and height and uses the parameters to weigh body mass.

The principle of measuring heart rate by using wearable products is that sensors emit a beam of light with a specific wavelength, which is absorbed and reflected by blood vessels and then received by a photoelectric sensor. The heart rate is calculated by analysing the received pulse wave pattern. By extracting the cycle (T) of each pulse wave, the heart rate can be obtained (Heart rate = 60 / cycle T).

The transportation of oxygen in the blood is mostly in the way of combining with Hemoglobin, which means that oxygen combines with Hemoglobin to produce Oxyhemoglobin. Therefore, Hemoglobin and Oxyhemoglobin are presented in the blood. When the light beam passes through the blood vessel, the absorption degrees of the above two substances are different. The concentration of Oxyhemoglobin can be obtained by selecting the wavelength with the largest difference between the absorbance of two substances, usually 660nm and 940nm, and establishing the equation of light absorption degree at 660nm and 940nm respectively.

A blood pressure bracelet is based on the method of pulse transmission time to measure the continuous blood pressure of the human body. The measurement of the continuous blood pressure value of the human body can be calculated by the pulse wave transmission speed, that is, the time difference between the corresponding characteristic points in the simulation mathematical model and the PPG can obtain the pulse transmission time (PTT) or pulse transmission speed (PWV), and then calculate the blood pressure. The accuracy of blood pressure value is directly related to the location of PPG signal feature points. Because of the influence of different characteristic points of PCP on the accuracy of blood pressure measurement, technology improves the accuracy of blood pressure measurement by fusing the results of PCP peak and starting point when measuring pulse transmission time. The accuracy of human arterial blood pressure calculated by the pulse wave peak and the starting point of the optical capacitance product is estimated. When the waveform quality index is low, the filtering result depends on the estimated value more, and when the waveform quality index is high, it depends on the direct measurement value more. Then, the arterial blood pressure obtained by the two methods is fused according to the filtering residual.

The process of identifying and fixing the problem data is also called data cleaning.

Examples of statistical methods used in data cleaning include:

• Abnormal point detection. A method of identifying outliers in the data distribution.

• Data filling. A method of repairing or filling in damaged or missing data in observations.

The decision Tree algorithm is an advanced classification algorithm based on three theories. Decision Tree is a tree integration model, which sums the results of K (number of trees) trees as the final prediction value.

The decision tree is used for classifying data in the highest layer of this graph database.

The decision tree classification process can be explained as:

Input dataset $D = \{(x_1, y_1), (x_1, y_1), \ldots, (x_8, y_8)\}$

Attribute Set $A = \{a_1, a_2, \ldots, a_8\}$;

Function Tree(D, A);

Generating nodes;

If samples in D all belong to the same class C;

Then mark nodes from D as leaf nodes in class C;

Return;

If $A = \emptyset$ | samples in D have the same values on A;

Then record nodes in Set D as leaf nodes. The class is marked as a class with the most samples in Set D;

Return;

Select the optimised attribute of the body index dataset in Set A, being recorded as a';

For every value a'_i in recorded subset a';
Generating a branch for the node, D_i is defined as a sample subset including elements a'_i;
If $D_i = \emptyset$;
Then mark the branch nodes as leaf nodes.
Return;
Else regard $(D_i, A\backslash\{a'\})$ as branch nodes.
end;
Output: decision tree regards node as root nodes.

Decision tree classification in this research is used to analyse predicted outcomes to which the body index data belongs. Based on the definition and each connection between differentiated body index data, the entropy of each data unit can be calculated by:

$$H(T) = I_E(p_1, p_2, \dots, p_8)$$

The sum of $p_1, p_2, \dots, p_8$ is 100%, which are used to represent the percentage of each category in the body index database. Different characteristics of the target body index database can be used for defining classification labels through calculating the entropy of them. Characteristics with the highest entropy are used for the first classification for the target database. Then, the same process in the child nodes iterates.

4.2 Graph Theory-Based Knowledge Connection with Body Index Data

The input data of this step is the body index data that are collected by chips and sensors in the wearable products. Body index data are classified into different categories in eight aspects. For body index data, connections between different categories and emotions can be detected based on medical research. Voice expression data, facial expression data, and behaviour data have connections with body index data as well.

Body indexes data, voice data, image for facial expression data, video for behaviour data should be connected for further emotion analysis. Four types of data have relationships with each other. To establish a knowledge graph for collected data, there are still some distinguished aspects compared with the general knowledge graph.

For a general knowledge graph, from the semantic point of view, knowledge graph describes the concepts, entities, and their relationships in the objective world, so that computers can better organise, manage and understand the massive information. More specifically, in the process of human interaction with the Internet world, a large amount of complex information is generated, which is generally preserved by the body index, voice, and video data carriers. The knowledge graph is made to attempt to make the computer analysis, reading and understanding these data, accurately mining and finding valuable knowledge hidden behind the data, and providing knowledge services for requirements in mental health analysis, supervision, and management.

Nodes in the knowledge map include:

Entity: it refers to something distinguishable and independent, such as a person, a city, a plant, a commodity. All things in the world are made up of concrete things, which refers to entities. The entity is the most basic element in the knowledge map. Different entities have different relationships.

Semantic class (concept): it is a collection of entities with the same characteristics, such as state, nationality, books, computers. The concept mainly refers to the set, category, object type, the kind of things, such as people, geography.

Content: it is usually used as the name, description, and explanation of entity and semantic class, and can be expressed by text, image, audio, and video, etc.

Property (value): it points to an entity. Different attribute types correspond to the edges of different types of attributes. Property value mainly refers to the value of the property specified by the object.

Relation: it is formalised as a function that maps k points to a Boolean value. In the knowledge map, the relation is a function that maps K graph nodes (entity, semantic class, attribute value) to a Boolean value.

In this research, four types of data have relationships that can be shown below:

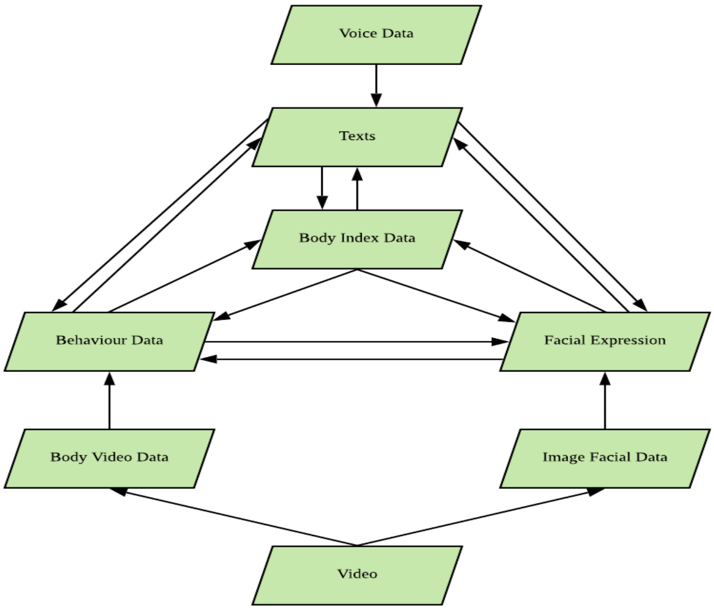

Figure 4. 2 Relationships between Body Index Data and Mental Health-Related Data

Each two of the data types has relationships with each other. The knowledge graph in this research is used for building connections between mental health data. Entities, relationships, and attributes are extracted by using different methods. As texts, behaviour, facial expression, body indexes data are in the different data structure, extraction methods are distinguished.

General emotions value formula can be represented as:

$$E = A_g G + A_y Y + A_v V + A_h H$$

E represents emotion value based on the collected data.

Y represents body index data emotion value.

G represents facial expression emotion value.

H represents texts' emotional value, which are emotions that are presented by language.

V represents behaviour emotion value.

A_g, A_y, A_v, A_h represents related parameters for four types of emotional data.

The voice data is important data for mental health analysis. Wearable products and related microphones and related chips and sensors can collect voice data and other types of data. Voice data can be collected and being analysed to detect emotions. Other mental related data, including body index data and video data, have influences on the emotion analysis results.

For body index data Y, it can be represented by the formula:

$$Y = \frac{E - (A_g G + A_v V + A_h H)}{A_y}$$

As the body index data have relationships with the other three types of data directly, so the formula can be generated as:

$$Y = \frac{A_g G + A_v V + A_h H}{\partial A_y}$$

∂ is the parameter that represents the weight between body index data and other types of data.

As $Y = \frac{A_g G + A_v V + A_h H}{\partial A_y} = \frac{E - (A_g G + A_v V + A_h H)}{A_y}$,

setting $\beta = A_g G + A_v V + A_h H$,

Therefore, $Y = \frac{\beta}{\partial A_y} = \frac{E - \beta}{A_y}$ (when $A_y \neq 0$)

Then, $\partial E - \partial \beta = \beta$

$$\partial = \frac{\beta}{E - \beta}$$

Lastly, E can be represented as:

$$E = \frac{\beta(1 - \alpha)}{\partial} = \frac{(A_g G + A_v V + A_h H) * (1 - \alpha)}{\alpha}$$

In the formula, it is can be concluded that emotions have close relationships with facial expression, behaviours and language expression. Meanwhile, body index data has connections with facial expression, behaviour and language expression as well. Knowledge graph can be established based on the quantitative relationships between each of these entities.

4.3 Body Index Data Analysis and Emotion Recognition

In Figure 4. 3, the entire workflow for analysing body index and connecting emotion changes with body indexes is presented. Body index data is collected by using sensors in the wearable products, such as intelligent shoes. Blood pressure, body temperature, body mass index, heart rate, weight, and blood oxygen existence change in a period when the emotion of an individual with wearable products reaches to be extreme.

The workflow of the statistical algorithm includes three steps, which are the SVM classification algorithm, model generation, and associating rules. The final output of this step is the possible emotion based on body index changes.

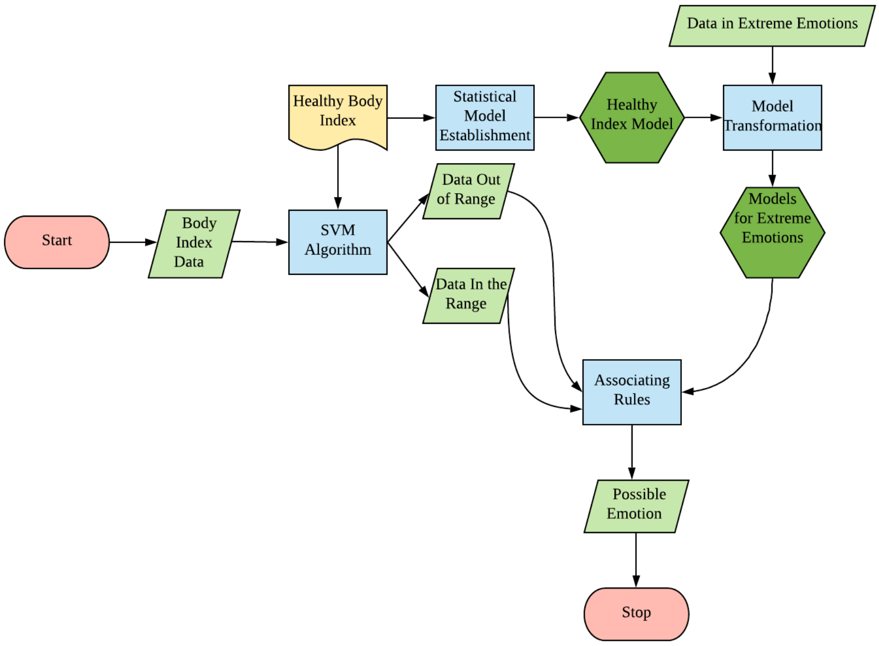

Figure 4. 3 Workflow of Statistical Algorithm for Body Index Analysis

The kernel of the statistical algorithm is based on body indexes. The body index value can be represented by using collected six types of data that can be used for expressing body states, including blood pressure, body temperature, body mass index, heart rate, weight changes in a period, and blood oxygen. Based on medical subject theories and practical statistical data, for all the six data categories, normal healthy data is listed below.

Table 4. 1 Normal Health Body Index Data Range

Body Index	Normal Data	Max Threshold	Min Threshold
Blood Pressure	80-130mmHg	140mmHg	60 mmHg
Body Temperature	36.3℃-37.2℃	37.3℃	35.0℃
Heart Rate	75 Times per Minute	100 Times per Minute	60 Times per Minute
Blood Oxygen	>=95%	100%	90%
Body Mass Index	18.5-23.9	24	16
Weight	$\Delta \leq 2$ per month	-	-

The relationships between BiV and emotional value of BiV can be presented by formula,

$$E_{biv} = f(BiV)t$$

The mapping relationships between body index value and emotional value can be presented with simple formula expression with another variable t, that represents time. All six body index data changes along with the time. Each index has a linear relationship with a body index value, which has connections with emotional expression. Then, the body index value can be represented by the formula,

$BiV = w_1X_1 + w_2X_2 + w_3X_3 + w_4X_4 + w_5X_5 + w_6X_6$ +b

X represents the changes compared with the basic index level. Weights of different indexes are distinguished for each individual.

X_1 represents the blood pressure.

X_2 represents the body temperature.

X_3 represents the heart rate.

X_4 represents blood oxygen.

X_5 represents the body mass index.

X_6 represents the weight changes in a period (usually compare with history data)

To confirm the weight for each element in the body index data type, a principle for calculating the emotion relevance value is required. The relationship between body index value and sub-elements is multi-variate linear regression. The formula can be represented as,

[w1

W2

W3

…w6]   [x1, x2, … x6]

$$BiV = w^T x_i + b$$

To confirm the weights and bias of the multi-variable formula, the least square method with Euclidean space is applied to estimate parameters.

Set $f(x_i)$ represent the real value of body index; BiV is the estimated value. The mean square error between real value and estimated value can be calculated,

$$(w^*, b^*) = \arg\min \sum_{1}^{6} (f(x_i) - BiV)^2 = \arg\min \sum_{1}^{6} (f(x_i) - w^T x_i - b)^2$$

To confirm the weight value and bias, it is a process of calculating the minimum value of the function $(w^*, b^*) = \sum_1^6 (f(x_i) - w^T x_i - b)^2$, which is the parameter estimation of linear regression least square. To do the deviation for w and b,

$$\frac{\partial(w^*, b^*)}{\partial w} = 2(w\sum_1^6 x_i^2 - \sum_1^6 (f(x_i) - b) * x_i)$$

$$\frac{\partial(w^*, b^*)}{\partial b} = 2(6b - \sum_1^6 (\ f(x_i) - wx_i))$$

To set two-equation to zero, the value of weight and bias can be output based ordinary least squares,

$$w = \frac{\sum_1^6 f(x_i)(x_i - \bar{x})}{\sum_1^6 x_i^2 - \frac{1}{6}(\sum_1^6 x_i)^2}$$

$$b = \frac{1}{6}\sum_1^6 (f(x_i) - wx_i)$$

For this multi-variable formula, the matrix can be used for weight and bias representation. When the real value of each sub-data aspect is collected, the mean of related aspects can be calculated in the time interval. Weight and bias are confirmed. The weight of each sub-data aspect in the body index value formula represents the relevance between body health states and specific index. Based on the data from Table 4. 2, the weight of each body index can be calculated. The floating percentage of each body index is the basis for calculating the weight and bias, which are variable x. Therefore, the weights are 0.20, 0.75, 0.20, 0.20, 0.19. Thus, the final formula of body index value for emotion is,

$$BiV = 0.20X_1 + 0.75X_2 + 0.20X_3 + 0.20X_4 + 0.19X_5 + X_6 + b$$

Table 4. 2 Emotion Relevance Percentage of Body Indexes

Sub-Data Aspects	Threshold	Emotion Relevance Percentage
Blood Pressure	80-130mmHg	20%
Body Temperature	36.3℃-37.2℃	75%
Heart Rate	75 Times per Minute	20%
Blood Oxygen	>=95%	20%
Body Mass Index	18.5-23.9	19%
Weight	$\Delta \leq 2$ per month	-

Collected data of users are classified into two categories with support vector machine linear classification algorithm. In machine learning, a support vector machine (SVM, also known as support vector network) is a supervised learning model and related learning algorithm to analyse data in classification and regression analysis. Given a set of training instances, each training instance is marked as belonging to one or the other of two categories. SVM training algorithm creates a model that assigns a new instance to one of two categories, making it a non-probability binary linear classifier. In SVM model, instances are represented as points in space, so the mapping makes the instances of individual categories separated by as wide and obvious intervals as possible. Then, the new instances are mapped to the same space, and the categories are predicted based on which side of the interval being fallen on. In this algorithm, SVM is simply used for classifying changed data and unchanged data from the collected dataset. The categories are based on the normal range of each body index.

Healthy body indexes and related data from the expert system is used for generating a healthy index model for processing extreme emotion dataset. Extreme emotions, ecstasy, terror, amazement, grief, loathing, rage, matching with an extreme range of body indexes. The max and minimum value of each body index matching with extreme emotions. The healthy index model is applied for identifying extreme emotions with body index data.

The changing data of body indexes match the healthy index model with extreme parameters, the extreme emotion is supervised and should be warned to the wearable products user.

The output result of this algorithm is the possible emotion of the user with a statistical model. The possible emotion will be processed in the consensus mechanism and integration model to complete eventual confirmation about the real-time emotion.

4.4 Summary

This chapter illustrated the body index data-based mental health analysis technique, including body index pre-processing, graph theory-based knowledge connection with body index data and body index data analysis and emotion recognition algorithm. The entire technique can process body index data that is collected from the user by wearable products. Body index data collection and body index data clearance can be processed initially preparing for further analysis. Graph theory-based knowledge graph have been built for establishing weighted connections between body index data and other mental health-related data. Weighted connections have influences on entire possible emotion analysis. Body index data and mental health (emotions) have quantitative relationships based on statistical theory and medical theory. The final output of this technique is the possible emotions of the user in the time interval based on body index data.

Chapter 5

Voice-Based Mental Health Analysis Technique

Objectives

- To employ voice related data collection techniques and pre-processing techniques.
- To discover graphical relationships between voice data and other mental health related data.
- To depict quantitative analysis for emotion and voice data analysis algorithm for emotion recognition.
- To explain the entire workflow of voice data analysis.

5.1 Voice Data Pre-Processing

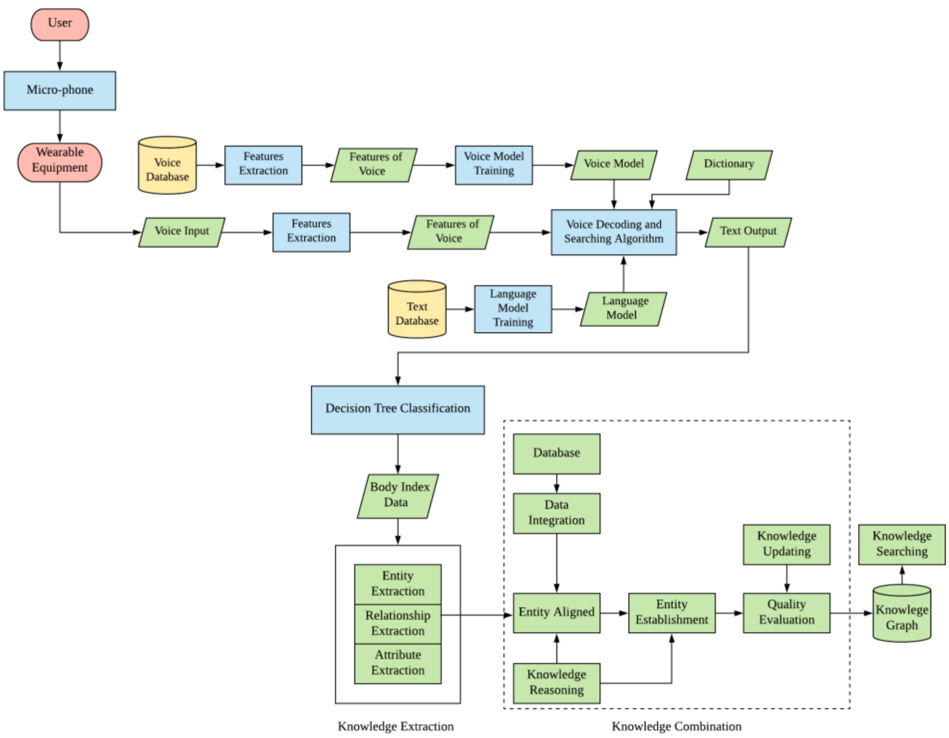

Figure 5. 1 Mental Health Related Voice Data Pre-processing Workflow

The wearable products development and advanced techniques that can be applied in the interactions between wearable products and users as illustrated in Chapter 4, the voice data collection process is easier to be stated. The interaction between wearable products, including intelligent shoes and clothes, is based on existing mature techniques with creativity and imagination to some extent.

Interaction relationships between user’s voice data collection and wearable products can be depicted in Figure 5. 1. In this research, wearable products are important carriers for intelligent mental health system. Mental health supervision and management should be based on sufficient data collection and analysis. Data is ccollected based on the interactions between the user and the wearable products.

Begining with the industrial design aspect, the intelligent shoes for mental health voice data collection and interaction with the user will be explained. The chips and sensors locate on the inside of the existing wearable intelligent shoes are used for identifying body indexes from user’s feet. For voice data, microphones are considered to be the best choice for collecting data. In the market, MEMS microphone is popular for broad application. MEMES refers to Micro-Electro-Mechanical System, and MEMS is developed based on microelectronic technology (semiconductor manufacturing technology), which integrates lithography, etching, thin-film, Liga, silicon micromachining, non-silicon micromachining and precision machining technologies. Micro electromechanical system (MEMS) is a type of micro device or system which integrates micro sensors, micro actuators, micro mechanical structure, micro power and micro-energy, signal processing and control circuit, high-performance electronic integrated device, interface and communication. MEMS is a revolutionary new technology, which is widely used in the high-tech industry. It is also a key technology related to the development of science and technology, economic prosperity and national defense security. MEMS focuses on ultra-precision machining, involving microelectronics, materials, mechanics, chemistry, mechanics and many other disciplines. It covers the branches of physics, chemistry and mechanics such as force, electricity, light, magnetism, sound and surface in micro-scale.

MEMS microphone refers to the microphone made by MEMS technology, also known as microphone chip or silicon microphone. The pressure-sensing film of MEMS microphone is directly etched on a silicon chip by MEMS technology. The integrated circuit chip is usually integrated into some related circuits, such as a preamplifier. In principle, the design of most MEMS microphones are a variant of the capacitive microphone. MEMS microphones are often built-in analogue digital converters, which directly output digital signals and become digital microphones to facilitate the connection with today's digital circuits.

MEMS microphone is mainly used in some small mobile products such as mobile phones and PDAs. In the past, almost all of the miniature microphones were electric condenser microphones.

Embedded microphones are placed in the shoes, which are both at the top of the shoes. Data collection can be achieved in this way as the permitted voice collection distance is over 50 meters.

The process of identifying and fixing the problem data is also called data cleaning.

The decision tree algorithm is an advanced classification algorithm based on tree theories. Decision Tree is a tree integration model, which sums the results of K (number of trees) trees as the final prediction value.

The decision tree is used for classifying data in the highest layer of this graph database. Decision tree classification can be used to analyse the predicted outcomes to which the data belongs. Based on the definition and each connection between differentiated knowledge, the entropy of each knowledge unit can be calculated by:

$$H(T) = I_E(p_1, p_2, \dots, p_i)$$

The sum of $p_1, p_2, \dots, p_i$ is 100%, which is used to represent the percentage of each category in the entire database. Different characteristics of the target knowledge database can be used for defining classification labels through calculating the entropy of them. Characteristics with the highest entropy are used for the first classification for target knowledge database. Then, iterating the same process for the child nodes.

5.2 Graph Theory-Based Knowledge Connection

The input data at this step is the voice data that were collected from the microphones in the wearable products. The connection between voice data, emotions and other mental health related data can be detected based on medical research. Except the above data, the body index data, facial expression data, and behaviour data have connections with voice expression data as well.

The body indexes data, voice data, images for facial expression data, video for behaviour data should be connected for further emotion analysis. In fact, these four types of data are also related with each other. The elements and the structure of general knowledge graph were explained in Chapter 4. As well as the relationships between body index data, voice data, video data were presented in Figure 4. 2. The two of the data types have relationships with each other. Knowledge graph in this research is used for building connections of mental health data. Entities, relationships, and attributes are extracted by using different methods. As texts, behaviour, facial expression, body index data have different data structures, therefore, the extraction methods should be distinguished.

The general emotions value formula has been stated in the previous chapter.

The voice data is the basic data for mental health analysis. Wearable products and related microphones can detect the voice data and other types of data that are related to it. Real-time changes of the body index data can be catched directly by sensors and chips. But the facial related data, voice data, and behaviour related data requires further analysis to match the relevant emotions.

For body index data Y, it can be represented by the formula:

$$H = \frac{E - (A_g G + A_y Y + A_v V)}{A_h}$$

As the body index data have relationships with the other three types of data directly, so the formula can be generated as:

$$H = \frac{A_g G + A_y Y + A_v V}{\partial A_h}$$

∂ is the parameter that represents the weight between body index data and other types of data.

As $H = \frac{A_g G + A_y Y + A_v V}{\partial A_h} = \frac{E - (A_g G + A_y Y + A_v V)}{A_h}$,

setting $\beta = A_g G + A_y Y + A_v V$,

Therefore, $H = \frac{\beta}{\partial A_h} = \frac{E - \beta}{A_h}$ (when $A_h \neq 0$)

Then, $\partial E - \partial \beta = \beta$

$$\partial = \frac{\beta}{E - \beta}$$

Lastly, E can be represented as:

$$E = \frac{\beta(1 - \alpha)}{\partial} = \frac{(A_g G + A_v V + A_h H) * (1 - \alpha)}{\alpha}$$

In this formula, it is can be concluded as emotions have close relationships with facial expression, behaviours and language expression. The weight of other four types of data can be confirmed in the following analysis based on consensus mechanisms with medical theory. In this step, the quantitative relationships between emotion value and text data is transferred from voice data. They are confirmed as a multi-variable influential state.

Meanwhile, voice data has connections with body index data, facial expression, behaviour as well. The knowledge graph can be established based on the quantitative relationships between each of these entities.

5.3 Voice Data Analysis and Emotion Recognition

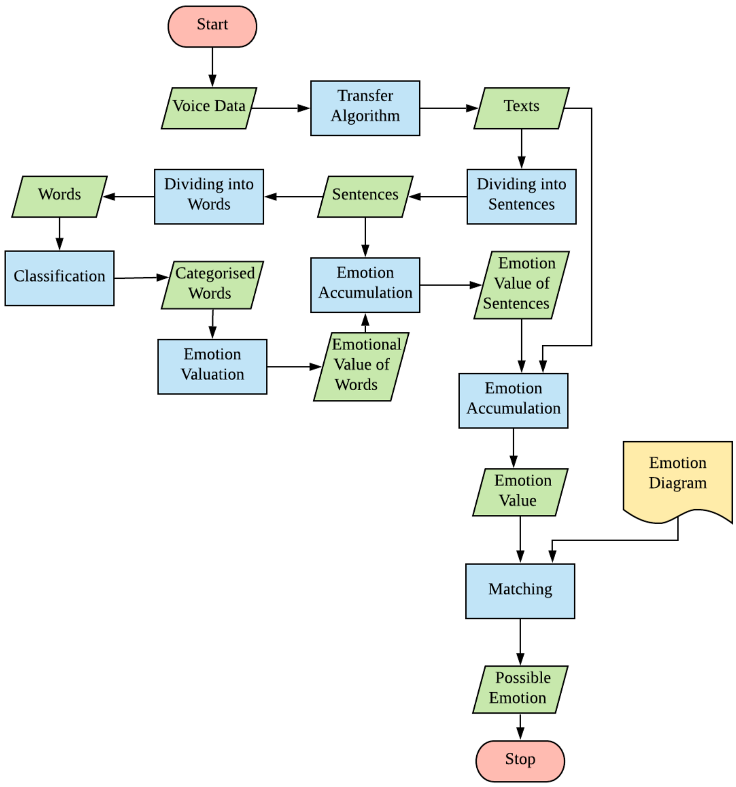

Figure 5. 2 Workflow of Voice Data Emotion Analysis

In Figure 5. 2 presents the entire workflow of voice data emotion analysis. Voice data is collected by using the microphone in wearable products, including wearable intelligent clothes, wearable intelligent shoes, and some other equipment.

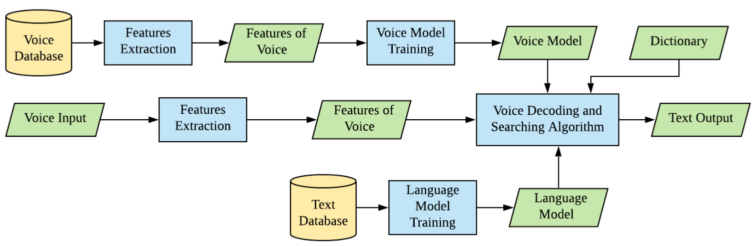

Figure 5. 3 Processing Flow of Voice-Text Transferring

As voice can rarely be processed directly, the data will be required to be transferred into texts. Mechanism of transferring is listed in Figure 5. 3. The whole process of speech recognition system construction includes two parts: training and recognition. Training is usually done off-line, and the pre-collected massive speech and language databases are processed and mined to acquire the "acoustic model" and "language model" required by the speech recognition system. At the meantime, the recognition process is usually done on-line, which automatically recognises the real-time speech of users. The recognition process can be divided into two modules: front-end module and back-end module. The main function of the front-end module is detecting the endpoints (removing the redundant mute and non-voice), reducing noise and extracting features, etc.. The function of the "back-end" module is to use the trained "acoustic model" and "language model" to carry out statistical pattern recognition (also known as "decoding") on the user's speech feature vector to get the text information contained in it. In addition, there is an "adaptive" feedback module in the back-end module, which can self-study the user's voice, to "acoustic model" and "voice" The model "carries out necessary" correction "to further improve the accuracy of recognition.

Pre-treatment:

- Mute removal at the head and tail to reduce interference.
- The sound is divided into frames, that is to say, the sound is divided into small segments. Each segment is called a frame, which is realised by using the moving window function. It is not just a simple cut, and it also has overlaps between the frames.

Feature extraction: It has two main algorithms which are LPCC and MFCC. The purpose of it is to transform each frame of waveform into a multi-dimensional vector containing the sound information.

Acoustic model (AM): It is acquired by training voice data. Eigenvector is its input, and the output is phoneme information.

Dictionary: It’s the correspondence between words and phonemes. For example, English is the correspondence between phonetic symbols and words.

Language model (LM): Through the training of text information, the probability of a single word or word related to each other is obtained.

Decoding: Text data is the output of the acoustic model, dictionary, and language model.

Output texts include the information that the user wants to express in the time interval. There are three steps in the workflow that will be used to analysis the emotion in the tests, which are cutting the texts into words, analysing words emotions values, and accumulate emotions of words to the texts.

Table 5. 1 Emotion Words Classification and Relevance

Level 1	Level 2	Level 3	Level 4
Disgust	Avoidance	Hesitant	Loathing
		Aversion	
	Awful	Detestable	
		Revulsion	
	Disappointed	Revolted	
		Repugnant	
	Disapproval	Loathing	
		Judgmental	
Anger	Critical	Sarcastic	Rage
		Skeptical	
	Distant	Suspicious	
		Withdrawn	
	Frustrated	Irritated	
		Infuriate	
	Aggressive	Hostile	
		Provoked	
	Mad	Enraged	
		Furious	
	Hateful	Violated	
		Resentful	
	Threatened	Jealous	
		Insecure	

	Hurt	Devastated	
		Embarrassed	
Fear	Humiliated	Ridiculed	Terror
		Disrespected	
	Rejected	Alienated	
		Inadequate	
	Submissive	Insignificant	
		Worthless	
	Insecure	Inferior	
		Inadequate	
	Anxious	Worried	
		Overwhelmed	
	Scared	Frightened	
		Terrified	
Surprise	Startled	Shocked	Amazement
		Dismayed	
	Confused	Disillusioned	
		Perplexed	
	Amazed	Astonished	
		Awe	
	Excited	Eager	
		Energetic	
Happy	Joyful	Liberated	Ecstasy
		Ecstatic	
	Interested	Amused	
		Inquisitive	
	Proud	Important	

		Confident	
	Accepted	Respected	
		Fulfilled	
	Powerful	Courageous	
		Provocative	
	Peaceful	Loving	
		Hopeful	
	Intimate	Sensitive	
		Playful	
	Optimistic	Open	
		Inspired	
Sad	Bored	Indifferent	Depressed
		Apathetic	
	Lonely	Isolated	
		Abandoned	
	Despair	Vulnerable	
		Powerless	
	Abandoned	Victimised	
		Ignored	
	Guilty	Ashamed	
		Remorseful	

Initially, texts are cut into sentences based on periods and other punctuation that mean the end of the sentence. Then each sentence will be cut into words for further processing. English words can be simply cut into three steps, which are getting word groups based on space, symbol, paragraph separation, filtering out stop word and extracting the stem of the sentence. Most of the emotion related words are adjectives. Based on words listed in Table 5. 1, all the words are adjectives and they are related to emotion expressions or descriptions. The table of words is divided into four levels with six basic emotions. The first level contains six basic emotions. The second level includes some other related emotions with a heavier tension. The third level is heavier than the words in the second level. The fourth level includes the extreme words compared with basic emotion words. The extreme emotion values of each level are 1, 2, 3 and 4 points. Further, the words in the emotion words diagram have related emotions words as well. The related words and searching data can be presented based on google searching index. If the word is connected with level 1 more than others, the points will be the same as the word in level 1. The others obey the same rule. Therefore, the emotion value of each sentence can be calculated in this way based on knowledge graph for emotion words connection supports. Furthermore, the different sentences are accumulated to be texts with emotions values separately. Texts' emotion, which is the emotion that is expressed by the voice from the user, is identified.

The possible emotion that is output in this step will be processed further in the consensus algorithm to confirm the actual emotion of the user in the time interval.

5.4 Summary

In this chapter, entire workflow of voice data collection, clearance, classification and analysis methods were explained, as wll as the specific techniques and algorithms.

Voice data is different from the body index data in type. The collected voice data should be transferred into text data for further processing. Therefore, based on transferring methods, voice data is transferred into text data. The specific workflow for analysing text data and mining emotions in the text data is completed. The eventual output of this chapter is the possible emotion that is expressed by voice. The specific techniques and algorithms that are applied for pre-processing voice data and analysing voice data. Natural language process combined with words emotion expression form the final possible emotion of voice data. Creative computing is applied in the model developing with inter disciplines. Theories and methods are combined to be considered to confirm that most of the influential elements are considered in the model developing process.

Chapter 6

Video-Based Mental Health Analysis Technique

Objectives

- To depict mechanisms for separating facial expression data and behaviour data from video data.
- To employ video related data collection techniques and pre-processing techniques.
- To discover graphical relationships among facial data, behaviour data and other mental health related data.
- To state facial data pre-processing technique.
- To depict facial data analysis algorithm for emotion recognition.
- To state behaviour data pre-processing technique.
- To depict behaviour data analysis algorithm for emotion recognition.

6.1 Facial Expression-Based Mental Health Analysis Technique

6.1.1 Facial Expression Data Pre-Processing

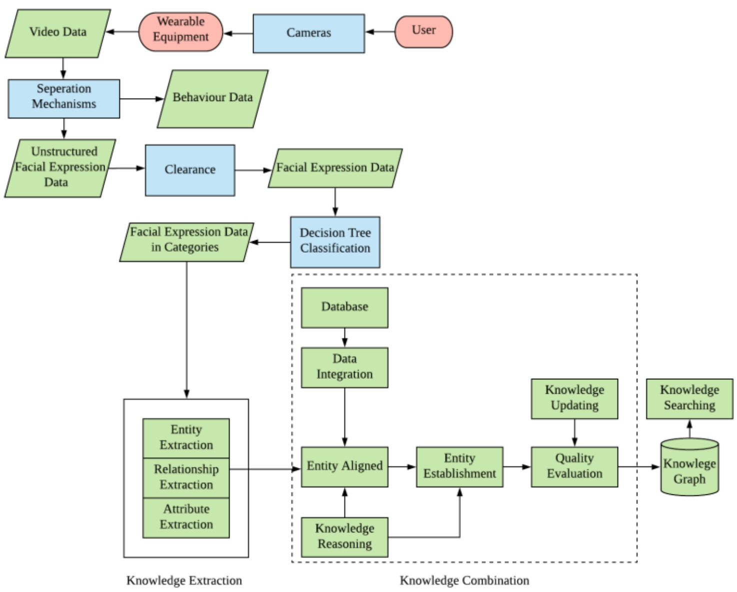

Figure 6. 1 Mental Health Related Facial Expression Data Pre-processing Workflow

As being illustrated in Chapter 4, the wearable products development and advanced techniques that can be applied in the interactions between wearable products and users, video data collection process can be completed. The interaction between wearable products, including intelligent shoes and clothes, is based on existing mature techniques with creativity and imagination to some extent.

Interaction relationships between user's video data collection and wearable products can be depicted in Figure 6. 1. In this research, wearable products can be used as carriers for AI based algorithms for facial expression data collection. Mental health supervision and management should be based on sufficient data collection and analysis. Data collection is based on interactions between the user and wearable products.

Starting with the industrial design aspect, intelligent shoes for mental health voice data collection and interaction with the user will be explained. The existing wearable intelligent shoes contains cameras on the top inside the shoes, which are used for identifying video data from the users. For video data, minicameras are considered to be the best choice for data collection.

The process of identifying and fixing the problem data is also called data cleaning.

Examples of statistical methods used in data cleaning include:

- Abnormal point detection: It is a method of identifying outliers in data distribution.
- Data filling is a method of repairing or filling in damaged or missing data in observations.

The decision tree is used for classifying data in the highest layer of this graph database. Decision tree classification can be used to analyse predicted outcomes to which the data belongs. Based on the definition and the connections between differentiated knowledge, the entropy of each knowledge unit can be calculated by:

$$H(T) = I_E(p_1, p_2, \dots, p_i)$$

The sum of $p_1, p_2, \dots, p_i$ is 100%, which is used to represent the percentage of each category in the entire database. Different characteristics of the target knowledge database can be used for defining classification labels through calculating the entropy of them. Characteristics with the highest entropy are used for the first classification for the target knowledge database. Then, iterating the same process for its child nodes.

6.1.2 Graph Theory-Based Knowledge Connection

The input data of this step is the facial expression data that are collected by cameras in the wearable products. The connections between facial data, emotions and other mental health related data can be detected based on medical research. In addition, body index data, facial expression data, and behaviour data also have connections with voice expression data.

Body indexes data, voice data, image for facial expression data, video for behaviour data should be connected for further emotion analysis. Actually, four types of data have relationships with each other. The elements and the structure of general knowledge graph elements have been shown in Chapter 4. As well as the relationships between body index data, voice data, video data are presented in Figure 4.2.

Two of the data types has relationships with each other. Knowledge graph in this research is used for building connections between mental health data. Entities, relationships and attributes are extracted by using different methods. As texts, behaviour, facial expression, body indexes data are in different data structure, therefore, the extraction methods must be distinguished.

General emotions value formula can be represented as:

$$E = A_g G + A_y Y + A_v V + A_h H$$

E represents emotion value based on collected data.

Y represents body index data emotion value.

G represents facial expression emotion value.

H represents texts' emotional value, which are emotions that are presented by language.

V represents behaviour emotion value.

A_g, A_y, A_v, A_h represents related parameters for four types of emotion data.

The body index data is the basic data for mental health analysis. Wearable products and related sensors and chips can detect the body index data and other types of data are related to the basis. Real-time changes of the body index data can be detected directly by sensors and chips. But the facial-related data, voice data, and behaviour related data are required further analysis to match relevant emotions.

For facial expression data G, it can be represented by formula:

$$G = \frac{E - (A_h H + A_y Y + A_v V)}{A_g}$$

As the body index data have relationships with other three types of data directly, so the formula can be generated as:

$$G = \frac{A_h H + A_y Y + A_v V}{\partial A_g}$$

∂ is the parameter represents the weight between facial expression data and other types of data.

As $G = \frac{A_h H + A_y Y + A_v V}{\partial A_g} = \frac{E-(A_h H + A_y Y + A_v V)}{A_g}$,

setting $\beta = A_h H + A_y Y + A_v V$,

Therefore, $H = \frac{\beta}{\partial A_g} = \frac{E-\beta}{A_g}$ (when $A_h \neq 0$)

Then, $\partial E - \partial\beta = \beta$

$$\partial = \frac{\beta}{E-\beta}$$

Lastly, E can be represented as:

$$E = \frac{\beta(1-\alpha)}{\partial} = \frac{(A_h H + A_y Y + A_v V) * (1-\alpha)}{\alpha}$$

From the above formula, it is can be concluded as emotions have close relationships with facial expression, behaviours and language expression. The weight of four kinds of data can be confirmed in the following analysis based on consensus mechanisms with medical theory. In this step, the quantitative relationships between emotion value and facial expression data are confirmed as a multi-variable influential state.

Meanwhile, facial expression data has connections with body index data, voice data, behaviour as well. knowledge graph can be established based on the quantitative relationships between each of these entities.

6.1.3 Facial Expression Data Analysis and Emotion Recognition

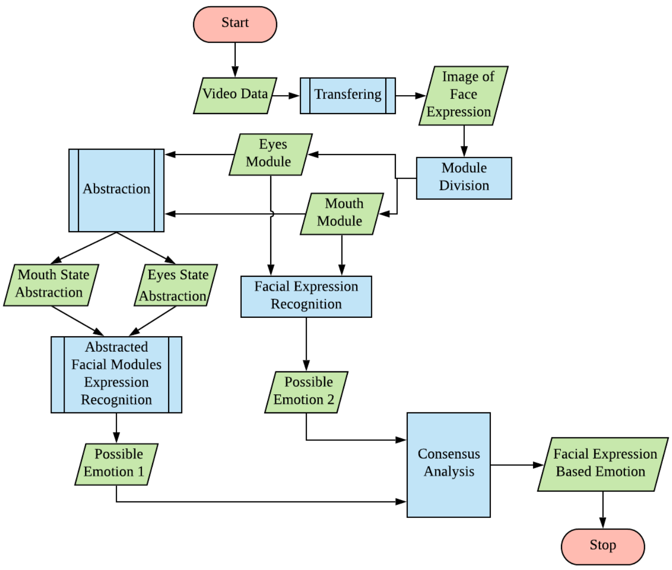

Figure 6. 2 Workflow of Facial Data Emotion Analysis

In this step, facial expression is identified for emotion reasoning. Traditionally, facial expression analysis for detecting emotion uses a conventional neural network for identifying and analysing. In this research, a new method is proposed. The entire workflow is presented in Figure 6.2. Video data have been transferred into images. As data is collected by using wearable products, the video data can collect most of the user's faces and bodies. Cameras are positioned at the top of shoes and sides of clothes. Facial images can easily be cut out for further processing.

Traditionally, in facial expression recognition, face detection technology is needed. When the face recognition is completed, the expression image is pre-processed (colour image greying, image geometric normalisation and light pre-processing), and then the expression features are extracted and analysed to realise expression recognition. In recent years, there are some researches on facial expression recognition at home and abroad, and many algorithms emerge, but the recognition accuracy of facial expression still needs to be improved.

This design report uses face detection technology, and carries on the marking, the image grayscale, the image geometry normalisation and so on. Through extracts the mouth, the size changes of the eyes to judge, the recognition accuracy is low, therefore, the subsequent improvement and the consummation is needed.

Firstly, the face, mouth and eyes are detected, recognised and marked, and then image is greyed and normalised. By using TensorFlow and OpenCV for processing image of user/s face, the related output of normalised images is in Figure 6.3,

Figure 6. 3 Outline of Faces with Facial Expression

The facial expression with outlines can be presented. To identify the facial expression, the entire faces are divided into different modules, include the eyes module and the month module. Original images can be processed with the CNN algorithm to analysing emotions in two modules. In the process of image processing, matrix convolution to calculate image features is usually being used. There are two types of matrix convolution: they are full convolution and valid convolution. Full convolution is used for image classification based on six basic emotions and six extreme emotions. The categories cover the emotion-changing range of an individual.

Image segmentation can be achieved based on graph theory. This kind of method is based on graph theory to map the image to an undirected graph with weight. The pixel is used as the node, regards the image segmentation problem as the vertex partition problem of the graph, and uses the minimum cut criterion to get the best segmentation of the image. In this method, the problem of image segmentation is associated with the problem of Min cut. The usual method is to map the image to be segmented to

$$g = (V, e)$$

V represents the set of nodes, can be represented as$V = \{ v_1, \dots, v_n\}$.

E represents the set of edges.

Each node belongs to set V in the graph and relating to each pixel of the image. Each edge belongs to E connecting to a pair of adjacent pixels. The weight of the edge $w(v_i, v_j)$ represents the weights of edges. The principle of segmentation is to keep the similarity between the divided subgraphs to the maximum and the similarity between the subgraphs to the minimum. The eyes module and mouth module can be segmented in this way for further processing.

The most important step in facial recognition for emotion identifying is to discover the features of each face image. As it can be seen for the face outline images, the different features can be recognised directly to different facial expressions. The machine should be trained to detect features in different modules and different angles. In Figure 6.4, side faces should be recognised as well. The camera in the wearable products can obtain face data from different angles. Side face facial expression analysis is essential for emotion analysis. According to all the profile images from the video data, outlines of user's face can be obtained in this way. The entire face is abstracted in lines. Meanwhile, the eyes module and month module are segmented in such processed images as well.

Lines will be analysed by using CNN to matching different emotions. Full convolution for profile image recognition definition formula is,

$$f(u,v) = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} x_{i,j} * k_{u-i,v-j}$$

Figure 6. 4 Profile of Side Face

Setting the image to be an m*m pixels image, the formula for grey profile image of facial expression recognition is:

$$f(u,v) = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} x_{i+u,j+v} * k_{i,j} * X(i,j)$$

To calculate the activation value, the data should exist in a three-dimensional form. At the input layer, if it is a grey image, then there is only one feature. If it is a coloured image, it should have three features. The features of the previous layer will be convoluted with the corresponding convolution kernel to output new features. For eyes module and month module recognition, l layer is set, the formula should be:

$$f(u,v)^{l} = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} x_{i+u,j+v}^{(l-1)} * k_{i,j}^{(l)} * X(i,j) + b^{(l)}$$

The input feature image is $x^{l-1}(m * m)$. b represents bias value.

After recognition of entire face image and modules are segmented into the eyes module and mouth module, the sub-sample layer can work on sub-features extraction.

Consensus analysis methods are used at this step for combining two possible emotions from the entire face image emotion expression and profile image emotion expression. Specific consensus mechanism and integration methods based on block chain consensus mechanism theory will be illustrated in the next section. The output of this step is the possible emotion based on facial expression analysis.

6.2 Behaviour Expression-Based Mental Health Analysis Technique

6.2.1 Behaviour Data Pre-Processing

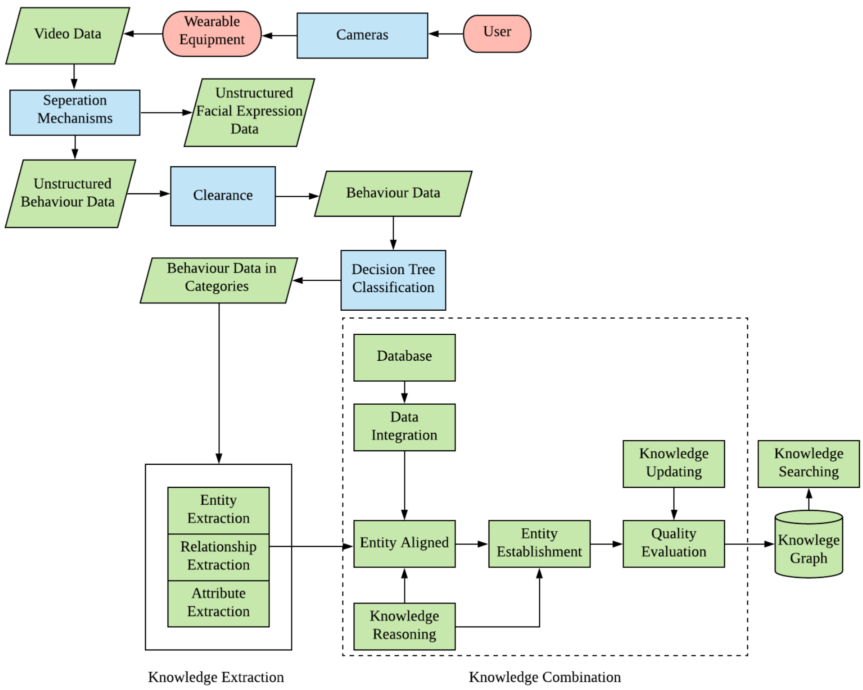

Figure 6. 5 Mental Health Related Behaviour Data Pre-processing Workflow

Comparing to the wearable products development and advanced techniques that can be applied in the interactions between wearable products and users in Chapter 4, the voice data collection process is easier to be stated. The interaction between wearable products, including intelligent shoes and clothes is based on existing mature techniques with creativity and imagination to some extent.

Interaction relationships between user's video data collection and wearable products can be depicted in Figure 6.5. In this research, wearable products are used in intelligent shoes. Mental health supervision and management should be based on sufficient data collection and analysis. Data collection is based on interactions between the user and wearable products.

From the industrial design aspect, intelligent shoes for mental health video data collection and interaction with the user will explained. Existing wearable intelligent shoes contain chips and sensors at the bottom inside the shoes, which are used for identifying body indexes from user's feet. For behaviour data, cameras are considered to be the best choice for data collection.

The process of identifying and fixing the problem data is also called data cleaning. Examples of statistical methods used in data cleaning include:

- Abnormal point detection is a method for identifying outliers in data distribution.
- Data filling is the method for repairing or filling in damaged or missing data in observations.

The decision tree is used for classifying data in the highest layer of this graph database. Decision tree classification can be used to analyse the predicted outcomes to which the data belongs. Based on the definition and each connection between differentiated knowledge, the entropy of each knowledge unit can be calculated by:

$H(T) = I_E(p_1, p_2, \dots, p_i)$

The sum of $p_1, p_2, \dots, p_i$ is 100%, which is used to represent the percentage of each category in the entire database. Different characteristics of the target knowledge database can be used for defining classification labels through calculating the entropy of them. Characteristics with the highest entropy are used for the first classification for the target knowledge database. Then, iterating the same process at the child nodes.

6.2.2 Graph Theory-Based Knowledge Connection

The input data of this step is the behaviour data that are collected by cameras in the wearable products. The connections between behaviour data, emotions and other mental health related data can be detected based on medical research. Body index data, facial expression data, and behaviour data also have connections with voice expression data.

Body indexes data, voice data, image for facial expression data, video for behaviour data should be connected for further emotion analysis. Actually, four types of data have relationships with each other. General knowledge graph elements and structure has been illustrated in Chapter 4. The relationships between body index data, voice data, video data are presented in Figure 4.2.

Two of the data types has relationships with each other. Knowledge graph in this research is used for building connections between mental health data. Entities, relationships and attributes are extracted by using different methods. As texts, behaviour, facial expression, body indexes data are in the different data structure, therefore, the extraction methods should be distinguished.

General emotions value formula can be represented as:

$$E = A_g G + A_y Y + A_v V + A_h H$$

E represents emotion value based on collected data.

Y represents body index data emotion value.

G represents facial expression emotion value.

H represents texts' emotional value, which are emotions that are expressed by language.

V represents behaviour emotion value.

A_g, A_y, A_v, A_h represents related parameters for four types of emotion data.

The body index data is the basic data for mental health analysis. Wearable products and related sensors and chips can detect the body index data and other types of data are related to the basis. Real-time changes of the body index data can be detected directly by sensors and chips. But the facial-related data, voice data, and behaviour related data require further analysis to match relevant emotions.

For behaviour data V, it can be represented by formula:

$$V = \frac{E - (A_g G + A_y Y + A_h H)}{A_v V}$$

As the body index data have relationships with the other three types of data directly, so the formula can be generated as:

$$V = \frac{A_g G + A_y Y + A_h H}{\partial A_v}$$

∂ is the parameter that represents the weight between body index data and other types of data.

As $V = \frac{A_g G + A_y Y + A_h H}{\partial A_v} = \frac{E - (A_g G + A_y Y + A_h H)}{A_v V}$,

setting $\beta = A_g G + A_y Y + A_h H$,

Therefore, $H = \frac{\beta}{\partial A_v} = \frac{E - \beta}{A_v}$ (when $A_h \neq 0$)

Then, $\partial E - \partial\beta = \beta$

$$\partial = \frac{\beta}{E - \beta}$$

Lastly, E can be represented as:

$$E = \frac{\beta(1-\alpha)}{\partial} = \frac{(A_g G + A_y Y + A_h H) * (1-\alpha)}{\alpha}$$

In the formula, it can be concluded as emotions have close relationships with facial expression, behaviours, and language expression. The weight of four kinds of data can be confirmed in the following analysis based on consensus mechanisms of medical theory. In this step, the quantitative relationships between emotion value and text data, which is transferred from voice data, are confirmed as a multi-variable influential state. Meanwhile, behaviour data has connections with body index data, facial expression, voice data as well. A knowledge graph can be established based on the quantitative relationships between each of these entities.

6.2.3 Behaviour Data Analysis and Emotion Recognition

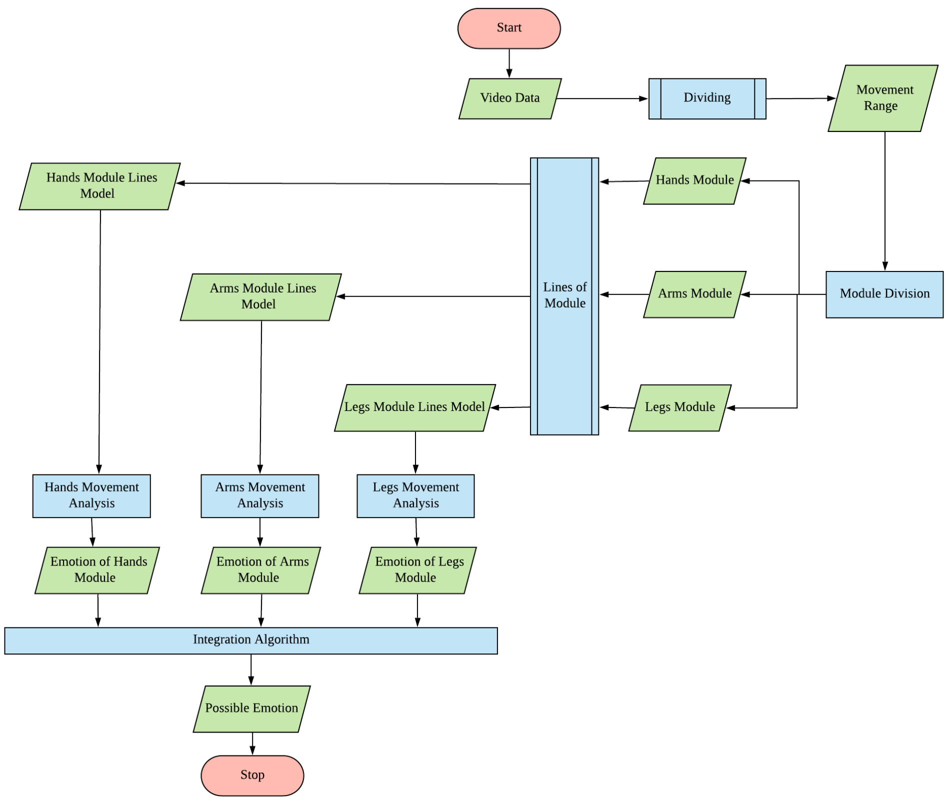

Figure 6. 6 Workflow of Behaviour Data Emotion Analysis

In this step, the workflow of behaviour data analysis and emotion output is explained. The graph theory and recurrent neural network (RNN) are used to build the basic framework. The framework is designed for learning effective features and modelling the dynamic process in the time domain to achieve end-to-end behaviour recognition and detection, which is the kernel technique in this workflow.

Initially, the video data are segmented into movement actions based on the time interval of emotion detecting of the system. As it is known, the process of action has to go through multiple states (corresponding to many time frames), and the human body also presents different postures at each time. Thus, each frame is different in entire behaviour or action. Taking "boxing" as an example, the whole process has gone through the initial approach stage, the climax stage, and the end-stage. In contrast, the climax stage of fist and foot swing contains more information, which is the most helpful to distinguish the movements.

The movement will be divided further into three categories, corresponds to the three parts of human body, that are hands, arms and legs. The three modules are three essential parts for emotion expression in behaviour. For example, it is proposed that there are 27 small bones in the human hand, which are connected by a network like a ligament structure and rely on muscle stretching to complete various joint activities. For many subconsciouses, without noticing it, it's transmitted to the fingers, making the fingers move. Based on psychology theories, the body linguists point out that every finger in people has its language. The hand does not only have emotions, but also a lot of emotions. The hand does not only allow people to grasp things flexibly but also delicately depicts people's emotions. Such as, when a person is in a state of doubt or low degree, he will gently rub one hand against the other. But when ten fingers cross the friction and placed on the table or one side of the body, it looks like self-confidence. In fact, on the contrary, this action shows distress and depression.

Three modules are divided in a similar method with facial data segmentation. The formula is,

$$f(u,v,r) = \sum_{i=-\infty}^{\infty} \sum_{j=-\infty}^{\infty} x_{i,j} * k_{u-i,v-j}$$

Two RNN networks (temporal RNN of time channel and spatial RNN of space channel) are used to process the key point data of profile of behaviour in video data. Finally, the weighted average method is adopted in the fractional layer. These two networks can be regarded as a whole of end-to-end training.

The key point coordinates of each time are spliced into a vector, and the RNN network is used to learn the change of coordinates with time. Here, there are two different structures: multilayer RNN and hierarchical RNN. Multilayer RNN simply stacks a single RNN, and the output of the upper RNN is the input of the next RNN. It is can be found that the best result is when stacking 2-3 layers. Hierarchical RNN is inspired by previous work, that is, the key points of the human body are divided into five parts (trunk, for each part of the coordinate point, the coordinates at the same time are spliced into a vector, and RNN is used to learn the movement of this part. Then, the input of RNN of different parts at the same time is spliced together. Moreover, the RNN network is used to learn the movement law of the whole human body. The schematic diagram of hierarchical RNN is shown in the figure below.

For spatial channels, spatial RNN aims to learn the connection between different coordinate points. To facilitate RNN processing, it is required to transform the structure of the key point graph into a sequence. For example, for Kinect V1 data, there are 20 key points in total, and the structure is shown in (a) below. Two methods are used to transform the structure of the key point graph into a sequence. The first method (chain sequence) is shown in figure (b) below. According to the physical connection, it was found that the key points of the human body can be divided into three sequences: hands, trunk, and feet. So these three sequences are concatenated into a sequence. The second method (traversal sequence) is shown in Figure (c) below. Starting from the centre of the human body, the method of traversal is used to access all the key points once. Output a sequence according to the order of node access.

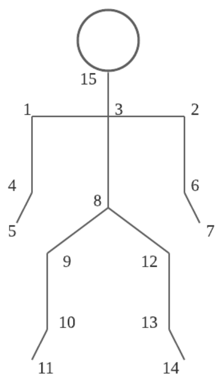

Figure 6. 7 Profile of Human Body

Hands, arms and legs are positioned with points to recognition the actions. The threshold of each module is related to extreme emotional expression in actions. For skeleton based behaviour recognition, three-dimensional coordinates of key points of human body are input. In order to enhance the generalisation ability of the network and prevent overfitting in the process of network training, the data enhancement technology is explored based on 3D coordinate transformation, including rotation, scaling, and hill transformation.

6.3 Summary

This chapter considers the video data is processed for emotion evaluation. Video data is separated into facial expression data and behaviour data. Facial expression data is processed by using CNN based algorithm to analyse emotions that are expressed by the user. The outline of the user's facial expression is abstracted for more accurate emotion analysis. Behaviour data are processed by using RNN based reinforcement learning algorithm. The outline of the entire user's body is used for more accurate emotion analysis. Possible emotions are output at the end of this chapter. The entire chapter explains the specific processing procedure with algorithm working mechanisms. Creative computing is applied in this section for model development that is used for analysing facial expression data analysis and behaviour expression data analysis. The elements from facial expression analysis and behaviour expression analysis are considered in the model developing process. Further, the elements from mental health area are considered as well.

Chapter 7

Consensus Mechanisms and Mental Health Supervision and Advice Generation Techniques

Objectives

- To depict the consensus algorithm for integrating possible emotions
- To state mental health supervision mechanism
- To explain the mental health expert system and methods for generating advice
- To explain specific techniques that are used in mental health warning function and emotion moderation.

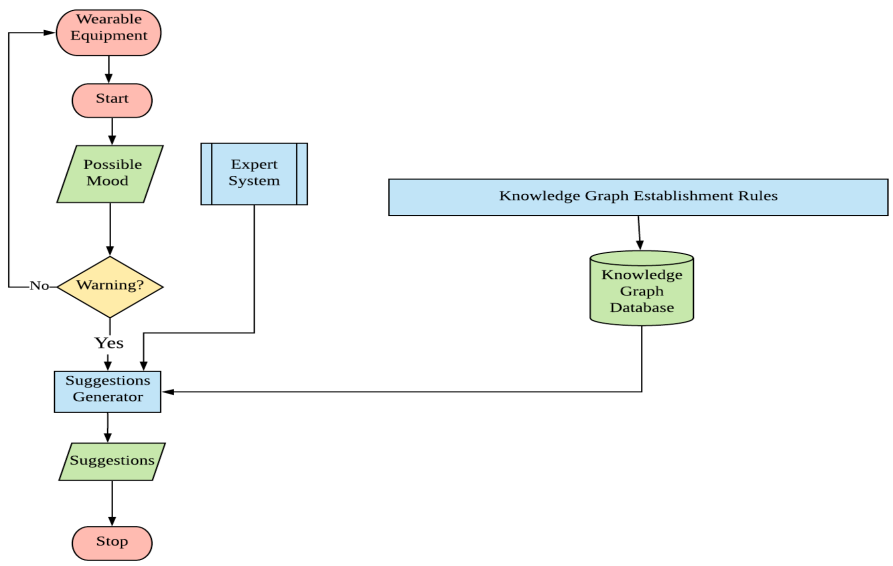

Figure 7. 1 Mental Health Supervision and Problems Advice Generator Workflow

In this chapter, the workflow of the mental health supervision and problems advice generator is explained. Entire workflow includes two steps, they are emotion evaluation and advice generation. Based on analysis of four kinds of mental health related data, body indexes data, voice data, facial data, and behaviour data, the possible emotion is output with relevant value.

The entire process can be set on the wearable products and using the cloud resources. The data workflow can be described as data collecting, data storage and classification, data extraction, emotion analysis, and suggestions generation. The data can be collected from the user based on wearable products. Cloud resources are set by using the internet connecting with the system. Emotion analysis algorithms are used for analysing collected data to supervise the emotions of people in order to manage the mental health. The emotions that can be detected by the system represent the mental health states of the user.

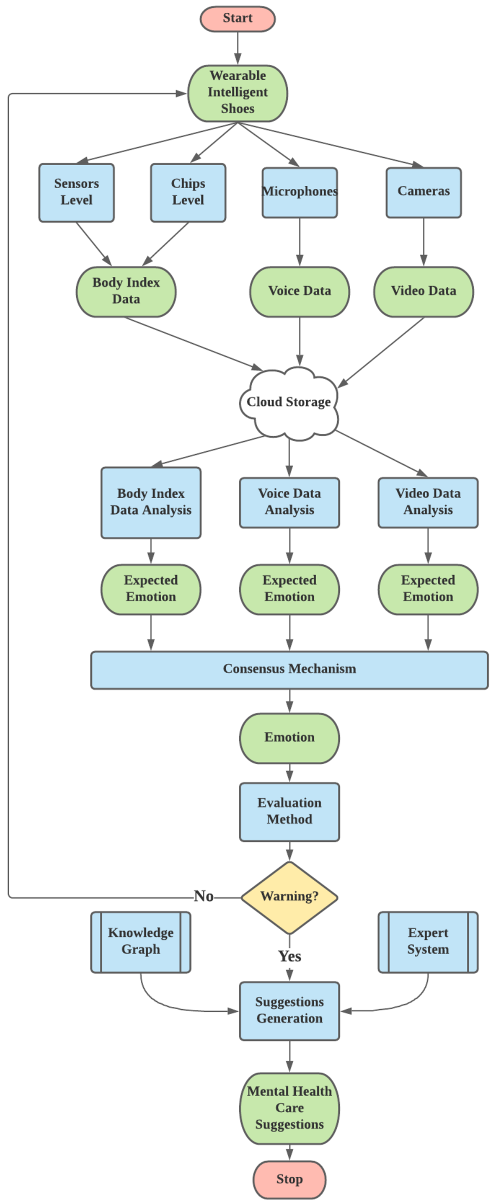

Figure 7. 2 Mental Health Care System Set on the Wearable Shoes

7.1 Consensus Mechanism and Integrated Mental Health Diagnosis

Psychologist Mehrabrian stated that emotional expression can be depicted by the formula [11]:

$$Emotion = 7\% * Language + 38\% * Voice + 55\% * Facial\ Expression \quad (1)$$

PDA model is a traditional emotion evaluating model. The model considers that the emotion of human has three dimensions: pleasure, activation, and dominance. In this model, P represents pleasure, which indicates the positive and negative characteristics of an individual emotional statement. A represents Arousal-nonarousal, which indicates the level of individual neurophysiological activation. D represents dominance, which indicates the control state of an individual to situations and others.

At the same time, the values of these three dimensions can also represent specific emotions. For example, the coordinates of anger are (- 0.56,0.70,0.34) (the range of values on each dimension is - 1 to + 1. + 1 means the value of this dimension is high, and - 1 means the value on this dimension is low).

Based on the above stated method, the emotion evaluation methods of this research can be defined in this section. Initially, there are four aspects to confirm the emotion of an individual, which are body index, the voice of the individual, facial expression of the individual, and behaviours of the individual. Considering the application of the framework and applicable system for mental health supervision, data that can be collected by wearable products and related sensors can be used for completing four kinds of analysis.

Body index can be analysed by using a statistical model and healthy subject methods to confirm body index value, which is the basis for analysing emotion from body index data. Emotion has a close relationship with the mental health of individuals.

Voice data is used for analysing emotions that are expressed by people with language, which occupies 7% at least emotion expression based on traditional expression theory. The NLP technique is the kernel algorithm in the voice data analysis.

Facial data can represent about 55% of expressions of an individual. CNN algorithm is the kernel analysis algorithm for emotion analysis.

Behaviour dada is the fourth dimension for emotion analysis and presented in this research. Some actions can express emotions better compared with language and facial expression.

Based on four aspects of analysis and possible emotions output, consensus mechanisms, and integrated algorithms for analysing four possible emotions are completed at the end of this chapter. The techniques used at this step are the blockchain method and the logistic regression model. The final output is one emotion based on four possible emotions from four analysis methods.

The specific workflow of each algorithm and mechanisms of each step are illustrated below in three sub-sections, which are mental health analysis sub-algorithms, consensus mechanism and integrated mental health diagnosis, and a summary of this chapter.

Based on Figure 7.2, the entire workflow of the mental health analysis and recognition technique has two steps, which are the mental health analysis sub algorithms process step and consensus mechanism and the integrated algorithm step. At the first step, mental health analysis sub-algorithms are applied for processing data that are collected from the user by using wearable products (the sensors), and data from the knowledge graph database (the history data). Four types of data are processed in four distinguished algorithms. Eventually, four possible emotions are the output of this step. In the second step, a consensus mechanism and the integrated algorithm are established to evaluate four output emotions and combine them to be the result for the user. The possible emotion based on mental health analysis and recognition technique is generated based on body index, facial expression, voice expression, and behaviour expression. The detected emotion will be further processed in the next phase for being validated and mental health-related suggestion report will be generated.

Specific processes and related algorithms and techniques that are applied will be illustrated below.

In this sub-section, four sub-algorithms are explained and demonstrated with detailed workflow, formulas, and some data. Four algorithms include a statistical algorithm for body index analysis, voice data analysis, facial data analysis, and behaviour data analysis. Being connected with the knowledge graph database and applying the knowledge graph methods in the analysis process, weighted directed and undirected connections are applied in the entire analysis process. A statistical algorithm for body index analysis is used for focusing on matching between body index changes and emotional expression. Some basic body indexes present the variations when the emotion of individual changes in a time interval.

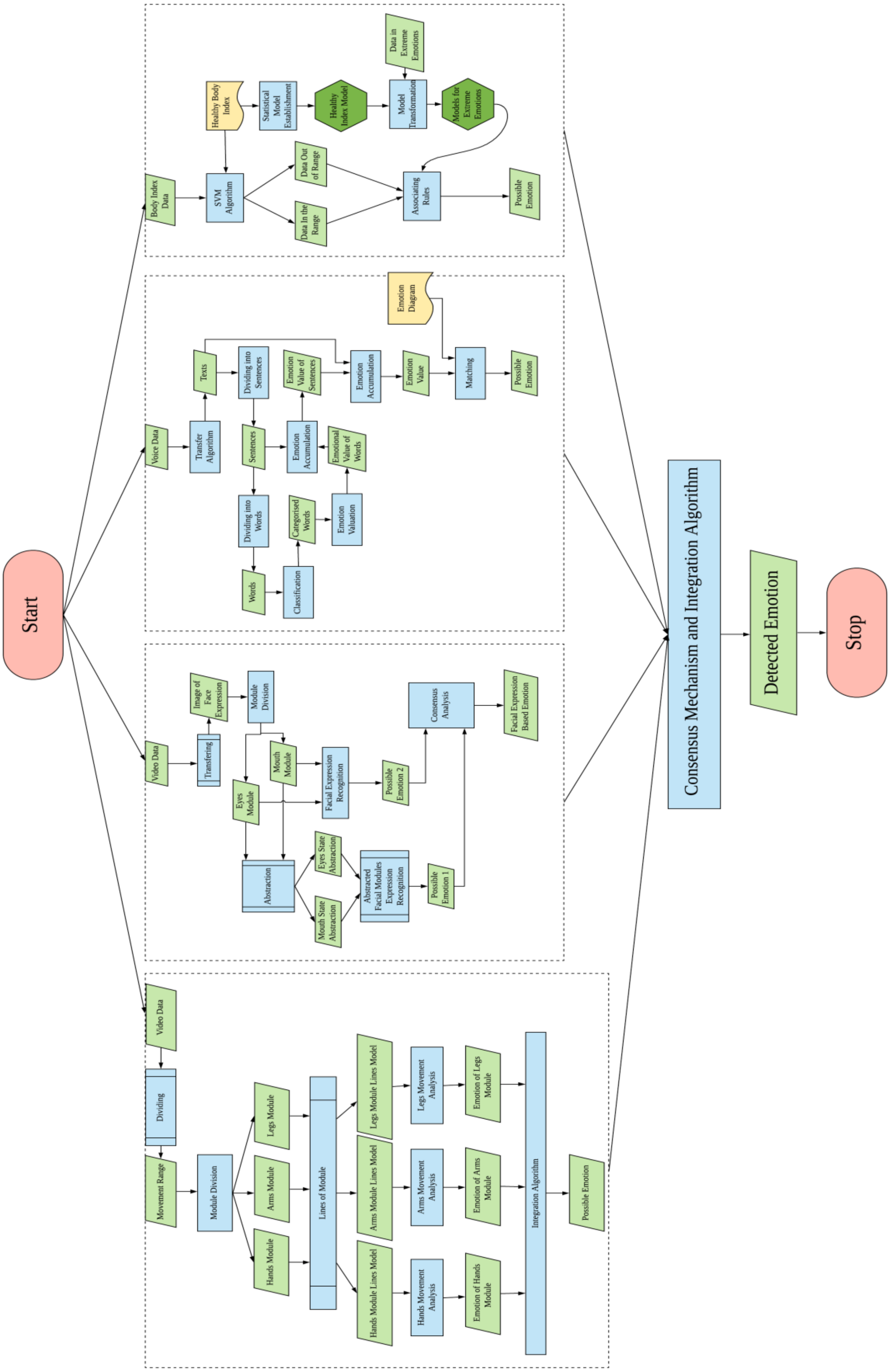

Figure 7. 3 Entire Workflow Structure of Mental Health Analysis and Recognition Technique

Table 7. 1 Expression Influential Index and Emotion Relevant Index for Four Kinds of Data Types

Data Types	Expression Influential Percentage	Emotion Relevance Percentage
Body Index	-	-
Voice Data	7%	25.8%
Facial Expression Data	38%	14.3%
Behaviour Data	55%	20.5%

Based on Mehrabrian' theory, people usually express themselves in three ways, language, voice, and facial expression. Body index is the standard evaluation type of data for stating body healthy description and emotion-related description. Therefore, body index is not one of the influential percentages for expression when communication happens between two individuals. The other three types of data are related to expression with percentages of 7%, 38%, and 55% based on proposed research and experiments by Mehrabrian.

The relationships between emotion value and value of voice data, facial data, behaviour data can be simply defined as,

$$E_{BiV} = f_{BiV}(BiV)t$$

$$E_g = f_G(G)t$$

$$E_h = f_H(H)t$$

$$E_v = f_V(V)t$$

Entire emotion value can be represented as:

$$E = [\ f_{BiV}(BiV) + f_G(G) + f_H(H) + f_V(V)]t \tag{2}$$

t represents the time interval that different kinds of data are collected.

E_{BiV} represents the body index emotion value.

E_v represents the voice data emotion value.

E_g represents the facial data emotion value.

E_h represents the behaviour data emotion value.

Each formula with mapping rules $f_i(i)$ is different, which are stated in the following sub-sections. Emotion value is an important indicator of mental health analysing and supervising.

Each formula will be built by four algorithms for emotion analysis and emotion value calculation. Emotion relevance percentage can be calculated after four functions being confirmed. The time sequence of each dataset has influences on emotion analysis and real-time emotion expressions. The general physical time interval is four minutes, which means that emergent physical diseases could threaten an individual's health and life after four minutes pass. The time interval is defined based on proposed research of the medical subject and practical experience, the most golden rescue time for an individual when he or she is required emergency medical rescue.

Table 7. 2 Time Interval Calculation Principle

Data Type	Sub-Data Aspects	Threshold	Time Interval (Seconds)
BiV	-	-	240
G(Facial Expression)	Eyes Module	70%	30
	Month Module	70%	30
H (Behaviours Data)	Hands Module	50%	30
	Arms Module	50%	30
	Legs Module	30%	30
V (Voice Data)	Content	40%	30
	Voice Volume	50%	30
	Intonation	50%	30

To confirm a scientific time interval calculation mechanism, the time interval calculation principle is formulated based on emotion expression relevance data [39]. The golden rescue time of physical diseases 4 minutes, which is 240 seconds is the basis of mental health supervision time interval calculation. Four kinds of data and eight kinds of sub-data types are considered to be calculation elements. Each element has 30 seconds for minus use. If one of the sub-data types reaches the threshold for expressing emotion extremely, the 30 seconds will be deducted from the entire 240 seconds. Then the time interval of the entire system will be changed to 210 seconds. For example, if the voice volume reaches the threshold (will be illustrated specifically in the following subsections) at 50%, the 30 seconds will be deducted from the time interval. On quantitative consideration, the evidence for formulating threshold and percentage for deducting time interval is based on the emotion influential value of each data type, which is stated in specific algorithms' explanation below. On qualitative consideration, an individual is already on the way to reaching extreme emotion most of the time when the voice volume is 50% higher than his or her normal voice volume. The influences on emotion value are larger.

Extreme emotions usually lead to extreme behaviours. Therefore, the time interval for mental health supervision is less than the general physical health supervision's time interval.

Based on the time interval and threshold definition, the emotion-relevant percentage can be calculated with the harmonic mean formula. For each data type, the value of variables and times of β is different.

$$Erp = \frac{(1+\beta^{i}) * \prod_{1}^{j} p}{(\beta^{i} * \prod_{1}^{j} p) + q}$$

Erp represents the emotion relevance percentage.

β represents influential relevance.

i represents the number of elements in each data type.

p represents elements threshold in each data type.

q represents the average percentage of the entire elements' threshold of each data type.

It is required to explain the definition of β. Based on bootstrapping, the probability of not collecting each data in the dataset can be calculated with the formula below.

$$\lim_{m\to\infty}\left(1-\frac{1}{m}\right)^{m} = \frac{1}{e} \approx 0.368$$

For influential relevance β, it can be calculated with this method. Influential relevance can be understood to be a probability of affecting the emotion of an individual. Therefore,

$$\beta = 1 - \lim_{m\to\infty}\left(1-\frac{1}{m}\right)^{m} = 1-\frac{1}{e} \approx 0.632$$

In this way, all the elements' emotion relevance percentage can be calculated below:

For facial data, the formula is,

$$Erp_{G} = \frac{(1+0.632^{2}) * 0.7 * 0.7}{(0.632^{2} * 0.7 * 0.7) + 0.7} = 0.143$$

For the behaviour data, the formula is,

$$Erp_{H} = \frac{(1+0.632^{3}) * 0.5 * 0.5 * 0.3}{(0.632^{3} * 0.5 * 0.5 * 0.3) + 0.43} = 0.205$$

For the voice data, the formula is,

$$Erp_{V} = \frac{(1+0.632^{3}) * 0.4 * 0.5 * 0.5}{(0.632^{3} * 0.4 * 0.5 * 0.5) + 0.46} = 0.258$$

The emotion relevance percentages represent the quantitative relationships between emotion and relevant module expressions.

The calculated emotion relevance percentage for each data type and threshold percentage of each sub-element is the basis of consensus mechanisms. Specific data and principles are the basis for the sub-algorithms data processing below.

The relationships between emotion value and value of voice data, facial data, behaviour data can be simply represented as:

$$E_g = f(G)t$$

$$E_h = f(H)t$$

$$E_v = f(V)t$$

Entire emotion value can be represented as:

$$E = [f(BiV) + f(G) + f(H) + f(V)]t$$

By combining the emotion calculating model and knowledge graph of original data, the weights between four types of data can be added in the formula to improve the relativity between possible emotion and the user.

An undirected knowledge graph between four types of data can represent the relationships between each two of them, which can be added as the weight of the emotion formula.

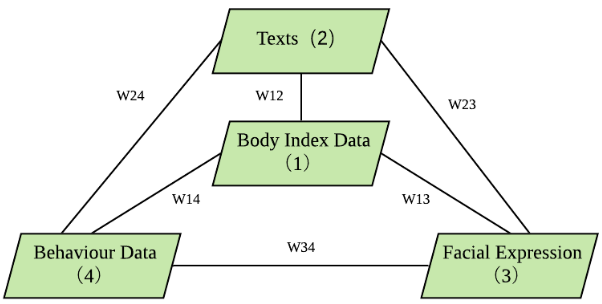

Figure 7. 4 Weighted Relationships between Entities

$$E_{possible} = \big[w_{13}\big(f(BiV) + f(G)\big) + w_{12}\big(f(BiV) + f(V)\big) + w_{14}\big(f(BiV) + f(H)\big) + w_{23}\big(f(V) + f(G)\big) + w_{24}\big(f(V) + f(H)\big) + w_{34}\big(f(H) + f(G)\big)\big]t$$

To simplify the formula, possible emotion value can be represented as:

$$E_{possible} = [f(BiV)(w_{13} + w_{12} + w_{14}) + f(G)(w_{13} + w_{23} + w_{34}) + f(V)(w_{12} + w_{23} + w_{24}) + f(H)(w_{14} + w_{24} + w_{34})]t$$

Consensus mechanism can be explained based on two words, consensus and mechanism. Consensus means the consensus of all participants means that everyone accepts and supports these decisions. The mechanism means the establishment process consists of clear rules to achieve specific goals. In the financial area, the consensus mechanism refers to the process of reaching a unified agreement on the state of the network in a decentralised way. It is also known as consensus algorithm. It helps to verify and verify that information is added to the ledger to ensure that only real transactions are recorded on the blockchain.

The consensus mechanism agrees that the consensus mechanism attempts to solve one of the most complex problems around distributed systems: the authenticity and accuracy of data to reach a unified agreement. Unlike centralised systems, users do not have to trust anyone in the system. Protocol rules embedded in the network ensure that the state of the public ledger is always updated with the consensus of the public.

Therefore, the consensus mechanism is responsible for updating the data state in the distributed network safely.

Rules that have been hardcoded into the protocol ensure that a unique source of data can always be found and agreed upon in a global computer network. These rules protect the whole network and realise the network without trust without central data or mediation.

In emotion identifying with four kinds of data, four algorithms analyse, and output possible emotions based on collected data by using wearable products. Four possible emotions should be integrated to generate the final output.

Consensus mechanisms in the blockchain domain mean a kind of decision-making based credit identification mechanism. The so-called "consensus mechanism" is to complete the verification and confirmation of the transaction in a short time through the voting of special nodes. For a transaction, if several nodes with unrelated interests can reach a consensus, the whole network can reach a consensus on this. More generally speaking, if a Chinese weibo blogger, an American virtual currency player, an African student, and a European traveller don't know each other, but they all agree that you are a good person, then you can basically conclude that you are not bad.

To maintain the same data for the whole blockchain network nodes and ensure the fairness of each participant, all participants in the whole system must have a unified protocol, which is the consensus algorithm that is used here. All nodes of bitcoin follow the unified protocol specification. Protocol specification (consensus algorithm) is composed of relevant consensus rules, which can be divided into two major cores: workload proof and longest chain mechanism. The ultimate embodiment of all the rules (consensus) is the longest chain of bitcoin. The purpose of consensus algorithm is to ensure that bitcoin runs continuously on the longest chain, to ensure the consistency and reliability of the entire accounting system.

Users in the blockchain do not need to consider the credit of the other party, neither need to trust the other party, nor need a trusted intermediary or central organisation. They only need to implement the transaction according to the blockchain protocol. The premise of this smooth transaction without a trusted third-party intermediary is the consensus mechanism of blockchain. That is, in the market environment of mutual ignorance and trust, each node participating in the transaction has no motivation or behaviour of cheating in violation of regulations for its interests. So each node will voluntarily abide by the pre-set rules to judge the authenticity and reliability of each transaction and writing the records passed the inspection to the blockchain. The interests of each node are different. Logically, they have no motive to conspire to cheat, especially when some nodes in the network have a public reputation. Blockchain technology uses the consensus algorithm based on mathematical principles to establish a "trust" network between nodes and uses technical means to achieve an innovative credit network.

7.2 Mental Health Supervision Mechanism

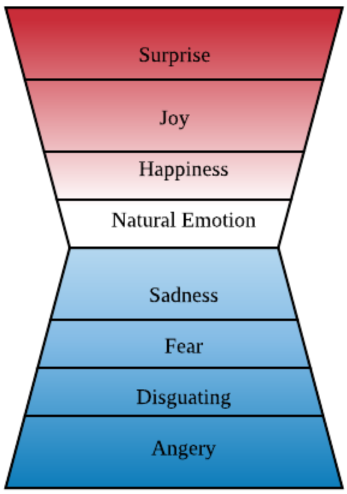

Figure 7. 5 Emotion Funnel for Evaluation

In Figure 7.5, eight basic emotions can be represented in a funnel model. Basic emotions can be evaluated by using emotion values and emotion index. There is an inseparable relationship between people's emotions and people's ideology. Therefore, the study of people's emotional changes can judge people's inner world -- Ideological dynamics. If it is said that mastering the ideological dynamics is the first step to mobilise people's enthusiasm, then the analysis of the emotional index is the first step in this first step.

People's mood is always related to people's requirements, which are the source of people's behaviour. Therefore, to stimulate people's motivation and make them be developed in a predetermined direction, it is very important to judge people's requirements, starting from observing and analysing emotions.

People's emotions are not only changeable but also calculable. According to psychology, it can be called emotion index, and its calculation formula is as follows:

$$Emotion\ Index = \frac{Emotion\ Value}{Expectation\ Value}$$

When the realisation value exceeds the expected value, the emotion index is greater than 1. Because the inner desire is satisfied, people's emotions will be excited. The greater the emotional index is, the more excited people will be. For example, if someone accidentally gets a floating salary that he didn't expect in advance, and he will feel a kind of unexpected satisfaction, and his enthusiasm for work will also rise unprecedentedly.

When the emotion index is less than 1, the realisation value is smaller than the expected value. Because the inner expectation is not satisfied, the emotion presents a depressive state. The smaller the emotional index, the lower the mood.

People's emotion is not only affected by the realisation value, but also restricted by the expected value.

As positive emotions and negative emotions have different influences on the emotion value of an individual. The emotion value formula can be represented as,

$$E = \begin{cases} -kEi^2 & Ei \leq 0 \\ kEi^2 & Ei \geq 0 \end{cases}$$

When the calculated emotion value of step two, mental health analysis and recognition, equals the emotion value that is calculated based on the emotion index, the outcomes of possible emotion are reliable. The output emotion in step two can be validated and the model is feasible and reliable. In this step, the emotion value is compared with the value that is output by the consensus step. Three kinds of emotion data are analysed to calculate the emotion value. The comparison is the evaluation step for the entire emotion analysis.

Further, eight emotions have a threshold based on the emotion value that is being calculated with the emotion index. When emotion value from the mental health analysis and recognition step reaches the extreme emotion threshold, the alarm of the supervision module will turn on. Further actions will be done by the mental health supervision and management system.

7.3 Mental Health Expert System for Suggestion Generation

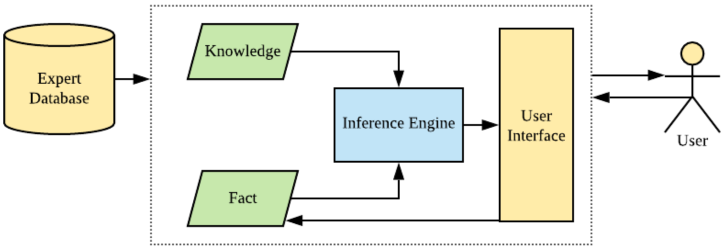

Figure 7. 6 Expert Architecture

Expert system (ES) is one of the most active and extensive fields of artificial intelligence. The expert system is defined as using the computer model of human expert reasoning to deal with complex problems that need experts to explain in the real world and draw the same conclusion as experts. In short, as shown in Figure 7.6, an expert system can be regarded as a combination of "knowledge base" and "inference machine".

The main work of a knowledge base system is to collect human knowledge, and expresses it systematically or modularises it so that computers can infer and solve problems. There are two types of knowledge base: one is knowledge itself, which is to analyse the substance and concepts and confirm the relationship between them; the other is the experience rule, judgment, and intuition of human experts. The knowledge base is different from traditional databases in information organisation, integration, execution, and other steps and methods. Generally speaking, the knowledge base contains knowledge that can be used for decision-making, while the content of a traditional database is unprocessed data, which can only be applied through retrieval, interpretation, and other processes.

The inference engine is based on algorithms or decision-making strategies to infer mental health knowledge to deduce the correct answer according to the user's questions. The problem-solving algorithms of the inference engine can be divided into three levels:

General approach: using blind search to find possible answers for mental health-related problems, or using heuristic searching to find the most likely answers.
Control strategies: there are three types of control strategies: forward chaining, backward chaining, and Bi-directional chaining. The forward formula is to find the answer from the known conditions and use the data to deduce the conclusion gradually. The backtracking type sets the goal first and then proves the goal.
Additional thinking skills: it is used to deal with the uncertainty between several concepts in the knowledge base, and generally uses fuzzy logic to calculate. Reasoning opportunity determines the applicable inference level according to the knowledge base, the user's problem, and the complexity of the problem.
The mental health care problems solution and advice generation expert systems include five categories of sub-systems, which are,

- Rule-based expert system: using a series of rules to express mental health-related knowledge.
- Framework-based expert system: This is a natural extension of the rule-based expert system, using object-oriented programming to describe mental health-related data structure.
- Case-based expert system: using previous cases to solve current problems.
- Model-based expert system: a clear definition of the model, design principal concept, and standard mental health knowledge base.
- Network-based expert system: positioning human-computer interaction in the network (Internet) level.

Related mental health advice can be generated in this method to control the extreme emotions of the user. The user can be protected from being hurt by extreme emotions. If the emotion did not reach the extreme threshold, the iteration would be back to the wearable sensors for real-time supervision.

7.4 Summary

In this chapter, consensus mechanisms and mental health supervision, and problems advice generation techniques are explained. Consensus mechanisms are established for integrating four kinds of emotions to output the final expected emotion. Mental health supervision working principles and specific algorithms are explained in this chapter. The mental health expert system is generated for problem advice. As the system will be set on the wearable products for interacting with users, warnings should be activated when extreme emotions are detected.

Chapter 8

Case Studies

Objectives

- To present the architecture of artificial intelligence-based Mental Health Care system
- To explain different functions blocks of the system, including sentiment analysis block, sentiment supervision block, and feedback block
- To depict related interfaces of artificial intelligence-based Mental Health Care system
- To demonstrate intelligent Mental Health Care system applying with wearable cloth serving the user for sentiment supervision and management
- To illustrate intelligent Mental Health Care system applying with wearable shoes serving the user for sentiment supervision and sentiment problems feedback

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8.1 Constructing an Artificial Intelligence-based Mental Health Care System

The proposed artificial intelligence-based mental health care system is based on mental health supervision and management framework. Artificial intelligence related techniques and algorithms are applied for generating a framework and system. In this chapter, the specific mental health care workflow and a developed mental health care system with three kinds of subsystems. Body index data, voice data, and video data can be processed by the system to present the emotion of the user. Data can be collected by using wearable shoes with sensors, chips, microphones, and cameras.

Especially, the specific workflow of the artificial intelligence-based mental health care with starting point and ending point are presented. Three subsystems are illustrated in this chapter for a specific application with wearable products. The workflows are stated in Chapter 3, specific techniques and algorithms are stated in Chapter 4, Chapter5, Chapter 6, and Chapter 7, which are the overall workflow of the entire artificial intelligence-based mental health care. The application version of the artificial

intelligence-based mental health care system includes three subsystems for analysing body index data, voice data, and video data for emotion analysis in the time interval.
Each subsystem includes three main processes, which are data preparation, data emotional analysis, supervision, and management function. The data processing procedure can be presented partly in the system.

8.1.1Architecture of Artificial Intelligence-based Mental Health Care System

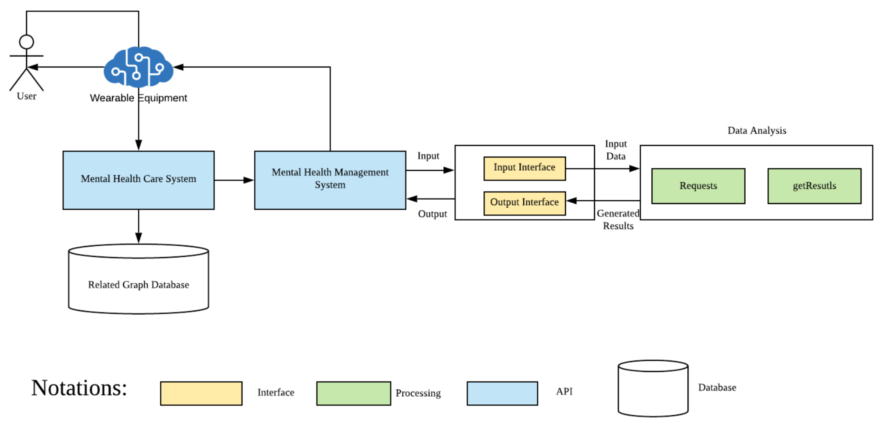

Figure 8. 1 Application Structures of Mental Health Care System

In Figure 8.1, the application structure of the mental health care system is set in the wearable products is presented. Wearable products are connected with the user for collecting data.
From the development perspective, the MHCS is developed by Java programming language as an Application Programming Interface (API). Kernel functions can be achieved by using Java techniques.
From a technical perspective, the mental health care system and three subsystems for different types of data processing are developed by classes. Overriding and overloading are used for coding the MHCS. The data is collected from the wearable products, which is the initial input of the system. Developed algorithms for emotion analysis are achieved at the backend of the system. Graph databases are applied in the system establishment, they are used for advice generation for the user for emotional problems.
For the mental health management system, the user interface is presented in this chapter. The user can check the states of each emotion analysis and possible emotions in the time interval. Initially, the user and wearable products have interacted for data collection and

storage. The system obtains the data and completes the emotion analysis. Different emotion percentages are presented in the system interfaces.

Especially, the results inferred in the system include four kinds of data types, which are body index data with numbers, voice data, image data, and behaviour active video data. The data are transferred into properties that were saved in the database. Connections between different kinds of data are built in the graph database, which is another basis for emotion analysis.

The tools that are used in the development process of the mental health care system are the Eclipse Integrated Development Environment (IDE) for Java Developers, Neo4j. Java is selected as the developing language since MHCS API is planned to be developed. Neo4j is written in Java programming language. Thus, Neo4j can be connected with Java developed API. An API developed in Java can be easily implemented cross-platform and called in different applications.

8.1.2 Mental Health Care System Interfaces

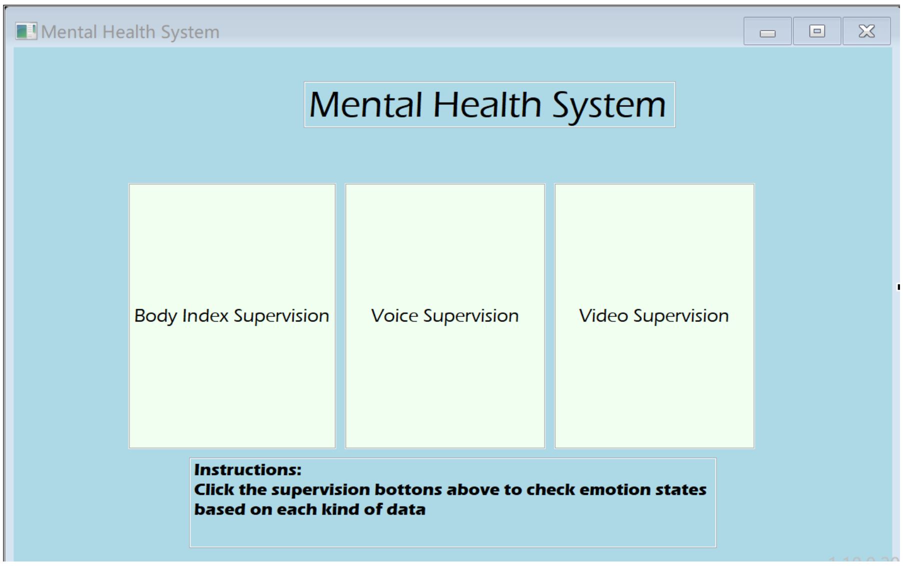

Figure 8. 2 Main User Interface of the Mental Health Care and Management System

The main user interface of the mental health care system includes three main buttons, which lead to three data processing subsystems for emotion analysis for the user. Data is collected by using sensors and chips, microphones, and cameras. The system can be used for addressing body index data, voice data, and video data for emotion analysis.

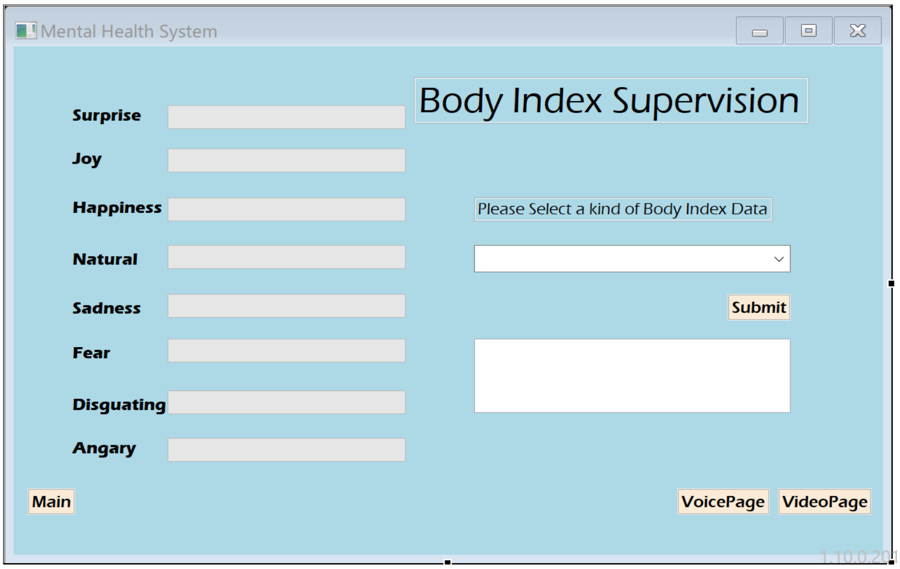

Figure 8. 3 Body Index Data Analysis Results Checking User Interface

In the body index data analysis emotion supervision interface, the basic eight emotion progress bars are implemented for presenting the emotions of the user. On the right side of the interface, the related body index data can be checked and compared with the basic healthy range.

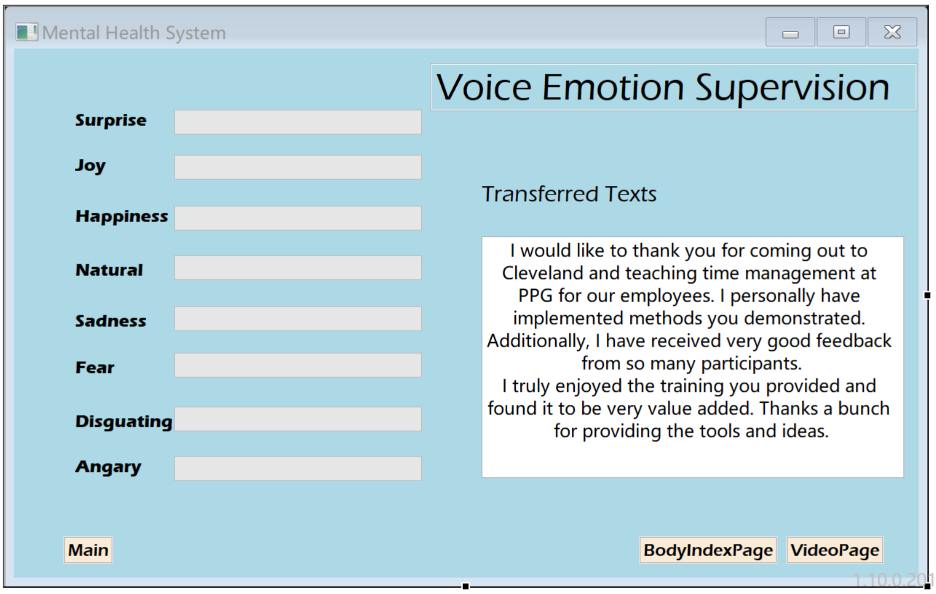

Figure 8. 4 Voice Emotion Analysis Interface

In the voice emotion analysis, the related progress bar for emotion presenting is listed on the left side of the interface. The transferred texts of the user's voice are presented on the right side of the interface, which is related to the emotion analysis in the same time interval.

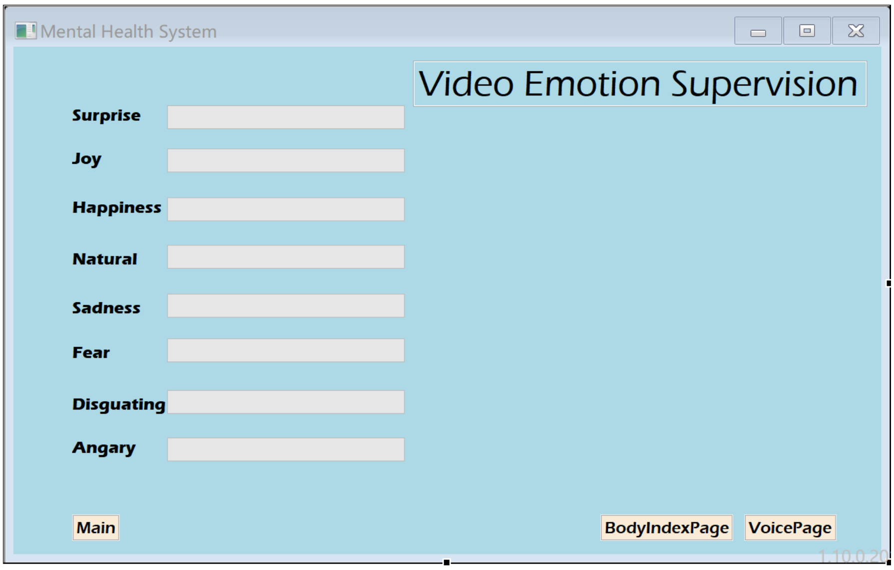

Figure 8. 5 Video Emotion Analysis Interface

Video data related to emotion analysis and supervision subsystem is used for analysing facial expressions and behaviours. Similar to the other two subsystems, emotion progress bars are used for emotion exhibition. Videos in the time interval are presented on the right side of the interface.

An advice interface can be used to present related tips for adjusting emotions. Wearable products' reactions to emotions are presented in this interface as well.

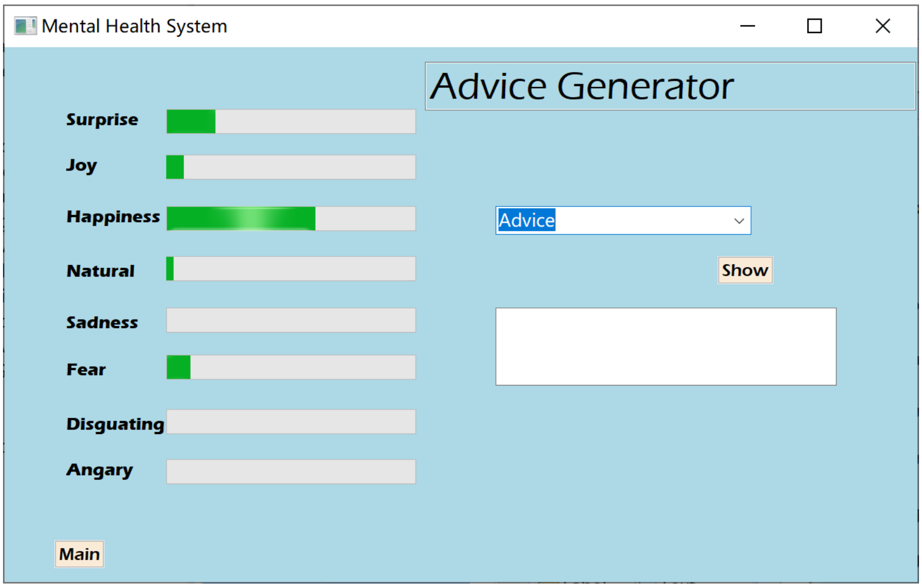

Figure 8. 6 Advice Generator Interface

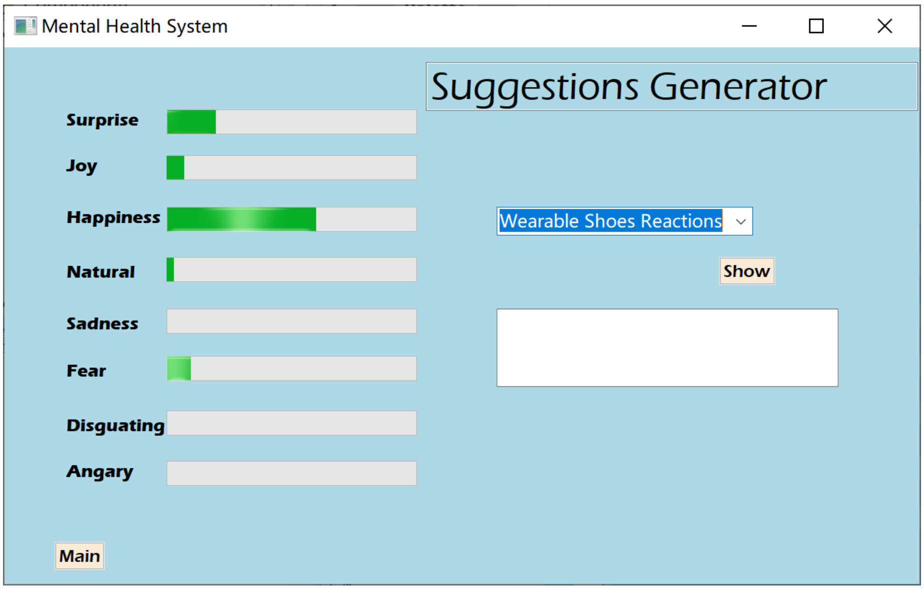

Figure 8. 7 Wearable Shoes Reaction Interface

An entire emotion analysis interface can be used for presenting data analysing results for the user. Connections mechanisms between the user and the wearable shoes will be explained in the next section. In the case study, the data is from the public internet case. The cases are about the people (Anonymous) who have or don't have mental health problems. Those data can be collected from the public internet. The system can run with those data and output results. Related experiments with individuals are not in the plan of my research. The individual experiment will cause privacy problems and leading to ethical problems.

8.2 Application in Wearable Shoes

The artificial intelligence-based mental health care system can be applied in wearable shoes. As being explained in the thesis above, sensors, chips, microphones, and cameras can be implemented in the wearable shoes for data collection. The design of intelligence shoes can be expressed in Figure 8.8.

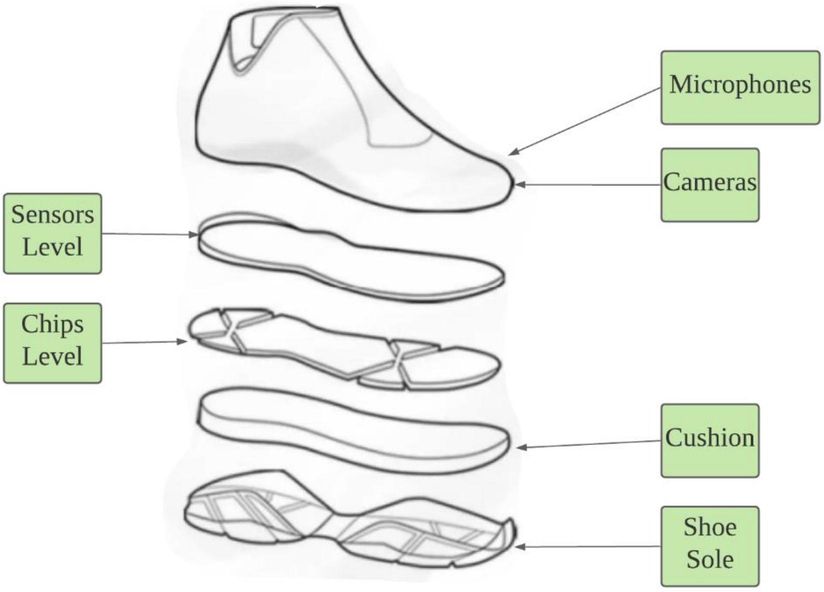

Figure 8. 8 Intelligent Shoe Structure

Body index data is collected by using sensors and chips, which are located at the bottom of the shoes. Blood pressure, body temperature, body mass index, heart rate, weight changes in a period, and blood oxygen-related data can be collected and transferred to the mental health care system by intelligent shoes.

On top of the shoes, microphones and tiny cameras are set for collecting voice data and video data. It is presented in Figure 8.8, the shoe sole level is at the bottom. The cushion is used for making a comfortable experience. Then chips level and sensors level are built above for collecting body index data. cameras and microphones are built on the top of the shoes for voice data collection and video data collection.

The mental health care system is set on the cloud to connect with intelligent shoes. In Figure 8.1, the mental health care system structure that is set on the wearable shoes is presented. the entire process is completed on the cloud. Data are collected by wearable shoes and being stored in the cloud. Three types of data are processed by the mental health system to supervise the emotions of the user and generating related advice for extreme emotions. Related experiment results can be checked in Appendix B.

8.3 Summary

This chapter stated how the proposed intelligence-based mental health care system is set in the wearable intelligence shoes.

A specific artificial intelligence-based mental health care system is established for setting on wearable intelligent shoes. The intelligence shoes are designed for building sensors, chips, microphones, and cameras for collecting data from the user. the architecture of the artificial intelligence-based mental health care system is presented in this chapter.

The mental health care system interfaces present how user could manage the intelligent equipment and the system. The system can be used for analysing different mental related data and detecting emotions in the time interval. Meanwhile, the data can be visualised by using the system.

A prototype is completed for presenting the management process of the user's mental health and related interfaces. Figures for intelligent shoe design are stated in this chapter and specific placing of the sensors, chips, microphones, and cameras are explained as well. The system processing structure in the wearable shoes is illustrated at the end of this chapter.

Chapter 9

Conclusions

Objectives

- To summarise the thesis and draw conclusions
- To answer the research questions and revisit the success criteria
- To revisit original contributions
- To explain the limitation of the work
- To propose future work

9.1 Summary of Thesis

Based on the objectives of this thesis and related research on wearable products, mental health care, machine learning, and computing-related techniques, scholars chase at improving mental health care intelligent level. Mental health care has become one of the concerns for the modern individual for high-level pressure in living life and working.

The system in this research is named artificial intelligence-based mental health care system, which includes three techniques, mental health-related data pre-processing technique, mental health analysis, and recognition technique, mental health supervision and problems suggestion generation technique. Knowledge combination theory is used for establishing a graph data structure database in the health care area.

In the data pre-processing technique, mental health-related data is collected through wearable product interactions with the user. Collected data is classified and stored into different categories for further analysis. Decision Tree Classification, which is a classification algorithm based on the decision tree, is applied for classifying health related data. Pre-processing of collected data on data corruptions, data cleaning, and transferring unstructured data to structured data are completed in this step. Further, knowledge graph and related graph database techniques are used for weighted connections establishment between different data entities and categories. The abstraction method, which is one of the essential creative computing methods is applied for completing building relationships and ‘imagining’ connections between entities. There are three types of data in the collected dataset, which are body indexes data, voice data, and video data. The dataset has been categorised into four levels to building connections between each label. Connections between different labels are established based on an essential factor, time intervals. The entire process of mental health-related data pre-processing techniques are stated in Chapter 4.

Then mental health-related data is processed by four algorithms. Body indexes data, voice data, facial expression data, and behaviour expression data are addressed by a statistical model, NLP-based emotion detecting algorithm, facial expression analysis algorithm, and behaviour expression analysis algorithm, which are explained in Chapter 5.

Mental health supervision and problems advice generation techniques work based on previous steps processing results. the possible mood has been evaluated based on emotion value. The warning is alarmed and advice is generated based on the real-time emotion of the user. The entire workflow is based on supervision mechanisms and expert system mechanisms, which have been stated in Chapter 6.

Being applied with wearable products, the real-time emotion and extreme emotions of the user are detected by the mental health care system. Application with wearable clothes and wearable shoes are stated as two experiments for this research.

Further evaluation of solutions for research questions and success criteria are listed in the following section.

9.2 Evaluation

9.2.1 Answering Research Questions

The entire thesis is used to discuss the problem of how to manage and supervise mental health in an intelligent way based on AI algorithms and wearable equipment. By using creative computing methods and artificial intelligence approaches, three data processing steps are established for generating AI-based mental health care framework and AI-based mental health supervision and management system with wearable products for the specific application. An artificial intelligence-based mental health care framework and an artificial intelligence-based mental health care system both obtain user’s data through wearable products with sensors, including chips and cameras, being stored in related graph-structured database, evaluating real-time emotions and supervising extreme emotions. Relevant advice and actions can be output for adjusting user’s emotion to be in a positive state. In the evaluation step, the accuracy of output results can be confirmed by user’s reaction. Real-time emotions and extreme emotions will be evaluated by using emotion value and user’s reaction to the results. Body indexes, voice expression, facial expression, and behaviour detecting data will be reused for re-evaluating the real-time state of the users

Regarding wearable products as carriers of the AI-based mental health care system, iteration in the system for supervising real-time emotion is useful for evaluating results and the entire workflow.

For research question No. 1, as being explained in Chapter 2 and Chapter 3, the emotions of human beings have been classified into six basic categories. Essential influential factors have been listed in Chapter 2, including language, issues, environments, and so forth. For AI-based mental health care supervision and management framework and system, four kinds of factors are imperative influential factors for emotion analysis and mental health analysis, which are body indexes data, voice data, facial expression data, and behaviour data. Based on different inputs, emotions will be detected by four algorithms. For research sub-question No. 1.1, in Chapter 2, existing research on mental health has been concluded and presented. Some factors that have been accepted by most scholars are imperative factors for this research. Mental health care influential factors can be discovered from literature reviews and experiments for emotion research. Explanations of influential factors in this research are stated in Chapter 3 and Chapter 5 respectively.

For research sub-question No.1.2, building mental health evaluation model, several aspects of the individual should be collected and considered, including basic body indexes, voice expression states, facial expression, and behaviour expression. Based on psychology theories for analysing the emotion of an individual, emotions can be expressed by using voices, gestures, facial subtle expressions, and behaviours. According to and traditional Chinese medical methods, diagnosing an illness is based on the data collected through “observing, listening, asking, and feeling”. Therefore, four aspects of factors, body indexes, voice data, facial expression data, and behaviours data, are confirmed as the most influential factors for mental health care analysis model establishment. Those statements are explained in Chapter 5.

For research sub-question No. 1.3, the models are established based on machine learning algorithms, statistical methods, and graph theory, which are illustrated in Chapter 4, and Chapter 5. Analysis of voice data and video data are completed with NLP algorithm and Artificial Neural Network algorithm with fitted characteristics and parameters for the research. Statistical methods are used for generating models for analysing body index data. Graph theory and graph databases are used for creating connections between different data types. The health care analysis model and mental health supervision and management can be more accurate.

For research question 2, the statistical model for body indexes data analysis and machine learning algorithms for voice and video data processing is illustrated in Chapter 5. Graph database and related quantitative connections are built in Chapter 4.

For research sub-question No. 2.1, body indexes data analysis, the multi-variable statistical model is established based on six basic body indexes that have relationships with emotion changes for individuals.

NLP model is established for voice data analysis. The entire model includes voice-text transferring, text cutting, emotion words accumulating, and emotion value calculating.

Artificial Neural Network for facial expression analysis is established for possible emotions that are expressed by different modules on an individual's face.

Behaviour emotion expression analysis model is connected with mental health care by analysing behaviours of the user.

For research sub-question No. 2.2, the decision tree algorithm is used as the basis for classifying collected mental health-related data in Chapter 4, data pre-processing step.

NLP algorithm is used for analysing and stating emotion values in texts for voice data emotion value calculation, which is explained in Chapter 5.

Conventional Neural Network is the basis for facial expression recognition so that module emotion analysis can be completed. This workflow is illustrated in Chapter 5.

Recurrent Neural Network is the basis for behaviour recognition to complete emotion analysis, which is illustrated in Chapter 5 as well.

For research sub-question No. 2.3, in Chapter 5, extreme emotions have related values that are calculated based on four kinds of data collected with wearable products. In the evaluation step, when the emotion value reaches the warning threshold, the emotion reaches the extreme state. the kernel step is to confirm the emotion value with established mental health care models.

For research question 3, artificial intelligence-based mental health care framework is established in Chapter 3. The specific workflow of the mental health care framework is explained in Chapter 3. The entire framework includes three steps, which are the data pre-processing step, mental health evaluation step, and the evaluation step. A specific system for mental health care is established based on this framework.

For research sub-question No. 3.1, AI-based mental health care framework includes three modules, which are the preparation module, emotion analysis module, and evaluation model. For specific systems, mental health supervision and management can be completed by using data collection and pre-processing, emotion analysis and recognition, and mental health supervision and suggestion generation. The whole contents about the framework and system workflow and specific approaches are illustrated in Chapter 3 to Chapter 6.

For research sub-question No. 3.2, to address emotion recognition and emotion supervision, general steps of the framework are imperative to be established. Further, specific models and algorithms are established in target points in the framework.

For research sub-question No. 3.3, to connect the mental health care system with wearable products, cloud resources are applied for data storage and data transferring. Relevant sensors and chips are used for disposing of the mental health care system.

For research question 4, wearable products are the carrier between the user and the mental health care system. Related data, including body indexes data, voice data, and video data, are collected by using wearable products. It means wearable products are the data source for mental health supervision. Further, real-time interactions between the user and wearable products can achieve real-time management for the user's mental health. Iteration in the system happens in the set time interval.

For research sub-question No. 4.1, connections between wearable products and the user are through sensors and chips. Body index data are collected by using sensors or chips in wearable products. Voice data is collected by microphones. Video data is collected by using cameras. Software with mental health supervision and management system is disposed of in the wearable products to achieve connections. All the demonstrations about the connections between mental health framework-based software and wearable products are in Chapter 4.

For research sub-question No. 4.2, a framework for mental health care is established based on general steps for processing data. The data flow in this research can be generally applied extensively. Further, based on medical diagnose methods, data that is collected in this research for mental health analysis and supervision includes all the kernel aspects that people express emotions normally. Sensors, chips, microphones, and mini-cameras are easy to be set in the wearable products for data collection. Specific setting mechanisms are illustrated in Chapter 2 and Chapter 4.

9.2.2 Revisiting Success Criteria

In Chapter 1, a series of success criteria are established for generating mental health care framework for supervising and managing mental health with wearable products for people in normal life. The general success criteria for this research is 'how to evaluate the framework is feasible for mental health care detecting, the eventual section of this thesis, evaluation of the output emotion and related value are completed based on the emotional funnel. The user of wearable products with mental health supervision and management system is another evaluation method to feel the accuracy of the output results.

For success criteria 'Discovering cross-domain methods for generating artificial intelligence-based mental health care management and supervision', creative computing has been applied for creating interdisciplinary implementation between artificial intelligence methods and mental health care management and supervision. Machine learning, deep learning knowledge graph techniques, and blockchain theory are combined with mental health-related theory. AI-related knowledge and mental health-related knowledge are fused to be an interdisciplinary system for solving emotion supervision and management problems.

For success criteria 'Building quantitative relationships between body health indexes and mental health states', based on body indexes medical diagnosis statistical model has been established for evaluating emotion value. It is a multi-variable formula for emotion value calculation.

For success criteria 'Generating framework of artificial intelligence-based mental health care detecting', the entire workflow of AI-based mental health care framework is explained in Chapter 3. Specific steps and techniques that are applied in the framework are depicted as well.

For success criteria 'Generating specific rules for evaluating mental health detecting outcomes', this research thesis has established an evaluation model in Chapter 6, which has been applied for extreme emotion supervision and further management and iterations in the system.

For success criteria 'Establishing mental health care systems to prove application of mental health care framework', specific applications can be presented by establishing mental health supervision and management system on wearable products. Connections between users and wearable products are completed and the framework can be proved to be applied in real-time mental health care.

For success criteria, 'Using a feasible case study to proof applying mental health care systems on wearable products', an AI-based mental health supervision and management system that is established to be an application software. Output results are validated at the end of the system. Advice on emotions is created based on collected user's data. Output results are used for warning user's abnormal emotions and ease emotions to be natural or even positive. An inference engine was developed in the experiment and was used for the advice generation of the prototype on generating creativity. The developed applications in the experiment illustrated how the mental health care system and related methods are applied in this prototype.

9.3 Revisiting Original Contributions

This thesis proposed an AI-based mental health care framework for generating specific systems to supervising and managing the mental health of the user in Chapter 3. In Chapter 4, Chapter 5, and Chapter 6, three main steps are illustrated, mental health analysis and recognition step, and advice generation step are the kernel steps of the system since real-time emotion is detected and evaluated in these steps. Collected data, includes body indexes data, voice data, video data are processed to detect emotions by using mental health analysis and recognition techniques and related approaches. There is a list of contributions of this research for achieving mental health supervision and management. The following revisits the expected original contributions in Section 1.5 and concludes the realised contributions according to this research. Specific revisiting original contributions are listed below:

C1: Mental health care framework and system are achieved by this research including mental health data preparation, mental health data analysis, and mental health report generation, which is illustrated generally in Chapter 3. Body indexes data, voice data, and video data are processed by using specific algorithms to output possible emotions of the user. The outcomes are provided for users to detect mental health. Chapter 4 to Chapter 6 are used for explaining algorithm and techniques details.

C2: Novel approaches for generating mental health by using collected mental health data based on combinations of knowledge in two subjects. Data processing techniques and algorithms are explained in Chapter 4 to Chapter 6. Collected three kinds of data are used in the statistical model, natural language processing algorithm, conventional neural network-based facial expression analysis, and recurrent neural network-based behaviour analysis.

C3: Quantitative relationships between mental health and body health indexes are established by using math models. Formulas can depict relationships between mental expressions and body indexes based on detecting people's behaviours, languages, and facial expressions. A statistical model with multi-variables is established and applied for matching body indexes changes and emotions of an individual.

C4: Novel algorithms for mental health care are created based on behaviour and facial expression analysis. Traditional algorithms for facial expression and behaviour analysis are NLP and RNN respectively. In this research, novel algorithms for facial expression analysis and behaviour analysis are created, including module dividing and consensus methods. Detailed processes of novel algorithms are explained mainly in Chapter 5 and Chapter 6.

C5: Outcomes evaluation is completed on evaluating output and mental health analysis process. The results of the entire system are the possible emotion of the user and advice for protecting the user from extreme emotions. The evaluation method for mental health analysis is completed and depicted in Chapter 6.

9.4 Overall Conclusions

This thesis has explored related approaches to supervising and managing mental health by using body index data, voice data, video data, which can be addressed to output real-time emotions of the user. The cardinal contribution of this research thesis was dedicated to generating a framework that can be applied for supervising and managing mental health with three main steps and three types of collected data. The entire system includes three steps and four kinds of algorithms. The data pre-processing step, mental health analysis and recognition step, and mental health supervision and advice generation step are three steps in the data flow. Relevant algorithms are applied for processing these four kinds of data respectively. Particularly, mental health care (supervision and management) systems are established in an applicable scene with wearable products, which are explained in the case study chapter. Further. Validation and evaluation of emotion analysis are essential. Emotion recognition should be accurate since the supervision of mental health for the user has enormous influences on the individual.

9.5 Limitations

The original contributions and success criteria have been revisited. It can be useful to evaluate limitations in this proposed research thesis.

Currently, Knowledge and related databases are required to be established manually but ideally these should be built more automatically. The relationships between data from different categories are also established manually and an automatic tool for generating relationships between different mental health related data is necessary for data processing efficiency improvement.

Behaviour expression-based mental health analysis and facial expression-based mental health analysis is required to be impacted between these two categories. The behaviour expression analysis algorithm is used for analysing the simulated skeleton of the user. Simply analysis of the skeleton and related actions can rarely be accurate about the emotion from the behaviour. More complicated and reliable algorithms are required for behaviour emotion expressions.

9.6 Future Work

Emotion-related data connections automation generator is one of the future works based on the proposed research. Even though the connections between different types of mental health data are established in Chapter 4, the relationships are completed manually. It is worth generating novel algorithms for establishing relationships between different types.

Generating novel behaviour mental health analysis algorithms is also essential for mental health care and management. Wearable shoes can be used to collect behaviour skeleton of the user for mental health analyss with higher accuracy.

References

[1] E. Alpaydin, *Introduction to Machine Learning*, MIT press, US, 2020.

[2] American Psychological Association, *The Psychological Review*, vol. 10, American Psychological Association, US, 1903.

[3] T. Aragones, "Method and System for Automated Personal Training," *U.S. Patent No. 9,283,429. 15*, US, Mar. 2016.

[4] M. Arnold, "Emotion and personality", vol. 1, *Psychological Aspects*, Columbia University Press, Washington, US, 1960.

[5] L. Barbosa and J. Feng, "Robust Sentiment Detection On Twitter From Biased and Noisy Data," *Proceedings of the 23rd International Conference on Computational Linguistics: Posters*, Association for Computational Linguistics, US, 2010.

[6] M. Baroni and L. Alessandro, "Distributional Memory: A General Framework for Corpus-Based Semantics," *Computational Linguistics,* MIT Press, Cambridge, US, vol. 36, no. 4, pp. 673-721, 2010.

[7] A. Barr, A. Edward and R. Paul, *The Handbook of Artificial Intelligence*, vol. 1, no. 2, *Reading*, MA: Addison-Wesley, Stanford, US, 1981.

[8] A. Berger, J. Vincent and A. Stephen, "A Maximum Entropy Approach to Natural Language Processing", *Computational Linguistics,* ACM Publisher, US, vol. 22, no. 1, pp. 39-71, 1996.

[9] T. Berners-Lee, "Tabulator: Exploring and Analyzing Linked Data on The Semantic Web", *Proceedings of the 3rd International Semantic Web User Interaction Workshop*, Cambridge, US, vol. 2006, p. 159, 2006.

[10] F. Bertola and P. Viviana, "Emotional Responses to Artworks in Online Collections", *6th International Workshop on Personalized Access to Cultural Heritage, PATCH 2013*, CEUR Workshop Proceedings, vol. 997, 2013.

[11] J. Cacioppo and L. Wendi, "Emotion", *Annual Review of Psychology,* American Psychological Association, US, vol. 50, no. 1, pp. 191-214, 1999.

[12] H. Che, Q. Liu, L. Zou, H. Yang, D. Zhou and F. Yu, "A Content-Based Phishing Email Detection Method", *Software Quality, Reliability and Security Companion (QRS-C)*, IEEE, UK, pp. 415-422, 2017.

[13] D. Chafale and P. Amit, "Review on Developing Corpora for Sentiment Analysis Using Plutchik'S Wheel of Emotions with Fuzzy Logic", *International Journal of Computer Sciences and Engineering (IJCSE),* vol. 2, no. 10, pp. 14-18, 2014.

[14] I. Chen, "Robustly Extracting Medical Knowledge from EHRs: A Case Study of Learning a Health Knowledge Graph", *Pac Symp Biocomput*, World Scientific Publishing Co Pte Ltd, US, 2020.
[15] M. Chen, "Multilingual Knowledge Graph Embeddings for Cross-Lingual Knowledge Alignment", *arXiv preprint arXiv:1611.03954,* Cornell University, US, 2016.
[16] M. Chertok and E. Warren, "Restart. com: Identifying, Securing and Maximizing the Liquidation Value of Cyber-Assets in Bankruptcy Proceedings", *Am. Bankr. Inst. L. Rev,* Heinonline, US, vol. 8, p. 255, 2000.
[17] G. Chowdhury, "Natural Language Processing", *Annual Review of Information Science and Technology,* Wiley Online Library, US, vol. 37, no. 1, pp. 51-89, 2003.
[18] S. Cohen and B. Tracy, "Health Psychology: Psychological Factors and Physical Disease from the Perspective of Human Psychoneuroimmunology", *Annual Review of Psychology,* American Psychology Association, US, vol. 47, no. 1 pp. 113-142, 1996.
[19] D. Colbert, *Deadly Emotions: Understand the Mind-Body-Spirit Connection That Can Heal*, Thomas Nelson Inc, 2006.
[20] R. Collobert, "Natural language Processing (Almost) from Scratch", *Journal of Machine Learning Research*, JMLR Organisation, US, pp. 2493-2537, 2011.
[21] A. Cowen and K. Dacher, "Self-report Captures 27 Distinct Categories of Emotion Bridged by Continuous Gradients", *Proceedings of the National Academy of Sciences,* New York University, US, vol. 114, no. 38, 2017.
[22] A. Cowen and K. Dacher, "What the Face Displays: Mapping 28 Emotions Conveyed by Naturalistic Expression", *American Psychologist,* New York University, US, vol. 75, no. 3, pp. 349–364, 2019.
[23] C. Darwin, *The Origin of Species*, New York: PF Collier & Son, 1909.
[24] Y. Ding and F. Arnar, "Garment Including Integrated Sensor Components and Feedback Components", *U.S. Patent Application No. 14/822,332*.
[25] M. Donaldson, "Plitchik's Wheel of Emotions–2017 Update", 2017.
[26] A. Eden, "Three Paradigms of Computer Science", *Journal of Minds and Computers Archive*, Kluwer Academic Publishers Hingham, MA, USA, vol. 17, no. 2, pp.135–167, 2007.
[27] J. Eder, "Knowledge Graph Based Search System", *U.S. Patent Application No. 13/404,109*.

[28] P. Ekman and R. Richard, *The Nature of Emotion: Fundamental Questions*, Oxford University Press, US, 1994.
[29] P. Ekman, "Facial Expression and Emotion", *American Psychologist,* American Psychological Association, US, vol. 48, no. 4, p. 384, 1993.
[30] B. Fahs, "Mapping 'Gross' Bodies: The Regulatory Politics of Disgust", *Aesthetic Labour*, Palgrave Macmillan, London, pp. 83-992017.
[31] E. Feigenbaum and J. Feldman, "Computer and Thought", Massachusetts, *MIT Press*, US, 2001.
[32] J. Feng, "Knowledge Graph Embedding by Flexible Translation", *Fifteenth International Conference on the Principles of Knowledge Representation and Reasoning*, ACM Publisher, US, pp. 557-560, 2016.
[33] N. Frijda, "The Laws of Emotion", *American Psychologist,* American Psychological Association, US, vol. 43, no. 5, p.349, 1998.
[34] S. Garcia and M. Laura, "Capturing & Measuring Emotions in UX", *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM Publisher, US, 2016.
[35] Y. Geng, "Analysis of the Development Status and Prospect of Wearable Devices", *Industrial Technology Innovation*, vol. 1, no. 2, p. 238, 2014.
[36] A. Go, R. Bhayani, and L. Huang, "Twitter Sentiment Classification Using Distant Supervision", *CS224N project report, Stanford,* vol. 1, no. 12, 2009.
[37] D. Goleman, *Emotional Intelligence,* New York, NY, England, 1995.
[38] L. Greenberg, *Emotion-Focused Therapy: Coaching Clients to Work Through Their Feelings*, American Psychological Association, US, 2015.
[39] J. Gross, "Emotion Regulation: Past, Present, Future", *Cognition and Emotion,* vol. 13, no. 5, pp. 551-573, 1999.
[40] J. Gross and F. Ricardo, "Emotion Regulation and Mental Health", *Clinical Psychology: Science and Practice,* Wiley Online Library, US, vol. 2, no. 2, pp. 151-164, 1995.
[41] A. Hugill and H. Yang, "The Creative Turn: New Challenges for Computing", International Journal of Creative Computing, Inderscience Enterprises Ltd, UK, vol. 1, no. 1, pp. 4-19, 2013.
[42] A. Hugill, "Creative Computing Processes: Musical Composition", Service Oriented System Engineering (SOSE), IEEE, Oxford, UK, 2014.

[43] B. Han, “Research on Data Privacy Protection Technology of Wearable Devices”, MS Thesis, Beijing Jiaotong University, 2018.
[44] P. Harrington, *Machine Learning in Action*, Manning Publications Co., 2012.
[45] L. Hermansson, "Entity Disambiguation in Anonymized Graphs Using Graph Kernels", *Proceedings of the 22nd ACM International Conference on Information & Knowledge Management*, 2013.
[46] U. Hess and T. Pascal, "Darwin and Emotion Expression", *American Psychologist,* vol. 64, no. 2, p. 120, 2009.
[47] J. Hoffart, "YAGO2: A Spatially and Temporally Enhanced Knowledge Base from Wikipedia", *Artificial Intelligence,* vol. 194, pp. 28-61, 2013.
[48] J. Huang and H. Zhang, "Discussion on Building Personal Ecological Information System Based on Wearable Devices", *Modern Communication: Journal of China Media University*, vol. 2, pp. 139-142, 2015.
[49] X. Huang, "Knowledge Graph Embedding Based Question Answering", *Proceedings of the Twelfth ACM International Conference on Web Search and Data Mining*, 2019.
[50] C. Izard, *Human Emotions*. Springer Science & Business Media, 2013.
[51] D. Jing, and H. Yang, "Creative Computing for Bespoke Ideation", Computer Software and Applications Conference (COMPSAC), 2015 IEEE 39th Annual, IEEE, Taiwan, China, vol. 1, 2015.
[52] Y. Jia, "Perceived User Preferences and Usability Evaluation of Mainstream Wearable Devices for Health Monitoring", *PeerJ,* vol. 6, 2018.
[53] M. Jordan and T. Mitchell, "Machine Learning: Trends, Perspectives, and Prospects", *Science,* Science Magzine, US, vol. 349, no. 6245, pp. 255-260, 2015.
[54] O. Khazan, "Mapping How Emotions Manifest in the Body", 2013.
[55] M. Klinnert, "Emotions as Behavior Regulators: Social Referencing in Infancy", *Emotions in Early Development*, Academic Press, Elsevier, US, pp. 57-86, 1983.
[56] M. Kranz, "The Mobile Fitness Coach: Towards Individualized Skill Assessment Using Personalized Mobile Devices", *Pervasive and Mobile Computing,* vol. 9, no. 2, Elsevier, US, pp. 203-215, 2013.
[57] R. Lazarus, *Stress and Emotion: A New Synthesis*, Springer Publishing Company, 2006.

[58] J. Lee, "Sustainable Wearables: Wearable Technology for Enhancing the Quality Of Human Life", *Sustainability,* vol. 8, no.5, p. 466, 2016.
[59] J. Lerner, "Emotion and Decision Making", *Annual Review of Psychology,* vol. 66, pp. 799-823, 2015.
[60] Z. Liang, "CNN-based Image Analysis for Malaria Diagnosis", *2016 IEEE International Conference on Bioinformatics and Biomedicine (BIBM)*, IEEE, US, 2016.
[61] L. Libero, E. Carl and K. Rajesh, "Attribution of Emotions to Body Postures: An Independent Component Analysis Study of Functional Connectivity in Autism", *Human Brain Mapping,* Wiley Online Library, US, vol. 35, no. 10 pp. 5204-5218, 2014.
[62] Y. Lin, "Learning Entity and Relation Embeddings for Knowledge Graph Completion", *Twenty-Ninth AAAI Conference on Artificial Intelligence*, Texas, US, 2015.
[63] K. Liu, M. Zhang, and Z. Pan, "Facial Expression Recognition with CNN Ensemble", *2016 International Conference on Cyberworlds (CW)*, IEEE, Chongqing, China, 2016.
[64] Pang, Liang, et al. "Text Matching as Image Recognition", *Thirtieth AAAI Conference on Artificial Intelligence*, Phoenix, Arizona, US, 2016.
[65] Q. Liu, H. Che, L. Zou, H. Yang, C. Zhang and L. Liu, “A Study on Creative Elements Detection in Application Domain Workflow Based on Educational Psychology Theories”, *Automation and Computing (ICAC)*, IEEE, Exeter, UK, pp. 1-6, 2017.
[66] Q. Liu, H. Zhou, H. Yang and C. Chu, “Solution Generation through Hybrid Intelligence and Creativity based on Investment Portfolio”, *International Journal of Performability Engineering*, Elsevier, London, UK, vol. 14, no. 7, pp. 1641-1650, 2018.
[67] Q. Liu, L. Zou and H. Yang, “A Creative Computing based Inspiration Assistant to Poem Generation”, *Pervasive Systems, Algorithms and Networks and 2017 11th International Conference on Frontier of Computer Science and Technology and 2017 Third International Symposium of Creative Computing (ISPAN-FCST-ISCC),* IEEE, Exeter, UK, pp. 469-476, 2017.
[68] Q. Liu, L. Zou and H. Yang, “An Approach to Proposing New Business Models based on Association Rule Learning, BP Neural Network and Creative Computing”, *42nd Annual Computer Software and Applications Conference (COMPSAC)*, IEEE, Italy, vol. 2, pp. 122-125, 2018.

[69]Q. Liu, L. Zou, S. Ma and H. Yang, “Intelligence to Artificial Creativity”, *International Conference on Creative Lifestyle Computing, international Journal of Performability Engineering,* Totem Publisher Inc., US, vol.15, no. 2, pp. 654-666, 2018.
[70]Q. Liu, Q. Duan, H. Yang and C. Chu, “A Hybrid Business Outlier Detection Algorithm Based on Creative Computing Methods”, *20th International Conference on High Performance Computing and Communications*, Exeter, UK, pp. 836-841, 2017.
[71]R. Liu and H. Yang, “Chaos and Fractal for Creative Computing”, *Service Oriented System Engineering (SOSE)*, IEEE, London, UK, pp. 470-473,2014.
[72]S. Malyshev, "Getting the Most out of Wikidata: Semantic Technology Usage in Wikipedia’s Knowledge Graph", *International Semantic Web Conference*, Springer, Cham, 2018.
[73]C. Manning, D. Christopher and H. Schütze, *Foundations of Statistical Natural Language Processing*, MIT Press, US, 1999.
[74]S. Marsland, *Machine Learning: An Algorithmic Perspective*, CRC Press, Boca Raton, Florida, US, 2015.
[75]E. Motta, *Reusable Components for Knowledge Modelling*, IOS Press, Amsterdam, Netherland, 1999.
[76]G. Marakas and J. Joyce, "Creativity Enhancement in Problem Solving: Through Software or Process?", *Management Science*, Informs Publishing Co., Catsvil, US, vol. 43, no. 8, pp. 1136-1146, 1997.
[77]G. Mora, A. Roman, R. Javier, and R. Eric, "An Optimization Algorithm Inspired by Musical Composition", *Artificial Intelligence Review,* Springer, London, UK, vol. 41, no. 3, pp.301-315, 2014.
[78]B. Min, "Distant Supervision for Relation Extraction with An Incomplete Knowledge Base", *Proceedings of the 2013 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, 2013.
[79]R. Mitchell, and T. M. Carbonell, *An Artificial Intelligence Approach*, Springer, Berlin, 2013.
[80]T. Mitchell, *Machine Learning*, 1997.
[81]M. Mohsin and A. Beltiukov, "Summarizing Emotions from Text Using Plutchik’s Wheel of Emotions", *7th Scientific Conference on Information Technologies for Intelligent Decision Making Support (ITIDS 2019)*, Atlantis Press, 2019.
[82]V. Morabito, "Big Data and Analytics", *Strategic and Organisational Impacts,* 2015.

[83] P. Mulder, "Emotion Wheel by Robert Plutchik", *ToolsHero,* 2018.
[84] P. Niedenthal, "Embodying Emotion", *Science,* vol. 316, no.5827, pp. 1002-1005, 2007.
[85] N. Nilsson and N. Nilsson, *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann, 1998.
[86] M. Nieto and P. Quevedo, "Absorptive Capacity, Technological Opportunity, Knowledge Spillovers, and Innovative Effort", *Technovation*, Elsevier, New York, US, vol. 25, pp. 1141-1157, 2005.
[87] K. Ochsner and J. Gross, "The Cognitive Control of Emotion", *Trends in Cognitive Sciences,* Elsevier, US, vol. 9, no. 5, pp. 242-249, 2005.
[88] M. Olsson and M. Martin, "Wearable Display Device", *U.S. Patent Application*, vol. 404, no. 29, p. 876.
[89] Oxford, Oxford English, *Oxford English Dictionary*, Oxford: Oxford University Press, UK, 2009.
[90] A. Pak and P. Paroubek, "Twitter as a Corpus for Sentiment Analysis and Opinion Mining", *LREc*. Vol. 10. No. 2010. 2010.
[91] J. Papez, "A Proposed Mechanism of Emotion", *Archives of Neurology & Psychiatry,* JAMA Network, US, vol. 38, no. 4, pp. 725-743, 1937.
[92] S. Patel, "A Review of Wearable Sensors and Systems with Application in Rehabilitation", *Journal of Neuroengineering and Rehabilitation,* Springer Nature, US, vol. 9, no. 1, p. 21, 2012.
[93] H. Paulheim, "Knowledge Graph Refinement: A Survey of Approaches and Evaluation Methods", *Semantic Web,* German, vol. 8, no.3, pp. 489-508, 2017.
[94] T. Pham, "Predicting Healthcare Trajectories from Medical Records: A Deep Learning Approach", *Journal of Biomedical Informatics,* Elsevier, US, vol. 69, pp. 218-229, 2017.
[95] R. Plutchik, "Emotions: A General Psychoevolutionary Theory", *Approaches to Emotion,* pp. 197-219, 1984.
[96] R. Plutchik, "The Nature of Emotions: Human Emotions Have Deep Evolutionary Roots, A Fact That May Explain Their Complexity and Provide Tools for Clinical Practice", *American Scientist,* JSTOR, US, vol. 89, no. 4, pp. 344-350, 2001.
[97] X. Pu, L. Li, H. Song, and Z. Wang, “A Self-Charging Power Unit By Integration of A Textile Triboelectric Nanogenerator and A Flexible Lithium - Ion Battery for

Wearable Electronics”, *Advanced Materials*, Wiley Online Library, US, vol. 27, no. 15, pp. 2472-2478, 2015.

[98] J. Pujara, "Knowledge Graph Identification", *International Semantic Web Conference*, Springer, Berlin, Heidelberg, 2013.

[99] J. Quinn, *Intelligent Enterprise: A Knowledge and Service Based Paradigm for Industr*, Simon and Schuster, 1992.

[100] D. Ravì, "Deep Learning for Health Informatics", *IEEE Journal of Biomedical and Health Informatics,* vol. 21, no. 1, pp. 4-21, 2016.

[101] R. Richards, "4 Darwin on Mind, Morals and Emotions", 2003.

[102] D. Rinser, D. Lange, and F. Naumann, "Cross-Lingual Entity Matching and Infobox Alignment in Wikipedia", *Information Systems,* Elsevier, US, vol. 38, no. 6, pp. 887-907, 2013.

[103] J. Sangers, "Semantic Web Service Discovery Using Natural Language Processing Techniques", *Expert Systems with Applications,* Elsevier, US, vol. 40, no. 11, pp. 4660-4671, 2013.

[104] A. Santos, "Clinical Knowledge Graph Integrates Proteomics Data into Clinical Decision-Making", *bioRxiv,* 2020.

[105] L. Sarmento, "An Approach to Web-Scale Named-Entity Disambiguation", *International Workshop on Machine Learning and Data Mining in Pattern Recognition*, Springer, Berlin, Heidelberg, 2009.

[106] J. Schmidhuber, "Deep Learning in Neural Networks: An Overview", *Neural Networks,* Elsevier, US, vol. 61, pp. 85-117, 2015.

[107] R. Schvaneveldt, T. Francis and W. Donald, "Network Structures in Proximity Data", *The Psychology of Learning and Motivation,* Elsevier, US, vol. 24, pp. 249-284, 1989.

[108] S. Seneviratne, "A Survey of Wearable Devices and Challenges", *IEEE Communications Surveys & Tutorials,* US, vol. 19, no. 4, pp. 2573-2620, 2017.

[109] B. Song, "Overview of The Current Situation and Future Development Direction of Wearable Devices", *Silicon Valley*, Springer, US, vol. 8,pp. 9-10, 2014.

[110] T. Starner, "Wearable Computing and Augmented Reality", *The Media Laboratory, Massachusetts Institute of Technology, MA, MIT Media Lab Vision and Modeling Group Technical Report,* Cambridge, US, vol. 355, 1995.

[111] T. Steiner, "Adding Realtime Coverage to The Google Knowledge Graph", *11th International Semantic Web Conference (ISWC 2012)*, Citeseer, US, 2012.

[112] X. Sun, and Z. Feng, "Research on Wearable Device Interaction Design", Decoration, vol. 2, pp. 28-3, 2013

[113] Z. Sun, "Bootstrapping Entity Alignment with Knowledge Graph Embedding", *IJCAI*, 2018.

[114] Z. Sun, W. Hu, and C. Li, "Cross-Lingual Entity Alignment Via Joint Attribute-Preserving Embedding", *International Semantic Web Conference*, Springer, Cham, 2017.

[115] X. Tian, *Research and Implementation of Key Technologies for Field Processing of Complex Data*, DIS, China University of science and technology, 2014.

[116] H. Wallbott, "Bodily Expression of Emotion", *European Journal of Social Psychology,* Wiley Online Library, US, vol. 28, no. 6, pp. 879-896, 1996.

[117] Z. Wang, "On the Application of Physics in The Development of Artificial Intelligence -- Take Wearable Watch As An Example", *Science Chinese*, p. 181, 2017.

[118] H. Wang, "Asian Transnational Corporations And Labor Rights: Vietnamese Trade Unions in Taiwan-Invested Companies", *Journal of Business Ethics,* Springer, New York, US, vol. 56, no. 1, pp. 43-53, 2005.

[119] Y. Wang and W. Fang, "Innovation and Development Strategy of China's Sports Industry under the New Economic Ecology", *2nd International Conference on Social Science, Public Health and Education (SSPHE 2018)*, Atlantis Press, 2019.

[120] T. Ward, "Cognition, Creativity, and Entrepreneurship", *Journal of Business Venturing,* Elsevier, New York, US, vol. 19, no. 2, pp. 173–188, 2004.

[121] M. Wu and C. Li, "Image Recognition Based on Deep Learning", *2015 Chinese Automation Congress (CAC)*, IEEE, UK, 2015.

[122] J. Wübbeke, "Made in China 2025", *Mercator Institute for China Studies, Papers on China,* Beijing ,China, vol. 2 pp. 6-74, 2016.

[123] I. Yamada, "Joint Learning of the Embedding of Words and Entities for Named Entity Disambiguation", *arXiv preprint arXiv:1601.01343,* 2016.

[124] L. Yan, Y. Bengio, and G. Hinton, "Deep Learning", *Nature,* vol. 521, no. 7553, pp. 436-444, 2015.

[125] L. Yao, "Incorporating Knowledge Graph Embeddings into Topic Modeling", *Thirty-First AAAI Conference on Artificial Intelligence*, Proceedings of the AAAI Conference on Artificial Intelligence, US, 2017.

[126] H. Yang and L. Zhang, "Controlling and being Creative: Software Cybernetics and Creative Computing", *Computer Software and Applications Conference Workshops (COMPSACW)*, IEEE, Vasteras, Sweden, 2014.

[127] H. Yang and L. Zhang, “Promoting Creative Computing: Origin, Scope, Research and Applications”, *Digital Communications and Networks*, IEEE, London, UK, vol. 2, no.2, pp. 84-91, 2016.

[128] H. Yang, D. Jing and L. Zhang, "Creative Computing: An Approach to Knowledge Combination for Creativity?", *Service-Oriented System Engineering (SOSE)*, IEEE, Vasteras, Sweden, 2016.

[129] Q. Zhang and H. Li, "Analysis on Methods to Applying Triz to Solve Management Innovation Problems", In *Proceedings of the 21st International Conference on Industrial Engineering and Engineering Management*, Atlantis Press, Paris, pp. 655-658, 2015.

[130] B. Zhao, "Research on Design Trend And Strategy Of Wearable Devices," *Packaging Engineering*, vol. 36, no. 2,pp. 18-20, 2015.

[131] X. Zhao, "Multi-source Knowledge Fusion: A Survey", *2019 IEEE Fourth International Conference on Data Science in Cyberspace (DSC)*, IEEE, 2019.

[132] H. Zheng, "Learning Multi-Attention Convolutional Neural Network for Fine-Grained Image Recognition", *Proceedings of The IEEE International Conference on Computer Vision*, Open Access, US, 2017.

[133] D. Zhou, "Emotion Distribution Learning from Texts", *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, Austin, Texas, US, 2016.

[134] L. Zhang and H. Yang, "Definition, Research Scope and Challenges of Creative Computing", *The 19th IEEE International Conference on Automation and Computing (ICAC)*, IEEE, London, UK, 2013.

[135] L. Zhang and H. Yang, "Knowledge Discovery in Creative Computing for Creative Tasks", *Creativity in Intelligent Technologies and Data Science: First Conference, CITandDS*, Springer, Volgograd, Russia, vol. 535, 2015.

[136] L. Zou, Q. Liu, C. Zhang, and H. Yang, “An Approach to Applying Creative Computing in Tourism by Constructing a Big Data based Knowledge System Framework”, *International Conference on Automation and Computing (ICAC)*, IEEE, Exeter, UK, pp. 244-249, 2017.

[137] N. Zvi, Y. Gross, D. Mavor, and D. Tamarkin, "Dermal Patch", *U.S. Patent 7,643,874*, Issued January 5, 2010.

Appendix 1

Selected Source Code of Intelligent Mental Health Care System

Appendix 1.1 Main User Interface Code

```
package org.eclipse.wb.swt;

import org.eclipse.swt.widgets.Display;
import org.eclipse.swt.widgets.Shell;
import swing2swt.layout.BoxLayout;
import org.eclipse.swt.widgets.Button;
import org.eclipse.swt.SWT;
import org.eclipse.swt.layout.FormLayout;
import org.eclipse.swt.layout.FormData;
import org.eclipse.swt.layout.FormAttachment;
import org.eclipse.swt.widgets.Composite;
import org.eclipse.swt.events.SelectionAdapter;
import org.eclipse.swt.events.SelectionEvent;
import org.eclipse.swt.widgets.Text;

import prototypeGUI.ACSInputGUI;

import org.eclipse.swt.widgets.ProgressBar;
import org.eclipse.swt.widgets.Label;

public class mainUI {

    protected Shell shlMentalHealthSystem;
    private Text txtInstructions;
    private Text txtMentalHealthSystem;

    /**
     * Launch the application.
     * @param args
     */
    public static void main(String[] args) {
        try {
            mainUI window = new mainUI();
```

```
            window.open();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    /**
     * Open the window.
     */
    public void open() {
        Display display = Display.getDefault();
        createContents();
        shlMentalHealthSystem.open();
        shlMentalHealthSystem.layout();
        while (!shlMentalHealthSystem.isDisposed()) {
            if (!display.readAndDispatch()) {
                display.sleep();
            }
        }
    }

    /**
     * Create contents of the window.
     */
    protected void createContents() {
        shlMentalHealthSystem = new Shell();

    shlMentalHealthSystem.setBackground(SWTResourceManager.getColor(173,
216, 230));
        shlMentalHealthSystem.setSize(634, 399);
        shlMentalHealthSystem.setText("Mental Health System");
        shlMentalHealthSystem.setLayout(new FormLayout());

        Button btnvoice = new Button(shlMentalHealthSystem, SWT.NONE);
        btnvoice.setFont(SWTResourceManager.getFont("Eras Medium ITC", 10,
SWT.NORMAL));
        btnvoice.setBackground(SWTResourceManager.getColor(240, 255, 240));
        btnvoice.addSelectionListener(new SelectionAdapter() {
            @Override
```

```
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// 隐藏窗口
                voiceSupervision voicesupervision = new voiceSupervision();
                voicesupervision.open();
            }
        });
        FormData fd_btnvoice = new FormData();
        btnvoice.setLayoutData(fd_btnvoice);
        btnvoice.setText("Voice Supervision");

        Button btnbodyIndex = new Button(shlMentalHealthSystem, SWT.NONE);
        btnbodyIndex.setFont(SWTResourceManager.getFont("Eras Medium ITC",
10, SWT.NORMAL));
        btnbodyIndex.setBackground(SWTResourceManager.getColor(240, 255,
240));
        fd_btnvoice.left = new FormAttachment(btnbodyIndex, 6);
        fd_btnvoice.top = new FormAttachment(0, 96);
        btnbodyIndex.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);
                bodyIndexSupervision bodyindexsupervision = new
bodyIndexSupervision();
                bodyindexsupervision.open();
            }
        });
        FormData fd_btnbodyIndex = new FormData();
        fd_btnbodyIndex.left = new FormAttachment(0, 81);
        fd_btnbodyIndex.right = new FormAttachment(100, -393);
        fd_btnbodyIndex.top = new FormAttachment(0, 96);
        btnbodyIndex.setLayoutData(fd_btnbodyIndex);
        btnbodyIndex.setText("Body Index Supervision");


        Button btnvideo = new Button(shlMentalHealthSystem, SWT.NONE);
        btnvideo.setFont(SWTResourceManager.getFont("Eras Medium ITC", 10,
SWT.NORMAL));
        btnvideo.setBackground(SWTResourceManager.getColor(240, 255, 240));
        fd_btnvoice.right = new FormAttachment(100, -245);
```

```
        FormData fd_btnvideo = new FormData();
        fd_btnvideo.top = new FormAttachment(btnvoice, 0, SWT.TOP);
        fd_btnvideo.left = new FormAttachment(btnvoice, 6);
        fd_btnvideo.right = new FormAttachment(100, -97);
        btnvideo.setLayoutData(fd_btnvideo);
        btnvideo.setText("Video Supervision");
        btnvideo.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);
                videoSupervision videosupervision = new videoSupervision();
                videosupervision.open();
            }
        });

        txtInstructions = new Text(shlMentalHealthSystem, SWT.BORDER |
SWT.MULTI);
        txtInstructions.setFont(SWTResourceManager.getFont("Eras Bold ITC",
9, SWT.NORMAL));
        fd_btnvideo.bottom = new FormAttachment(txtInstructions, -6);
        fd_btnvoice.bottom = new FormAttachment(txtInstructions, -6);
        fd_btnbodyIndex.bottom = new FormAttachment(txtInstructions, -6);
        txtInstructions.setBackground(SWTResourceManager.getColor(173, 216,
230));
        txtInstructions.setTouchEnabled(true);
        txtInstructions.setText("Instructions:\r\nClick the supervision
bottons above to check emotion states \r\nbased on each kind of data");
        FormData fd_txtInstructions = new FormData();
        fd_txtInstructions.bottom = new FormAttachment(100, -10);
        fd_txtInstructions.top = new FormAttachment(0, 290);
        fd_txtInstructions.left = new FormAttachment(0, 124);
        fd_txtInstructions.right = new FormAttachment(0, 497);
        txtInstructions.setLayoutData(fd_txtInstructions);

        txtMentalHealthSystem = new Text(shlMentalHealthSystem,
SWT.BORDER);
        txtMentalHealthSystem.setText("Mental Health System");
        txtMentalHealthSystem.setFont(SWTResourceManager.getFont("Eras
Medium ITC", 20, SWT.NORMAL));
```

```
    txtMentalHealthSystem.setBackground(SWTResourceManager.getColor(173,
216, 230));
        FormData fd_txtMentalHealthSystem = new FormData();
        fd_txtMentalHealthSystem.top = new FormAttachment(0, 24);
        fd_txtMentalHealthSystem.right = new FormAttachment(100, -153);
        txtMentalHealthSystem.setLayoutData(fd_txtMentalHealthSystem);

    }
}
```

Appendix 1.2 Body Index Emotion Analysis User Interface Code

```
package org.eclipse.wb.swt;

import org.eclipse.swt.widgets.Display;
import org.eclipse.swt.widgets.Shell;
import swing2swt.layout.BoxLayout;
import org.eclipse.swt.widgets.Button;
import org.eclipse.swt.SWT;
import org.eclipse.swt.layout.FormLayout;
import org.eclipse.swt.layout.FormData;
import org.eclipse.swt.layout.FormAttachment;
import org.eclipse.swt.widgets.Composite;
import org.eclipse.swt.events.SelectionAdapter;
import org.eclipse.swt.events.SelectionEvent;
import org.eclipse.swt.widgets.Text;

import com.sun.org.glassfish.gmbal.NameValue;

import javafx.scene.control.TableColumn;
import prototypeGUI.ACSGeneral;

import org.eclipse.swt.widgets.ProgressBar;
import org.eclipse.swt.widgets.Label;
import org.eclipse.swt.widgets.Table;
import org.eclipse.jface.viewers.TableViewer;
import org.eclipse.jface.layout.TableColumnLayout;
import org.eclipse.swt.widgets.Combo;

public class bodyIndexSupervision {

    protected Shell shlMentalHealthSystem;
```

```
	private Text txtPleaseSelectA;
	private Text txtBodyIndexSupervision;
	private Text text;

	/**
	 * Launch the application.
	 * @param args
	 */
	public static void main(String[] args) {
		try {
			bodyIndexSupervision window = new bodyIndexSupervision();
			window.open();
		} catch (Exception e) {
			e.printStackTrace();
		}
	}

	/**
	 * Open the window.
	 */
	public void open() {
		Display display = Display.getDefault();
		createContents();
		shlMentalHealthSystem.open();
		shlMentalHealthSystem.layout();
		while (!shlMentalHealthSystem.isDisposed()) {
			if (!display.readAndDispatch()) {
				display.sleep();
			}
		}
	}

	/**
	 * Create contents of the window.
	 */
	protected void createContents() {
		shlMentalHealthSystem = new Shell();
		shlMentalHealthSystem.setBackground(SWTResourceManager.getColor(173, 216,
230));
		shlMentalHealthSystem.setSize(634, 399);
		shlMentalHealthSystem.setText("Mental Health System");
		shlMentalHealthSystem.setLayout(new FormLayout());

		ProgressBar progressBar = new ProgressBar(shlMentalHealthSystem, SWT.NONE);
```

```java
        progressBar.setSelection(7);
        FormData fd_progressBar = new FormData();
        fd_progressBar.top = new FormAttachment(0, 73);
        fd_progressBar.left = new FormAttachment(0, 110);
        progressBar.setLayoutData(fd_progressBar);

        ProgressBar progressBar_1 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_1.setSelection(70);
        FormData fd_progressBar_1 = new FormData();
        fd_progressBar_1.top = new FormAttachment(progressBar, 18);
        fd_progressBar_1.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_1.setLayoutData(fd_progressBar_1);

        ProgressBar progressBar_2 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_2.setSelection(10);
        FormData fd_progressBar_2 = new FormData();
        fd_progressBar_2.top = new FormAttachment(progressBar_1, 17);
        fd_progressBar_2.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_2.setLayoutData(fd_progressBar_2);

        ProgressBar progressBar_3 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_3 = new FormData();
        fd_progressBar_3.top = new FormAttachment(progressBar_2, 18);
        fd_progressBar_3.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_3.setLayoutData(fd_progressBar_3);

        ProgressBar progressBar_4 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_4.setSelection(3);
        FormData fd_progressBar_4 = new FormData();
        fd_progressBar_4.top = new FormAttachment(progressBar_3, 15);
        fd_progressBar_4.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_4.setLayoutData(fd_progressBar_4);

        ProgressBar progressBar_5 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_5 = new FormData();
        fd_progressBar_5.top = new FormAttachment(progressBar_4, 20);
        fd_progressBar_5.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_5.setLayoutData(fd_progressBar_5);
```

```
        ProgressBar progressBar_6 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_6.setSelection(10);
        FormData fd_progressBar_6 = new FormData();
        fd_progressBar_6.bottom = new FormAttachment(progressBar, -14);
        fd_progressBar_6.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_6.setLayoutData(fd_progressBar_6);

        ProgressBar progressBar_7 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_7 = new FormData();
        fd_progressBar_7.top = new FormAttachment(progressBar_5, 17);
        fd_progressBar_7.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_7.setLayoutData(fd_progressBar_7);

        Label lblNewLabel = new Label(shlMentalHealthSystem, SWT.NONE);
        lblNewLabel.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblNewLabel.setBackground(SWTResourceManager.getColor(173, 216, 230));
        FormData fd_lblNewLabel = new FormData();
        fd_lblNewLabel.top = new FormAttachment(progressBar_6, 0, SWT.TOP);
        lblNewLabel.setLayoutData(fd_lblNewLabel);
        lblNewLabel.setText("Surprise");

        Label lblJoy = new Label(shlMentalHealthSystem, SWT.NONE);
        lblJoy.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9, SWT.NORMAL));
        lblJoy.setBackground(SWTResourceManager.getColor(173, 216, 230));
        fd_lblNewLabel.left = new FormAttachment(lblJoy, 0, SWT.LEFT);
        lblJoy.setText("Joy");
        FormData fd_lblJoy = new FormData();
        fd_lblJoy.top = new FormAttachment(progressBar, 0, SWT.TOP);
        lblJoy.setLayoutData(fd_lblJoy);

        Label lblHappiness = new Label(shlMentalHealthSystem, SWT.NONE);
        lblHappiness.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblHappiness.setBackground(SWTResourceManager.getColor(173, 216, 230));
        fd_lblJoy.left = new FormAttachment(lblHappiness, 0, SWT.LEFT);
        lblHappiness.setText("Happiness");
        FormData fd_lblHappiness = new FormData();
        fd_lblHappiness.top = new FormAttachment(progressBar_1, 0, SWT.TOP);
        fd_lblHappiness.right = new FormAttachment(progressBar_1, -4);
        lblHappiness.setLayoutData(fd_lblHappiness);
```

```
        Label lblNatural = new Label(shlMentalHealthSystem, SWT.NONE);
        lblNatural.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblNatural.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblNatural.setText("Natural");
        FormData fd_lblNatural = new FormData();
        fd_lblNatural.bottom = new FormAttachment(progressBar_2, 0, SWT.BOTTOM);
        fd_lblNatural.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblNatural.setLayoutData(fd_lblNatural);

        Label lblSadness = new Label(shlMentalHealthSystem, SWT.NONE);
        lblSadness.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblSadness.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblSadness.setText("Sadness");
        FormData fd_lblSadness = new FormData();
        fd_lblSadness.bottom = new FormAttachment(progressBar_3, 0, SWT.BOTTOM);
        fd_lblSadness.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblSadness.setLayoutData(fd_lblSadness);

        Label lblFear = new Label(shlMentalHealthSystem, SWT.NONE);
        lblFear.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblFear.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblFear.setText("Fear");
        FormData fd_lblFear = new FormData();
        fd_lblFear.bottom = new FormAttachment(progressBar_4, 0, SWT.BOTTOM);
        fd_lblFear.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblFear.setLayoutData(fd_lblFear);

        Label lblDisguating = new Label(shlMentalHealthSystem, SWT.NONE);
        lblDisguating.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblDisguating.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblDisguating.setText("Disguating");
        FormData fd_lblDisguating = new FormData();
        fd_lblDisguating.bottom = new FormAttachment(progressBar_5, 0, SWT.BOTTOM);
        fd_lblDisguating.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblDisguating.setLayoutData(fd_lblDisguating);

        Label lblAngary = new Label(shlMentalHealthSystem, SWT.NONE);
        lblAngary.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblAngary.setBackground(SWTResourceManager.getColor(173, 216, 230));
```

```java
		lblAngary.setText("Angary");
		FormData fd_lblAngary = new FormData();
		fd_lblAngary.top = new FormAttachment(progressBar_7, 0, SWT.TOP);
		fd_lblAngary.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
		lblAngary.setLayoutData(fd_lblAngary);


		Button btnMain = new Button(shlMentalHealthSystem, SWT.NONE);
		btnMain.setBackground(SWTResourceManager.getColor(250, 235, 215));
		btnMain.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
		FormData fd_btnMain = new FormData();
		fd_btnMain.top = new FormAttachment(lblAngary, 22);
		fd_btnMain.left = new FormAttachment(0, 10);
		btnMain.setLayoutData(fd_btnMain);
		btnMain.setText("Main");
		btnMain.addSelectionListener(new SelectionAdapter() {
			@Override
			public void widgetSelected(SelectionEvent e) {
				shlMentalHealthSystem.setVisible(false);// hiding
				mainUI mainui = new mainUI();
				mainui.open();
			}
		});

		Button btnVoicepage = new Button(shlMentalHealthSystem, SWT.NONE);
		btnVoicepage.setBackground(SWTResourceManager.getColor(250, 235, 215));
		btnVoicepage.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
		FormData fd_btnVoicepage = new FormData();
		fd_btnVoicepage.bottom = new FormAttachment(btnMain, 0, SWT.BOTTOM);
		fd_btnVoicepage.right = new FormAttachment(100, -81);
		btnVoicepage.setLayoutData(fd_btnVoicepage);
		btnVoicepage.setText("VoicePage");
		btnVoicepage.addSelectionListener(new SelectionAdapter() {
			@Override
			public void widgetSelected(SelectionEvent e) {
				shlMentalHealthSystem.setVisible(false);// hiding
				voiceSupervision voicesupervision = new voiceSupervision();
				voicesupervision.open();
			}
		});
```

```
        Combo combo = new Combo(shlMentalHealthSystem, SWT.NONE);
        combo.setBackground(SWTResourceManager.getColor(255, 255, 255));
        FormData fd_combo = new FormData();
        fd_combo.top = new FormAttachment(progressBar_2, 0, SWT.TOP);
        fd_combo.right = new FormAttachment(btnVoicepage, 15, SWT.RIGHT);
        combo.setLayoutData(fd_combo);
        combo.add("Blood Pressure");
        combo.add("Body Temperature");
        combo.add("Heart Rate");
        combo.add("Blood Oxygen");
        combo.add("Body Mass Index");
        combo.add("Weight");


        txtPleaseSelectA = new Text(shlMentalHealthSystem, SWT.BORDER);
        fd_combo.left = new FormAttachment(txtPleaseSelectA, 0, SWT.LEFT);
        txtPleaseSelectA.setFont(SWTResourceManager.getFont("Eras Medium ITC", 9,
SWT.NORMAL));
        txtPleaseSelectA.setBackground(SWTResourceManager.getColor(173, 216, 230));
        txtPleaseSelectA.setText("Please Select a kind of Body Index Data");
        FormData fd_txtPleaseSelectA = new FormData();
        fd_txtPleaseSelectA.left = new FormAttachment(progressBar_1, 49);
        fd_txtPleaseSelectA.top = new FormAttachment(progressBar_1, 0, SWT.TOP);
        txtPleaseSelectA.setLayoutData(fd_txtPleaseSelectA);

        txtBodyIndexSupervision = new Text(shlMentalHealthSystem, SWT.BORDER);
        txtBodyIndexSupervision.setText("Body Index Supervision");
        txtBodyIndexSupervision.setFont(SWTResourceManager.getFont("Eras Medium
ITC", 20, SWT.NORMAL));
        txtBodyIndexSupervision.setBackground(SWTResourceManager.getColor(173, 216,
230));
        FormData fd_txtBodyIndexSupervision = new FormData();
        fd_txtBodyIndexSupervision.top = new FormAttachment(0, 22);
        fd_txtBodyIndexSupervision.left = new FormAttachment(progressBar_6, 6);
        txtBodyIndexSupervision.setLayoutData(fd_txtBodyIndexSupervision);

        Button btnVideopage = new Button(shlMentalHealthSystem, SWT.NONE);
        btnVideopage.setBackground(SWTResourceManager.getColor(250, 235, 215));
        btnVideopage.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
        btnVideopage.setText("VideoPage");
        FormData fd_btnVideopage = new FormData();
        fd_btnVideopage.top = new FormAttachment(btnMain, 0, SWT.TOP);
        fd_btnVideopage.left = new FormAttachment(btnVoicepage, 6);
```

```
        btnVideopage.setLayoutData(fd_btnVideopage);
        btnVideopage.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                videoSupervision videosupervision = new videoSupervision();
                videosupervision.open();
            }
        });

        Button btnSubmit = new Button(shlMentalHealthSystem, SWT.NONE);
        btnSubmit.setBackground(SWTResourceManager.getColor(250, 235, 215));
        btnSubmit.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
        btnSubmit.setText("Submit");
        FormData fd_btnSubmit = new FormData();
        fd_btnSubmit.top = new FormAttachment(progressBar_3, 0, SWT.TOP);
        fd_btnSubmit.right = new FormAttachment(combo, 0, SWT.RIGHT);
        btnSubmit.setLayoutData(fd_btnSubmit);

        text = new Text(shlMentalHealthSystem, SWT.BORDER);
        FormData fd_text = new FormData();
        fd_text.bottom = new FormAttachment(btnVoicepage, -54);
        fd_text.top = new FormAttachment(progressBar_4, 0, SWT.TOP);
        fd_text.left = new FormAttachment(combo, 0, SWT.LEFT);
        fd_text.right = new FormAttachment(100, -66);
        text.setLayoutData(fd_text);
        btnVoicepage.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                videoSupervision videosupervision = new videoSupervision();
                videosupervision.open();
            }
        });

    }


}
```

Appendix 1.3 Voice Emotion Analysis User Interface Code

```
package org.eclipse.wb.swt;
```

```java
import org.eclipse.swt.widgets.Display;
import org.eclipse.swt.widgets.Shell;
import swing2swt.layout.BoxLayout;
import org.eclipse.swt.widgets.Button;
import org.eclipse.swt.SWT;
import org.eclipse.swt.layout.FormLayout;
import org.eclipse.swt.layout.FormData;
import org.eclipse.swt.layout.FormAttachment;
import org.eclipse.swt.widgets.Composite;
import org.eclipse.swt.events.SelectionAdapter;
import org.eclipse.swt.events.SelectionEvent;
import org.eclipse.swt.widgets.Text;
import org.eclipse.swt.widgets.ProgressBar;
import org.eclipse.swt.widgets.Label;
import org.eclipse.swt.widgets.Table;
import org.eclipse.jface.viewers.TableViewer;
import org.eclipse.jface.layout.TableColumnLayout;

public class voiceSupervision {

    protected Shell shlMentalHealthSystem;
    private Text txtVoiceEmotionSupervision;
    private Text txtIWouldLike;

    /**
     * Launch the application.
     * @param args
     */
    public static void main(String[] args) {
        try {
            voiceSupervision window = new voiceSupervision();
            window.open();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    /**
     * Open the window.
     */
    public void open() {
        Display display = Display.getDefault();
        createContents();
```

```
        shlMentalHealthSystem.open();
        shlMentalHealthSystem.layout();
        while (!shlMentalHealthSystem.isDisposed()) {
            if (!display.readAndDispatch()) {
                display.sleep();
            }
        }
    }

    /**
     * Create contents of the window.
     */
    protected void createContents() {
        shlMentalHealthSystem = new Shell();
        shlMentalHealthSystem.setBackground(SWTResourceManager.getColor(173, 216,
230));
        shlMentalHealthSystem.setSize(634, 399);
        shlMentalHealthSystem.setText("Mental Health System");
        shlMentalHealthSystem.setLayout(new FormLayout());

        ProgressBar progressBar = new ProgressBar(shlMentalHealthSystem, SWT.NONE);
        progressBar.setSelection(7);
        FormData fd_progressBar = new FormData();
        fd_progressBar.top = new FormAttachment(0, 73);
        fd_progressBar.left = new FormAttachment(0, 110);
        progressBar.setLayoutData(fd_progressBar);

        ProgressBar progressBar_1 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_1.setSelection(60);
        FormData fd_progressBar_1 = new FormData();
        fd_progressBar_1.top = new FormAttachment(progressBar, 18);
        fd_progressBar_1.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_1.setLayoutData(fd_progressBar_1);

        ProgressBar progressBar_2 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_2.setSelection(3);
        FormData fd_progressBar_2 = new FormData();
        fd_progressBar_2.top = new FormAttachment(progressBar_1, 17);
        fd_progressBar_2.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_2.setLayoutData(fd_progressBar_2);

        ProgressBar progressBar_3 = new ProgressBar(shlMentalHealthSystem,
```

```
SWT.NONE);
        FormData fd_progressBar_3 = new FormData();
        fd_progressBar_3.top = new FormAttachment(progressBar_2, 18);
        fd_progressBar_3.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_3.setLayoutData(fd_progressBar_3);

        ProgressBar progressBar_4 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_4.setSelection(10);
        FormData fd_progressBar_4 = new FormData();
        fd_progressBar_4.top = new FormAttachment(progressBar_3, 15);
        fd_progressBar_4.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_4.setLayoutData(fd_progressBar_4);

        ProgressBar progressBar_5 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_5 = new FormData();
        fd_progressBar_5.top = new FormAttachment(progressBar_4, 20);
        fd_progressBar_5.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_5.setLayoutData(fd_progressBar_5);

        ProgressBar progressBar_6 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_6.setSelection(20);
        FormData fd_progressBar_6 = new FormData();
        fd_progressBar_6.bottom = new FormAttachment(progressBar, -14);
        fd_progressBar_6.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_6.setLayoutData(fd_progressBar_6);

        ProgressBar progressBar_7 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_7 = new FormData();
        fd_progressBar_7.top = new FormAttachment(progressBar_5, 17);
        fd_progressBar_7.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_7.setLayoutData(fd_progressBar_7);

        Label lblNewLabel = new Label(shlMentalHealthSystem, SWT.NONE);
        lblNewLabel.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblNewLabel.setBackground(SWTResourceManager.getColor(173, 216, 230));
        FormData fd_lblNewLabel = new FormData();
        fd_lblNewLabel.top = new FormAttachment(progressBar_6, 0, SWT.TOP);
        lblNewLabel.setLayoutData(fd_lblNewLabel);
        lblNewLabel.setText("Surprise");
```

```
        Label lblJoy = new Label(shlMentalHealthSystem, SWT.NONE);
        lblJoy.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9, SWT.NORMAL));
        lblJoy.setBackground(SWTResourceManager.getColor(173, 216, 230));
        fd_lblNewLabel.left = new FormAttachment(lblJoy, 0, SWT.LEFT);
        lblJoy.setText("Joy");
        FormData fd_lblJoy = new FormData();
        fd_lblJoy.top = new FormAttachment(progressBar, 0, SWT.TOP);
        lblJoy.setLayoutData(fd_lblJoy);

        Label lblHappiness = new Label(shlMentalHealthSystem, SWT.NONE);
        lblHappiness.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblHappiness.setBackground(SWTResourceManager.getColor(173, 216, 230));
        fd_lblJoy.left = new FormAttachment(lblHappiness, 0, SWT.LEFT);
        lblHappiness.setText("Happiness");
        FormData fd_lblHappiness = new FormData();
        fd_lblHappiness.top = new FormAttachment(progressBar_1, 0, SWT.TOP);
        fd_lblHappiness.right = new FormAttachment(progressBar_1, -4);
        lblHappiness.setLayoutData(fd_lblHappiness);

        Label lblNatural = new Label(shlMentalHealthSystem, SWT.NONE);
        lblNatural.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblNatural.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblNatural.setText("Natural");
        FormData fd_lblNatural = new FormData();
        fd_lblNatural.bottom = new FormAttachment(progressBar_2, 0, SWT.BOTTOM);
        fd_lblNatural.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblNatural.setLayoutData(fd_lblNatural);

        Label lblSadness = new Label(shlMentalHealthSystem, SWT.NONE);
        lblSadness.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblSadness.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblSadness.setText("Sadness");
        FormData fd_lblSadness = new FormData();
        fd_lblSadness.bottom = new FormAttachment(progressBar_3, 0, SWT.BOTTOM);
        fd_lblSadness.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblSadness.setLayoutData(fd_lblSadness);

        Label lblFear = new Label(shlMentalHealthSystem, SWT.NONE);
        lblFear.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
```

```java
        lblFear.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblFear.setText("Fear");
        FormData fd_lblFear = new FormData();
        fd_lblFear.bottom = new FormAttachment(progressBar_4, 0, SWT.BOTTOM);
        fd_lblFear.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblFear.setLayoutData(fd_lblFear);

        Label lblDisguating = new Label(shlMentalHealthSystem, SWT.NONE);
        lblDisguating.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblDisguating.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblDisguating.setText("Disguating");
        FormData fd_lblDisguating = new FormData();
        fd_lblDisguating.bottom = new FormAttachment(progressBar_5, 0, SWT.BOTTOM);
        fd_lblDisguating.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblDisguating.setLayoutData(fd_lblDisguating);

        Label lblAngary = new Label(shlMentalHealthSystem, SWT.NONE);
        lblAngary.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblAngary.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblAngary.setText("Angary");
        FormData fd_lblAngary = new FormData();
        fd_lblAngary.top = new FormAttachment(progressBar_7, 0, SWT.TOP);
        fd_lblAngary.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblAngary.setLayoutData(fd_lblAngary);

        Button btnMain = new Button(shlMentalHealthSystem, SWT.NONE);
        btnMain.setBackground(SWTResourceManager.getColor(250, 235, 215));
        btnMain.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
        btnMain.setText("Main");
        FormData fd_btnMain = new FormData();
        fd_btnMain.bottom = new FormAttachment(100, -10);
        fd_btnMain.left = new FormAttachment(0, 34);
        btnMain.setLayoutData(fd_btnMain);
        btnMain.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                mainUI mainui = new mainUI();
                mainui.open();
            }
        });
```

```
		Button btnVideopage = new Button(shlMentalHealthSystem, SWT.NONE);
		btnVideopage.setBackground(SWTResourceManager.getColor(250, 235, 215));
		btnVideopage.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
		btnVideopage.setText("VideoPage");
		FormData fd_btnVideopage = new FormData();
		fd_btnVideopage.bottom = new FormAttachment(100, -10);
		fd_btnVideopage.left = new FormAttachment(0, 530);
		btnVideopage.setLayoutData(fd_btnVideopage);
		btnVideopage.addSelectionListener(new SelectionAdapter() {
			@Override
			public void widgetSelected(SelectionEvent e) {
				shlMentalHealthSystem.setVisible(false);// hiding
				videoSupervision videosupervision = new videoSupervision();
				videosupervision.open();
			}
		});


		txtVoiceEmotionSupervision = new Text(shlMentalHealthSystem, SWT.BORDER);
		txtVoiceEmotionSupervision.setBackground(SWTResourceManager.getColor(173,
216, 230));
		txtVoiceEmotionSupervision.setFont(SWTResourceManager.getFont("Eras Medium
ITC", 20, SWT.NORMAL));
		txtVoiceEmotionSupervision.setText("Voice Emotion Supervision");
		FormData fd_txtVoiceEmotionSupervision = new FormData();
		fd_txtVoiceEmotionSupervision.bottom = new FormAttachment(progressBar_6, -
16, SWT.BOTTOM);
		fd_txtVoiceEmotionSupervision.top = new FormAttachment(0, 10);
		fd_txtVoiceEmotionSupervision.left = new FormAttachment(progressBar_6, 6);
		fd_txtVoiceEmotionSupervision.right = new FormAttachment(100, -1);
		txtVoiceEmotionSupervision.setLayoutData(fd_txtVoiceEmotionSupervision);

		Button btnBodyindexpage = new Button(shlMentalHealthSystem, SWT.NONE);
		btnBodyindexpage.setBackground(SWTResourceManager.getColor(250, 235, 215));
		btnBodyindexpage.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
		btnBodyindexpage.setText("BodyIndexPage");
		FormData fd_btnBodyindexpage = new FormData();
		fd_btnBodyindexpage.bottom = new FormAttachment(btnMain, 0, SWT.BOTTOM);
		fd_btnBodyindexpage.right = new FormAttachment(btnVideopage, -6);
		btnBodyindexpage.setLayoutData(fd_btnBodyindexpage);
```

```
        txtIWouldLike = new Text(shlMentalHealthSystem, SWT.BORDER | SWT.CENTER |
SWT.MULTI);
        txtIWouldLike.setText("I would like to thank you for coming out to
Cleveland and teaching time management at PPG for our employees. I personally have
implemented methods you demonstrated. Additionally, I have received very good
feedback from so many participants.\r\nI truly enjoyed the training you provided
and found it to be very value added. Thanks a bunch for providing the tools and
ideas.");
        FormData fd_txtIWouldLike = new FormData();
        fd_txtIWouldLike.bottom = new FormAttachment(progressBar_7, -2,
SWT.BOTTOM);
        fd_txtIWouldLike.right = new FormAttachment(100, -10);
        txtIWouldLike.setLayoutData(fd_txtIWouldLike);

        Label lblTransferredTexts = new Label(shlMentalHealthSystem, SWT.NONE);
        fd_txtIWouldLike.top = new FormAttachment(lblTransferredTexts, 20);
        fd_txtIWouldLike.left = new FormAttachment(lblTransferredTexts, 0,
SWT.LEFT);
        lblTransferredTexts.setBackground(SWTResourceManager.getColor(173, 216,
230));
        lblTransferredTexts.setFont(SWTResourceManager.getFont("Eras Medium ITC",
12, SWT.NORMAL));
        FormData fd_lblTransferredTexts = new FormData();
        fd_lblTransferredTexts.bottom = new FormAttachment(100, -255);
        fd_lblTransferredTexts.left = new FormAttachment(progressBar_1, 41);
        lblTransferredTexts.setLayoutData(fd_lblTransferredTexts);
        lblTransferredTexts.setText("Transferred Texts");
        btnBodyindexpage.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                bodyIndexSupervision bodyindexsupervision = new
bodyIndexSupervision();
                bodyindexsupervision.open();
            }
        });

    }
}
```

Appendix 1.4 Video Emotion Analysis User Interface Code

```
package org.eclipse.wb.swt;
```

```java
import org.eclipse.swt.widgets.Display;
import org.eclipse.swt.widgets.Shell;
import swing2swt.layout.BoxLayout;
import org.eclipse.swt.widgets.Button;
import org.eclipse.swt.SWT;
import org.eclipse.swt.layout.FormLayout;
import org.eclipse.swt.layout.FormData;
import org.eclipse.swt.layout.FormAttachment;
import org.eclipse.swt.widgets.Composite;
import org.eclipse.swt.events.SelectionAdapter;
import org.eclipse.swt.events.SelectionEvent;
import org.eclipse.swt.widgets.Text;
import org.eclipse.swt.widgets.ProgressBar;
import org.eclipse.swt.widgets.Label;
import org.eclipse.swt.widgets.Table;
import org.eclipse.jface.viewers.TableViewer;
import org.eclipse.jface.layout.TableColumnLayout;

public class videoSupervision {

    protected Shell shlMentalHealthSystem;
    private Text txtVideoEmotionSupervision;

    /**
     * Launch the application.
     * @param args
     */
    public static void main(String[] args) {
        try {
            videoSupervision window = new videoSupervision();
            window.open();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    /**
     * Open the window.
     */
    public void open() {
        Display display = Display.getDefault();
        createContents();
        shlMentalHealthSystem.open();
        shlMentalHealthSystem.layout();
```

```
        while (!shlMentalHealthSystem.isDisposed()) {
            if (!display.readAndDispatch()) {
                display.sleep();
            }
        }
    }

    /**
     * Create contents of the window.
     */
    protected void createContents() {
        shlMentalHealthSystem = new Shell();
        shlMentalHealthSystem.setBackground(SWTResourceManager.getColor(173, 216,
230));
        shlMentalHealthSystem.setSize(634, 399);
        shlMentalHealthSystem.setText("Mental Health System");
        shlMentalHealthSystem.setLayout(new FormLayout());

        ProgressBar progressBar = new ProgressBar(shlMentalHealthSystem, SWT.NONE);
        progressBar.setSelection(10);
        FormData fd_progressBar = new FormData();
        fd_progressBar.top = new FormAttachment(0, 73);
        fd_progressBar.left = new FormAttachment(0, 110);
        progressBar.setLayoutData(fd_progressBar);

        ProgressBar progressBar_1 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_1.setSelection(50);
        FormData fd_progressBar_1 = new FormData();
        fd_progressBar_1.top = new FormAttachment(progressBar, 18);
        fd_progressBar_1.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_1.setLayoutData(fd_progressBar_1);

        ProgressBar progressBar_2 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_2.setSelection(5);
        FormData fd_progressBar_2 = new FormData();
        fd_progressBar_2.top = new FormAttachment(progressBar_1, 17);
        fd_progressBar_2.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_2.setLayoutData(fd_progressBar_2);

        ProgressBar progressBar_3 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_3 = new FormData();
```

```
        fd_progressBar_3.top = new FormAttachment(progressBar_2, 18);
        fd_progressBar_3.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_3.setLayoutData(fd_progressBar_3);

        ProgressBar progressBar_4 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_4.setSelection(5);
        FormData fd_progressBar_4 = new FormData();
        fd_progressBar_4.top = new FormAttachment(progressBar_3, 15);
        fd_progressBar_4.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_4.setLayoutData(fd_progressBar_4);

        ProgressBar progressBar_5 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_5 = new FormData();
        fd_progressBar_5.top = new FormAttachment(progressBar_4, 20);
        fd_progressBar_5.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_5.setLayoutData(fd_progressBar_5);

        ProgressBar progressBar_6 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        progressBar_6.setSelection(30);
        FormData fd_progressBar_6 = new FormData();
        fd_progressBar_6.bottom = new FormAttachment(progressBar, -14);
        fd_progressBar_6.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_6.setLayoutData(fd_progressBar_6);

        ProgressBar progressBar_7 = new ProgressBar(shlMentalHealthSystem,
SWT.NONE);
        FormData fd_progressBar_7 = new FormData();
        fd_progressBar_7.top = new FormAttachment(progressBar_5, 17);
        fd_progressBar_7.left = new FormAttachment(progressBar, 0, SWT.LEFT);
        progressBar_7.setLayoutData(fd_progressBar_7);

        Label lblNewLabel = new Label(shlMentalHealthSystem, SWT.NONE);
        lblNewLabel.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblNewLabel.setBackground(SWTResourceManager.getColor(173, 216, 230));
        FormData fd_lblNewLabel = new FormData();
        fd_lblNewLabel.top = new FormAttachment(progressBar_6, 0, SWT.TOP);
        lblNewLabel.setLayoutData(fd_lblNewLabel);
        lblNewLabel.setText("Surprise");

        Label lblJoy = new Label(shlMentalHealthSystem, SWT.NONE);
```

```
        lblJoy.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9, SWT.NORMAL));
        lblJoy.setBackground(SWTResourceManager.getColor(173, 216, 230));
        fd_lblNewLabel.left = new FormAttachment(lblJoy, 0, SWT.LEFT);
        lblJoy.setText("Joy");
        FormData fd_lblJoy = new FormData();
        fd_lblJoy.top = new FormAttachment(progressBar, 0, SWT.TOP);
        lblJoy.setLayoutData(fd_lblJoy);

        Label lblHappiness = new Label(shlMentalHealthSystem, SWT.NONE);
        lblHappiness.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblHappiness.setBackground(SWTResourceManager.getColor(173, 216, 230));
        fd_lblJoy.left = new FormAttachment(lblHappiness, 0, SWT.LEFT);
        lblHappiness.setText("Happiness");
        FormData fd_lblHappiness = new FormData();
        fd_lblHappiness.top = new FormAttachment(progressBar_1, 0, SWT.TOP);
        fd_lblHappiness.right = new FormAttachment(progressBar_1, -4);
        lblHappiness.setLayoutData(fd_lblHappiness);

        Label lblNatural = new Label(shlMentalHealthSystem, SWT.NONE);
        lblNatural.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblNatural.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblNatural.setText("Natural");
        FormData fd_lblNatural = new FormData();
        fd_lblNatural.bottom = new FormAttachment(progressBar_2, 0, SWT.BOTTOM);
        fd_lblNatural.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblNatural.setLayoutData(fd_lblNatural);

        Label lblSadness = new Label(shlMentalHealthSystem, SWT.NONE);
        lblSadness.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblSadness.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblSadness.setText("Sadness");
        FormData fd_lblSadness = new FormData();
        fd_lblSadness.bottom = new FormAttachment(progressBar_3, 0, SWT.BOTTOM);
        fd_lblSadness.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblSadness.setLayoutData(fd_lblSadness);

        Label lblFear = new Label(shlMentalHealthSystem, SWT.NONE);
        lblFear.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblFear.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblFear.setText("Fear");
```

```
        FormData fd_lblFear = new FormData();
        fd_lblFear.bottom = new FormAttachment(progressBar_4, 0, SWT.BOTTOM);
        fd_lblFear.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblFear.setLayoutData(fd_lblFear);

        Label lblDisguating = new Label(shlMentalHealthSystem, SWT.NONE);
        lblDisguating.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblDisguating.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblDisguating.setText("Disguating");
        FormData fd_lblDisguating = new FormData();
        fd_lblDisguating.bottom = new FormAttachment(progressBar_5, 0, SWT.BOTTOM);
        fd_lblDisguating.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblDisguating.setLayoutData(fd_lblDisguating);

        Label lblAngary = new Label(shlMentalHealthSystem, SWT.NONE);
        lblAngary.setFont(SWTResourceManager.getFont("Eras Bold ITC", 9,
SWT.NORMAL));
        lblAngary.setBackground(SWTResourceManager.getColor(173, 216, 230));
        lblAngary.setText("Angary");
        FormData fd_lblAngary = new FormData();
        fd_lblAngary.top = new FormAttachment(progressBar_7, 0, SWT.TOP);
        fd_lblAngary.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        lblAngary.setLayoutData(fd_lblAngary);

        Button btnMain = new Button(shlMentalHealthSystem, SWT.NONE);
        btnMain.setBackground(SWTResourceManager.getColor(250, 235, 215));
        btnMain.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
        btnMain.setText("Main");
        FormData fd_btnMain = new FormData();
        fd_btnMain.bottom = new FormAttachment(100, -10);
        fd_btnMain.left = new FormAttachment(lblNewLabel, 0, SWT.LEFT);
        btnMain.setLayoutData(fd_btnMain);
        btnMain.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                mainUI mainui = new mainUI();
                mainui.open();
            }
        });

        txtVideoEmotionSupervision = new Text(shlMentalHealthSystem, SWT.BORDER);
```

```
        txtVideoEmotionSupervision.setText("Video Emotion Supervision");
        txtVideoEmotionSupervision.setFont(SWTResourceManager.getFont("Eras Medium
ITC", 20, SWT.NORMAL));
        txtVideoEmotionSupervision.setBackground(SWTResourceManager.getColor(173,
216, 230));
        FormData fd_txtVideoEmotionSupervision = new FormData();
        fd_txtVideoEmotionSupervision.top = new FormAttachment(0, 10);
        fd_txtVideoEmotionSupervision.left = new FormAttachment(progressBar_6, 6);
        txtVideoEmotionSupervision.setLayoutData(fd_txtVideoEmotionSupervision);

        Button btnVoicepage = new Button(shlMentalHealthSystem, SWT.NONE);
        btnVoicepage.setBackground(SWTResourceManager.getColor(250, 235, 215));
        btnVoicepage.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
        btnVoicepage.setText("VoicePage");
        FormData fd_btnVoicepage = new FormData();
        fd_btnVoicepage.bottom = new FormAttachment(btnMain, 0, SWT.BOTTOM);
        fd_btnVoicepage.right = new FormAttachment(100, -32);
        btnVoicepage.setLayoutData(fd_btnVoicepage);
        btnVoicepage.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                voiceSupervision voicesupervision = new voiceSupervision();
                voicesupervision.open();
            }
        });

        Button btnBodyindexpage = new Button(shlMentalHealthSystem, SWT.NONE);
        btnBodyindexpage.setBackground(SWTResourceManager.getColor(250, 235, 215));
        btnBodyindexpage.setFont(SWTResourceManager.getFont("Eras Demi ITC", 9,
SWT.NORMAL));
        btnBodyindexpage.setText("BodyIndexPage");
        FormData fd_btnBodyindexpage = new FormData();
        fd_btnBodyindexpage.bottom = new FormAttachment(btnMain, 0, SWT.BOTTOM);
        fd_btnBodyindexpage.right = new FormAttachment(100, -106);
        btnBodyindexpage.setLayoutData(fd_btnBodyindexpage);
        btnBodyindexpage.addSelectionListener(new SelectionAdapter() {
            @Override
            public void widgetSelected(SelectionEvent e) {
                shlMentalHealthSystem.setVisible(false);// hiding
                bodyIndexSupervision bodyindexsupervision = new
bodyIndexSupervision();
                bodyindexsupervision.open();
```

```
            }
        });

    }
}
```

Appendix 2

Selected Experiments Results

<table>
<tr><td colspan="2">Emotion Percentage</td><td colspan="2">Body Index Data</td></tr>
<tr><td>Surprise</td><td>10</td><td>Body Index</td><td>Normal Data</td></tr>
<tr><td>Joy</td><td>7</td><td>Blood Pressure</td><td>90-130mmHg</td></tr>
<tr><td>Happiness</td><td>70</td><td>Body Temperature</td><td>36.8℃</td></tr>
<tr><td>Natural</td><td>10</td><td>Heart Rate</td><td>98 Times per Minute</td></tr>
<tr><td>Sadness</td><td>0</td><td>Blood Oxygen</td><td>>=95%</td></tr>
<tr><td>Fear</td><td>3</td><td>Body Mass Index</td><td>22.9</td></tr>
<tr><td>Disgusting</td><td>0</td><td>Weight</td><td></td></tr>
<tr><td>Angry</td><td>0</td><td></td><td></td></tr>
<tr><td colspan="2">Emotion Percentage</td><td colspan="2">Voice Data</td></tr>
<tr><td>Surprise</td><td>20</td><td colspan="2" rowspan="8">I would like to thank you for coming out to Cleveland and teaching time management at PPG for our employees. I personally have implemented methods you demonstrated. Additionally, I have received very good feedback from so many participants.
I truly enjoyed the training you provided and found it to be very value-added. Thanks a bunch for providing the tools and ideas.</td></tr>
<tr><td>Joy</td><td>7</td></tr>
<tr><td>Happiness</td><td>60</td></tr>
<tr><td>Natural</td><td>3</td></tr>
<tr><td>Sadness</td><td>0</td></tr>
<tr><td>Fear</td><td>10</td></tr>
<tr><td>Disgusting</td><td>0</td></tr>
<tr><td>Angry</td><td>0</td></tr>
<tr><td colspan="2">Emotion Percentage</td><td colspan="2">Video Data</td></tr>
<tr><td>Surprise</td><td>30</td><td colspan="2" rowspan="3">Video Data includes facial image and behaviour actions in the time interval, which can be</td></tr>
<tr><td>Joy</td><td>10</td></tr>
<tr><td>Happiness</td><td>50</td></tr>
</table>

Natural	5	represented in the system.
Sadness	0	
Fear	5	
Disgusting	0	
Angry	0	