A Pattern Recognition System for the Automation of Learning Organisation – Learning Organisation Information System (LOIS)

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ABSTRACT

This thesis is about finding a solution to achieve the automation of the Learning Organisation Information System code, named LOIS, where large companies will be able to instigate a culture of team learning based on the analysis of the events that occur in their respective businesses. They will be able to categorise data and formulate measures that can be implemented to reinforce and adapt their business models to accommodate changes. Nevertheless, this can only work if the automation offers non-intrusiveness, ease of use and adaptability for the big companies. The main idea behind implementing LOIS is to provide a platform for employees to express their concerns and predict the number of leavers whereby Organization Management can formulate measures to retain those employees. The solution involves two algorithms; firstly K-means algorithm that is used to cluster data and secondly Time Series Prediction that is used in conjunction to make prediction on those clustered data. It explains how K-means algorithm runs through all the data until a 'no points change' cluster membership is reached and how Time Series Prediction is used to clustered data to predict by initially normalizing the set of data and then by fluctuating the number nodes (layers). The main idea of implementing Time Series Prediction into the system is to predict the number of employees that will potentially leave the organization over a certain period. An architectural framework has been incorporated within this thesis that has then been built based on a Case study that has been designed specifically to implement the framework whereby results are generated to be analysed, reviewed and formulate measures. The thesis explains in detail all the different components of the framework, the Process Flow, the Deployment Architecture while concluding with an Organisational Framework Process Flow. Furthermore, it explains and shows the different graphical user interface that the system has to offer to employees in order to help their day to day life within a company. The thesis concludes by comparing a huge amount of historical and actual data into the system to know if there are any improvement in the processes.

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Chapter 1: Introduction

1.1 Overview

Almost all leaders think that to be able to stay sophisticated, innovative and competitive; companies and businesses must learn and improve on their processes [1]. To bring out the best among employees, leaders are aware that they need to give them more room to grow. However, senior leadership and executives are still facing difficulty to resolve discrepancies between employee empowerment and operational practices [2]. Harvard Business Review stated that companies should become learning organization due to technological advances and shifting customer preferences which are becoming more and more crucial than ever with tougher competition [3]. Over the years, the terms organization learning and learning organization have been used in the same way which created a confusion of those two terms in people's mind. Learning organisation is viewed more as a form of organization whereas organizational learning is a process or set of activities [3]. However, reviews of the literatures reveal a lack of clarity regarding the learning organistion concept [3], [5], [8], [9]. The philosophy of learning has been achieved by only few companies as managers don't have the proper techniques, tools and skills to identify whether their teams are able to learn, and how that learning can help the organization to move and grow towards a comprehensive learning organization [3][4]. Another key challenge that organisations are facing to implement these techniques is the effort and time required, and the traditional organisation structural constraints that make it a tedious and intrusive set of activities to implement. This is because the most successful learning is built upon the individual visions of the employees at all levels of the organization, thus the creation of a shared vision can be hindered by traditional structures where the company vision is imposed from above. Therefore, learning organizations tend to have flat, decentralized organizational structures [5]. There had been several attempts by organizations to apply quick and easy fixes that were often driven by technology but most of them were in vain. Without understanding what really drives it, organization learning is neither possible nor sustainable [6].

The evolution of learning organisation from the era of Peter Senge's [8], [9] model where he structured the learning organisation into five core disciplines: 1. Systems Thinking 2. Personal Mastery, 3. Mental Models, 4. Shared Vision and 5. Team Learning, which rely only on a group of people working collectively to enhance their capabilities to create results that has value [8] [9] to this new continuously evolving era where finding a balance between agile processes and long-term learning in software organizations has become very important over time. In order to grow as a learning organization, companies need to put more emphasis on all of the different aspects of the organisation; including technical, organization and social solutions to the problems of learning from past experiences and categorising those results so they can be used in software development efforts.

"Balancing Agile Processes and Long-Term Learning in Software Organizations" has been one of the topics of the 4th International Workshop on Learning Software Organizations [7]. The workshop has also been implying that an organization learning requires more than just repositories, search engines and proper training. Its foundation must be based on crafting new ways of working that value the current practices while trying to look for enhancements that can be used in any software development efforts [7]. So far, many attempts of applying the disciplines of the learning organisation have failed due mainly to the commonly adopted rigid and centralised structure approach [17] [18] [19].

With the increase of information technology into firm's processes and structures and from research being conducted based on artificial intelligence and machine learning it has been proven that organization can learn [10]. Organizations are moving from a traditional approach based on artefacts inspection to a more fully computational architecture of artificial intelligence and machine learning [11]. The conventional approaches repeatedly suffer from several restrictions as they require a lot of manual evaluation, which is very time-consuming, authority constraints as not all data and information is accessible to everyone and lastly subjective evaluation where they suffer from biased evaluation results due to different ranks of human judgements in the evaluation process [12]. If data can be arranged and organised in a new way to adjust to a system so that it can handle input of unknown form, the value of the software as an information processing tool will improve significantly. With this same idea in mind, recognition and learning by a system or a computer can be looked at as the ability to process large amount of data and looking for patterns in those data. In this modern society machine learning technology and deep learning has been empowering many aspects: from web searches to smart phones.

1.2 Background and Challenges

Over the years, the demand for Cloud Computing and Service Oriented Architecture (SOA) have been increased massively whereby being adopted by both businesses and companies as they support the growth and diversity of their users' requirements [13] [14]. Recently, among a variety of proposed and available methodologies, agile methods have become very popular as they focus on the organisation and client needs [15]. There is a need for large organisations to become as agile as smaller companies due to the change in the nature and characteristics of the new digital marketplace. Given that the traditional organisational structure and processes are rigid and robust; it is very hard to be able to embrace business agility to compete with the new digital native companies. Being engrossed into their day to day activities, employees can find it tedious and intrusive to record events occurring daily throughout their working hours. Moreover, the time and effort required to formulate the patterns out of the recorded events can be too time consuming.

However, through the automation of learning organization concepts, large companies will be able to instigate a culture of team learning based on the analysis of the events that occur in their businesses. They can construct patterns to categorise these events and formulate measures that can be implemented to reinforce and adapt their business models to accommodate changes. But this can only work if the automation offers, non-intrusiveness, ease of use and ease of adoption for the large companies. In this work, a Pattern Recognition System for the automation of Learning Organisation in an agile environment, code named LOIS is proposed. LOIS is a pattern-based learning framework which will make use of machine learning to store, interpret, analyse events and where people in the organisation can formulate measures to address those events that occur in an organisation. This will allow the organisation to learn from the events and adapt to changes using machine learning to strengthen their business operations.

The proposed system will be evaluated using a case study aiming to help companies to retain employees while enhancing employee's satisfaction in a company. Employee turnover has been identified as an imminent threat as of its negative impact on work productivity, culture and long-term growth strategies. Cluster and predictive analysis in this research are to separate big data of multidimensional vectors (Patterns) that employees/HR/users are going to log into the system in terms of events. These events are going to be saved in our database and then be categorised into clusters in such a way that patterns within a cluster are more alike to each other than patterns belonging to different clusters [16]. Basically, we are going to find patterns in those events and then categorised them into clusters. Then predictive measures to address the clusters will be formulated by the HR (Human Resource) users through analysing the patterns produced by the pattern recognition algorithm. This algorithm will be the core aspect of the solution and will be vital to eliminate the need for the manual effort to analyse the events and create patterns, thus making the solution for the learning organisation less intrusive. In other terms, the application will be able to formulate graphs on how many people are leaving per month and how many people are predicted to leave over time while taking measures to retain the leavers and enhancing work satisfaction for the current employees in the organization. The environment that is being proposed has not been created nor applied before and will be designed solely and accordingly to be able to predict employees' attention and retention rate within a workplace.

1.3 Aims and Objectives

The aim of this thesis is to present a generic and comprehensive framework inclusive of solutions to automate and digitalize many parts of the learning method and produce a software with tools that will aid the employees within an organization. This will require the creation of an Information System with machine learning algorithms to store, interpret, analyze data and propose measures to both predict and address any events that may occur in an organization. This will allow the organization to learn from the system itself and improve on processes to adapt to changes by using a reinforcement model to strengthen their business operations. LOIS will be comprised of sequences of phases for the system to be designed, built, implemented and evaluated. The objectives of this research are as follows:

1. Acquire and Develop knowledge of Learning Organization and the link between the Individual and the Organization.
2. Illustrate the different models of Learning Organization.
3. Investigate how data can be stored and what tools to be used.
4. Gain knowledge on various types of Machine Learning algorithms and decide on the most appropriate strategy for illustration and use.
5. Investigate cloud computing and service-oriented architecture (SOA) concepts and main characteristics.
6. Investigate various approaches toward modern paradigms and the applicability of these approaches.
7. Design and propose a detailed Learning Organisation Information System framework.
8. Implement the framework while taking into consideration various scenarios or case studies.
9. Evaluate the proposed framework.
10. Analyse the results and discuss all the critical aspects

1.4 Structure of Thesis

The thesis follows the structure depicted in the following Figure 1

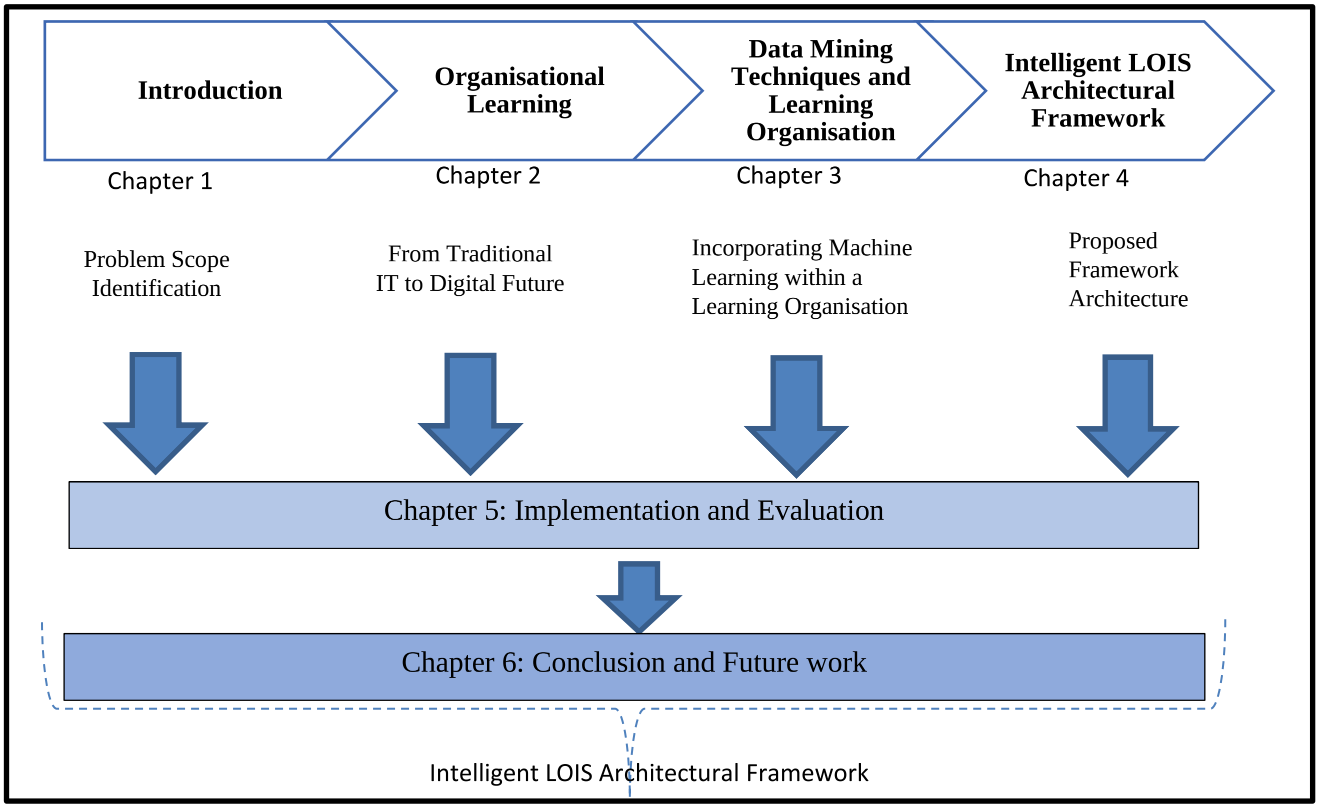


Figure 1.1: Abstract View of Key Aim and Approach of each chapter in the thesis

Chapter One: Introduction

The first chapter of this study provides a brief overview and background of learning organisation focusing on the need and benefits of learning organisation systems and the problems and challenges. This is followed by an explanation of the key aims and objectives of this research to develop a robust solution for organisational learning.

Chapter Two: Organisational Learning

This chapter addresses the topic of Organisational Learning as a need for transformation of traditional IT to digital future including the internal and external factors that drive system modernisation. It depicts how smart IT can be architected using newer capabilities including the SMAC stack 1). Social 2). Mobility 3). Analytics and 4). Cloud and how LOIS can be used to automate and digitalise various disciplines of the Learning Organisation. It will also highlight the different aspects of the Learning Organisation while considering the 6 factors of the Invest Model that was built on the 5 key aspects of Peter Senge's model and the link between an individual and the organisation devised by Daniel H. Kim in 1993 that included the 7 models of learning.

Chapter Three: Data Mining Techniques and Learning Organisation

This chapter demonstrates how data gathering underwent a drastic change since the 1950s until the mid-2000s when 'Big Data' was introduced while highlighting how data can be stored using different processing frameworks. This chapter focuses on three types of Machine learning algorithms; 1). K-means, 2). Hierarchical and 3). Time Series Prediction and the different types of Machine Learning including Supervised, Unsupervised and Reinforcement. Hence, the best approach will be chosen i.e the most appropriate algorithm and the best learning method to build the LOIS framework. Moreover, it explains how machine learning can be used to build a system and how it can be included within an Organisation whereby the Organisation can learn from the system itself and use it to improve on their processes. Once an understanding of how things work within an organisation is gained, re-engineering of various key processes can happen to enable companies to adapt to changes more easily and dynamically. Furthermore, the chapter will state some data mining applications, the major issues and the reason behind data mining.

Chapter Four: Intelligent LOIS Architectural Framework

This chapter introduces the LOIS framework and provides a comprehensive description of key components detailing key stages, phases, tasks and subtasks that cover every stage of the process and define the role of each stage. Chapter 4 focusses more on the structure of different components of the framework and how each component is inter-related. It starts by giving an overview of the framework, followed by a brief explanation of the process flow of the architectural pattern in relation to MVC, and how the organisation will use LOIS to automate the learning organisation. To sum up, the benefits of using the LOIS framework will be stated.

Chapter Five: Implementation and Evaluation: Results Analysis and Discussion

Chapter Five presents the implementation of the proposed framework while using a real-life case study as evaluation. The case study commences with an examination of the applicability of the framework followed by a description of the web-based application utilised. Moreover, LOIS will be explained in more details in relation to MVC while highlighting all the key features of application and stating its purpose and contribution to improve the organisation's processes. It demonstrates how a user can interact with the system and analyse information to formulate specific measures. Furthermore, the Analysis and Discussion section will discuss about the implementation of the framework that was built using different sets of data and how machine learning algorithms (explained above in Chapter 3: Data Mining Techniques and Learning Organisation) can be used to predict the number of employees that can leave the organisation over a period of time. Graphs, numbers and other useful information will be presented so that measures can be formulated to retain those employees.

Chapter Six: Conclusion and Future Work

The final chapter concludes this thesis and summarises the study and research outcome of the framework. The methodology and key research findings are presented in line with the research goal. The key contributions of this research are stated outlining the theoretical and managerial contribution into existing approaches. The chapter concludes with suggestions for future work that will provide opportunities for enhancing the framework and advancing knowledge in this field.

Chapter 2: Organisational Learning

2.1 Introduction

In recent years, the term digital future has been coined and predominantly, it means that traditional IT is no longer an enabler of automation of business processes anymore. It is not even a driver of new products anymore but IT has become Digital, which implies that the entire customer experience can be architected using smart IT and newer capabilities. These capabilities are 1) Social – exploiting the social networking channel to collaborate, 2) Mobility - the deployment of software applications on mobile platforms, 3) Analytics - the use of analytics to interpret Big Data and 4) Cloud - the deployment of their IT infrastructure on the Cloud. As these capabilities, often referred as the SMAC stack, become key business drivers and the fact that they can be adopted by anyone, large enterprises are being threatened by small, nimbler and agile companies.

With the rise of the digital wave, many industries are re-evaluating the definition of IT and software engineering. In other words, they are asking the vital question: “what does IT mean to their businesses and their marketplace”. Many believe that digitisation offers broader opportunities and challenges for defining a new value creation for their customers [20]. In the Banking and Financial Services [21], big banks are being outbid by smaller companies called Fintech [22], or Financial technology firms taking a share in products ranging from mortgages to payments and from deposits to small business loans. Fintechs are digital native and the fact that they do not have large legacy IT systems to maintain, they can provide financial services in a more agile and cost-effective manner.

Consequently, the large organisations have to adapt to changes of the digital wave. They need to become more agile, faster and cheaper in order to compete with the smaller companies. And to do so they need to foster the entrepreneurial spirit [22], which encompasses the people and culture, the business and operational model, and the technology that underpins the business and operations.

There are several studies that are being carried out to nurture agility within the complex constraints or rigidity of large organisation. There is the Three Horizons Framework [23], which discusses the different futures of an organisation. There is also the method of “Designed to Grow” [24] where the core concept is to teach managers how to become explorers. They absorbed the principle of collaboration and develop minimalist product prototypes quickly and cheaply to test their assumptions. Another method adopted by General Electrics called FastWorks [25] where the use of data and customer feedback drives strategic decisions. There is also a powerful method that, when implemented, enables large organizations to adapt to change and reinforce their strategy and it is called the Learning Organisation [26] devised by Peter Senge [8] and this method is the primary focus of this work. The Invest Model devised by Pearn, Roderick and Mulrooney [22] who was built on Senge’s theorising around learning organisations not only enables large organizations to adapt to changes, but also support the organisational learning.

This chapter starts with reviewing the Senge Model for learning organization. This is followed by a discussion of the Invest Model. The chapter also highlights the different aspects of the Learning Organisation while considering the 6 factors of the Invest Model that was built on the 5 key aspects of Peter Senge’s model and the link between an individual and the organisation. The chapter concludes with a summary.

2.2 Learning Organisation with Senge’s Model

As mentioned earlier the aim of this work is to build Learning Organisation Information System (LOIS) that will automate and digitalised the disciplines of the learning organisation. There are four key factors that underpin the disciplines of the learning organisation which are 1) Events, 2) Patterns, 3) Measures and 4) Repeat. In addition, there are several definitions of a learning organisation but Peter Senge stated that a learning organisation is a group of people working collectively to enhance their capabilities to create results that has value [7]. In his work, he structured the learning organisation into 5 core disciplines which are: 1) systems thinking 2) personal mastery, 3) mental models, 4) shared vision and 5) team learning.

System thinking enables people to study an organisation as objects with key properties and behaviour and to look at the objects in a systemic in its entirety rather than in an analytical way. The learning organisation method uses system thinking to assess the business and operational dynamics and to have an information system that records the performance or more precisely to record events that occurred in any given organisation. Personal mastery enables people to process learning, and the guidelines of the lessons learned are derived from evaluating and assessing the events recorded.

Mental models are models build out of the assumptions made by people when assessing the events of the organisation to create patterns. A pattern is a group of interrelated events together using some rules and expectations. The expectations should be challenged with an open culture to inspire inquiry and trust.

Shared vision enables people to collectively observe and analyse the characteristics of the patterns to formulate measures or solutions to improve a set of patterns. The impact of implementing the proposed measures is the vision that should be shared amongst the people. The analysis of the patterns and the implementation of the measures become the sources of learning and employing a shared vision creates a common identity amongst the employees to focus and get energised for learning.

Team learning is the accumulation of learning as prescribed above and repeating the whole process continuously for the team to grow in knowledge which consequently empower the organisation is adapt to the market by addressing the events and reinforcing its own structure based on the lesson learned.

This model will help employees of large organisation to work collectively to adopt the disciplines without adding overhead. This will also enable and encourage employees to create and log events and allowing the Information System to propose measures to address the many events that occurs in an organisation. This will allow the organisation to learn from the events and adapt to changes to strengthen their business operations.

2.3 The Invest Model

Figure 2.1 illustrates the Invest model which was devised by Pearn, Roderick and Mulrooney, [28], and built on Peter Senge's theory. The invest model is an evolution of the Senge's model which describes six factors that support the organisational learning: 1) Inspired Learners, 2) Nurturing Culture, 3) Vision for the Future, 4) Encouragement of Learning, 5) Supportive Management, and 6) Transforming Structures. Their theory emphasized on the need to analyse learning activities of all kinds, creating different enabling structures, and have a culture of ongoing personal development [27], [28].

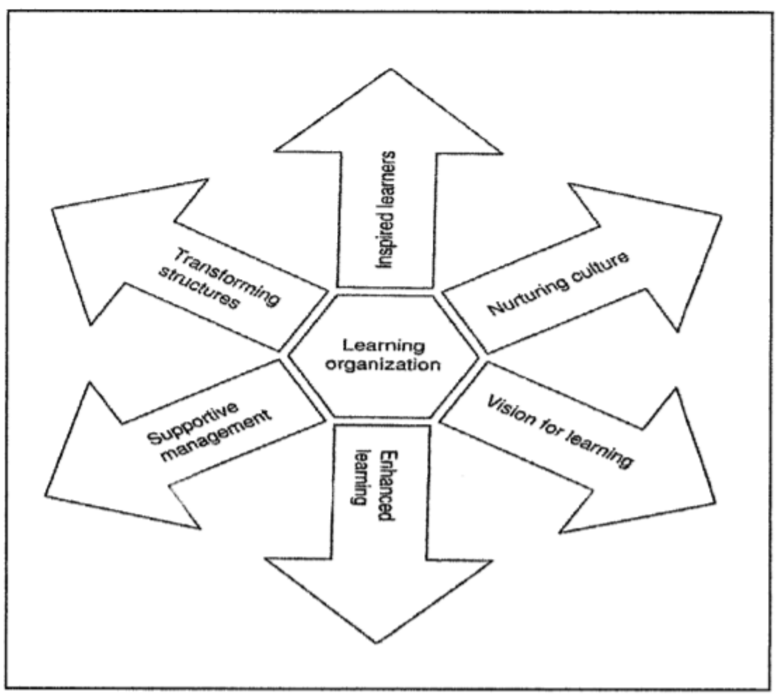


Figure 2.1: The INVEST Model of Learning Organisation [28]

2.3.1 Inspired Learners

Learning has important attributes; it not only makes us better in our work, but it also enables us to contribute and make the lives of other 'Beautiful'. Wherever continuous learning exists, workforce is more motivated and committed to self-development while seizing opportunities for learning from past experiences. For example, with the application of proposed LOIS, individuals within an organisation will find the necessity of continuous learning, contribution and development in relation tode continuous improvement and enhanced competitive advantage. Each employee will take the responsibility of using the application to solve their problems and by doing so, as LOIS aims to enable employees in their continuous learning and development. LOIS will also provide users with an interface whereby they can see a list of existing solutions that have been implemented in the past. Each solution will have a voting button where employees can vote for the better ones. Employees can also log into the system and share an idea. This will also help employees to be more motivated and committed as this new application will help them to reduce a few of their problems within the organizations [27], [28].

2.3.2 Nurturing Culture

Nurturing culture is a lifelong process of examining values and beliefs and developing an inclusive approach to practice with active intercultural engagement. A strong culture benefits a company's bottom line, attracts the best talent and most importantly keeps your employees happy and engaged. In order to maintain and nurture a strong culture, companies must be aware of their own culture. This also helps the company who to know best to hire into the company. Glassdor survey [29] stated that: '*67% of workers believe that the most important aspect of a job is to have an employer with similar values' and 'companies with engaged employees perform up to 202% better*'.

2.3.3 Vision for Learning

Vision for learning is where there is a shared vision where companies' have the capacity to recognise, respond to, and exploit new opportunities. This is discussed further in section (section 2.4.2: *Individual mental Model v/s Shared Mental Model* in Chapter 2) Individual mental Model v/s Shared Mental Model where the individual mental model influences the shared mental model of an organisation that recognises the importance of learning at a group, individual and system level allowing an organization to continuously learn and be able to adapt and survive in an ever-changing dynamic environment [27], [28].

2.3.4 Enhanced Learning

Enhanced learning is where a methodology is put in place for employees to be able to maintain, enhance, support and sustain a dynamically continuous learning environment.

In order to have an Enhanced Learning culture, abiding to the development of the System Thinking [26] as discussed in (section 2.2: *Learning Organisation Information System (LOIS) with Senge's Model* in Chapter 2), and the OADI-SMM Model of Organisation Learning [30],[31] and with Senge's theory of the shared mental models [26] as discussed below in (section 2.4: *The link between Individual and the Organisation* in Chapter 2).

2.3.5 Supportive Management

Supportive Management is where managers tend to act as Leaders instead of Managers itself. They help the organization and everyone in to achieve a shared vision. Minimum supervision is required as everyone is trusted to perform to their level of his or her competence. Employees are involved greatly in the decision-making process as their opinions are greatly values [27], [28]. With a strong shared mental model of the company in place and managers are more prone to share their knowledge and thinking with employees thus encouraging them to do the same. In summary, a strong supportive management helps the relationship between managers and employees to be transparent while improving communications between managers and the employees.

2.3.6 Transforming Structure

Transforming Structure is where organizations work towards facilitating a continuous learning at between different levels and functions while permitting rapid adaptation and change. Managers act as a facilitator to ensure that all assigned tasks are being done and organised into a self-managed autonomous way over their immediate behaviour.

2.4 The link between Individual and the Organisation

An organisation is a just a group of individuals working together and whenever a change occurs, the individuals need to change the way they think and how they act. People change by learning something new. To construct they need to deconstruct old habits and construct new ones. This construction process is called learning [30], [31]. Psychologists' views on how an employee learn in an organisation have changed and expanded in recent years. Learning is viewed here as a relatively permanent change in attitude [32].

Daniel Kim [30] proposed the link between Individual and Organization Learning where he described the seven models of Learning: 1) Role Constrained Learning 2) Audience Learning, 3) Superstitious Learning, 4) Learning under Ambiguity, 5) Situational Learning, 6) Fragmented Learning and 7) Opportunistic Learning [30], [31]. In the context of organisation learning, the economic environment and competitive advantage, organisational memory must be dynamic (that is, it cannot reside in the 'paperwork of the organisation'). Organisational memory must be active; that is, constantly changing at the individual level and at the same time; the organisational level [30],[31].

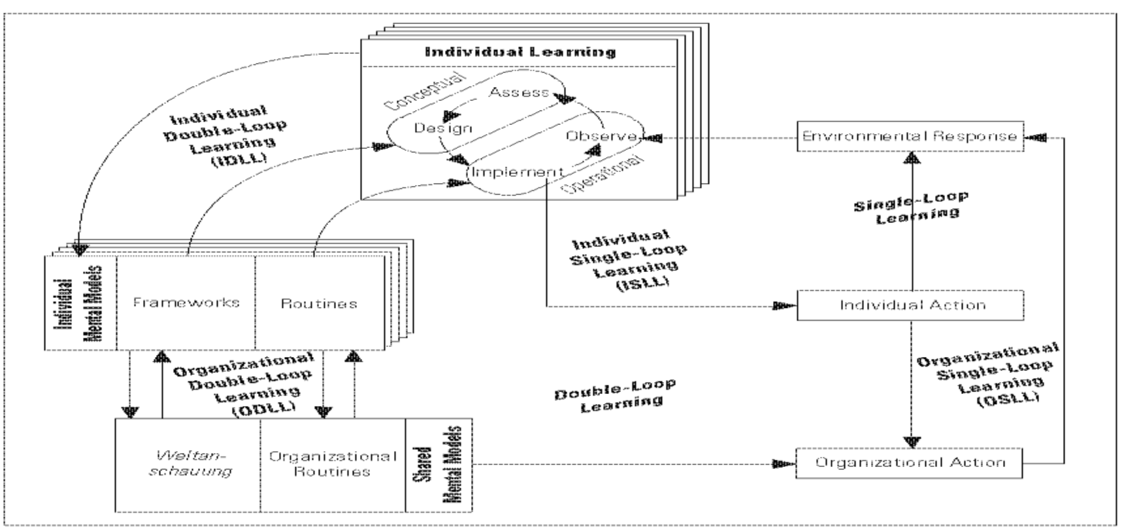


Figure 2.2: An integrated Model of an Organizational Learning OADI-Shared Mental Models (SMM) Cycle [30], [31]

Kim [30] presented OADI as Observer, Assess, Design and Implement -Shared Mental Models. The OADI cycle is applied to explain how individual learning, SMMs, single-loop and double-loop learning are integrated to give a model of Organisational Learning. Figure 2.2 describes both a single loop and double loop learning for both individual and organisational levels. Single looping which is the ‘know-how’ describes how individual learning changes individual action at the operational level in response to changes in the environment. However, the conceptual level which is the ‘know-why’ is where the individual can maintain the same response by acting on the environment. On the other hand, double-looping is where the individual methods used to solve organisational problem (model/framework) are changed while impacting the conceptual learning. The shared mental model that characterizes the strategies, assumptions, values and the norms that are shared across an organization is what changes individual learning to team learning [30],[31].

2.4.1 Individual Learning

Individual learning is where the employee assesses a situation (problem) and design a plan (solution) on how to act and implement that act in reality and observe how that reality response to it. There are basically two types of Individual Learning:

1. Conceptual Learning

A literature in industrial organizational psychology has stated that employees are most likely to succeed in training and on the job [32]. The conceptual model of the learning organisation consists of eleven domains. While learning has been classified as the central domain, the rest has been categorised into the following four pillars; direction, informal, infrastructure and change. Firstly, the main feature of the direction pillar which embodies strategy and vision, oversees the learning organisation and indicates the goals of the organisation in the future. Secondly, the informal pillar which involves culture, power and politics represents the non-visible facets of the organisation which, thereby, determine how the people and the organisations perceive and tackle the real world. Thirdly, the infrastructure pillar that consists of the framework, technology and processes, aid in supporting and inhibiting learning in the organisations. Finally, the change pillar that involves leadership and change, allows modifications and alterations in the learning organisation by manipulating the remaining domains in the organisation [30], [31], [32].

2. Operational Learning

Operational learning is learning by doing and it also changes the operational disciplines of an organization. It is about reviewing our learning outcomes, sharing what we learn with others while improving efficiency as it always creates new patterns or patterns that have been reconsidered and amended. The revised mental model of an organization contains the new patterns or revised patterns as well as the knowledge about how those patterns or routines will fit within a new or existing framework. Operational learning occurs most with learning under ambiguity where an employee is impacting the operational work practices of an organization directly, which then affects the environment; however, the link between the two events are not clear [30],[31].

2.4.2 Individual mental Model v/s Shared Mental Model

Employees' daily habits and routines can be changed through learning from past experiences within an organization. Hence, an employee will be highly motivated to use the system or the application to solve any pertaining issues, subjected to a similar event or situation to re-surface in the future. This is where the individual mental model influences the shared mental model of an organisation.

Basically, the shared mental model of an organisation is the sum of all the individual mental models within the organisation. The sum of mental model leads to organisational actions whereby an environmental response can be observed by the specific organisation. Maybe by launching learning the organisation can observe that employees are happier and motivated to work. In this way, the organisation has learnt something new and can continue to enhance the system to cater for his employees' needs [30], [31].

The different types of learning in an organization are described as follows; 1) Role Constrained Learning where people do not really act as they believe or maybe it does not comply to their roles in the workplace. Abiding to their role descriptions and operational disciplines within an organization; individuals tend to learn to change their beliefs and modes of interpretation accordingly. Thus, it results in dysfunctional learning since what the organisation put in action is totally different from the individuals' knowledge. 2). Audience Learning is when employees observe something that is being conducted in the organization and assume that this is how things are done thereby making it difficult for organizations to change sometimes. The main reason being that people tend to stick to their old routines. This usually have a high negative impact on the new comers as they mimic the ways of working of old employees instead of the organization's guidelines. 3). Superstitious Learning occurs whenever an employee does something resulting into a different scenario whereby the two things are linked together without not having any connection. This is where the individual mental framework can change. 4). Learning under Ambiguity is almost similar to superstitious learning but by linking the two together, employees are not sure of the cause and effect of the connection. Learning under ambiguity is more of an operational learning where the employee tends to change a few things to know the effect and the cause of that effect. Learning under Ambiguity is a type of Operational learning as mentioned in the above section. 5). Situational Learning is where an employee does an amazing assignment or have a great solution to a problem, but they are not fully aware of it and then it does not become part of their routines. They tend to do it once, but they do not repeat the same thing again. Employees can learn a lot from a situation for a better future but by doing so they don't actually learn anything. Once employees use our pattern recognition system and log data into the system, the data will be saved into the database and will help to produce a more refined and better solutions for other employees. 6). Fragmented Learning is where an individual learns something new but does not share it with other employees. Individual learning occurs but it does not get translated to a shared organizational mental model. The knowledge is isolated. Thus, the organization itself does not learn from it. LOIS will contribute to solve that issue as all data will be saved into the database as soon as the employee logs into the system and this knowledge will then be shared across the organization to help to solve issues in a given situation (Future Enhancements). Lastly, 7). Opportunistic Learning is where organizational action is not connected to the shared mental models of the organization as sometimes organization tend to take actions that contradict the shared mental model [33], [34], [35], [36].

2.5 Darwinian Model

It is understood that such variations are vital for evolution but however have not been well inferred so far. There have been many attempts made by businesses and companies trying to explain the evolution of organisations, in terms of growth or survival, by applying Darwin's principles of evolution. The theory states that organisms can develop designs that enable them to create more advantageous features. The theories behind organisational learning is explaining how organisations can develop knowledge where knowledge is a dependent variable that represents the state of the organization, and that this state results from the process of learning. That is, explanation of that dependent variable rest on a process in time rather than on an independent variable or a group of variables. Nevertheless, powerful designs are developed by the organisms that have the potential to generate the past selection processes and might be resolute for subsequent environments [38], [39]. The resolution from a recent theory that was proposed by Watson and Szathmary [40], conveys a strong metaphor between learning and evolution where the learning theory is applied to justify the conditions that can lead to more advantageous designs. Therefore, it is shown that the exact conditions that improve generalisation in the learning system, share biological equivalents as well as helping to understand the environmental noise and conservation costs which can guide the movement of progressive features [37].

2.6. Summary

Chapter 2 focused on how traditional IT is not helping businesses and companies to grow and improve processes. The learning organisation yield is essential for large organisation to learn and adapt to changes of the new digital marketplace and becoming as agile as smaller start-ups. But the learning organisation has to be adapted in such a way that it becomes non-intrusive and easy to use and easy to propagate within the operational dynamics of an organisation. The best way of achieving such result, is to automate the method of the learning organisation, wherever possible. Larger companies and businesses are being outbid by smaller companies as larger companies has a lot of maintenance concerning their legacies systems. The future is becoming more and more digital, and changing so rapidly, that smart IT and new capabilities are needed to architect the whole customer experience. This chapter has showed how powerful methods such as Peter Senge's model of Learning Organisation [7] (section 2.2 chapter 2) and The Invest Model [28] (section 2.3 chapter 2) who was built on top of Senge's model. One of the advantages of implementing such a model is to enable large businesses and companies to adapt to changes and reinforce their strategies. It has also demonstrated SMAC stack as the new digital capabilities, provided some research papers such as the "The Three Horizons framework" and "Designed to Grow" which discuss about the different future of a company and why and how managers should become explorers in this new digital world. However, one of the disadvantages is that managers do not have the proper tool and trainings to implement such capabilities within the operational disciplines of the organization. To be able to grow and reinforce strategies in this rapidly evolving world of IT, only theories and research papers are not enough; this is where machine learning comes into play. Machine learning can be used to predict the future trends by analysing and looking for patterns in data. In 2003, the tv show "House of Cards", was the most downloaded content in Netflix's history, but it came as no surprise to the company executives as they had been using machine learning to study their subscribers' habits and even predicted that the tv show was likely to become hit even before they were purchased [41]. To conclude, Peter Senge's model will be adopted to build a culture of individual commitment to the process of learning (Personal Mastery), everyone owns the vision and has focus and energy for learning (Shared Vision), exchange unwanted values for new and applicable values (Mental Models), individuals share what they've learned so the team becomes more knowledgeable (Team Learning) and lastly independence among all people and processes, working together as a whole system (System Thinking). The next chapter talks about the different types of machine learning and what is the best machine learning algorithm to be used for the Learning Organisation Information System (LOIS), how data is stored and some data mining techniques. Furthermore, it focusses on the data mining techniques with machine learning; explaining and describing the different types of machine learning algorithms that can be used, how data can be stored, and highlighting the major issues of data mining. The chapter concludes with a summary.

Chapter 3.0: Data Mining Techniques and Learning Organisations

3.1 Introduction

Large amount of data and databases are being generated by web servers in this new era where Information Technology is growing, expanding and evolving at a rapid pace. A lot of researches are being conducted on those data, databases and information technology giving rise to new approaches of storing, manipulating and extracting data for a better and refined decision making. The three steps involved to better decision making are, 1). **Exploration** is where data is being polished and transform into another form to be able to determine the nature of the data based on the problem. The first step is mainly about exploring, refining and defining data based on the problem. 2). **Pattern Identification** is where patterns are being identified and formed from the refined data in step 1 and lastly 3). **Deployment** is where the patterns are being deployed for desired outcome [63]. As data mining is becoming more and more popular and its usage in several industries is becoming more common, its techniques are being used to transform sensitive data to meaningful and useful information or knowledge as well as building automated systems [64].

This chapter starts by discussing how data gathering underwent drastic changes since the 1950s to mid-2000s and how data mining techniques and algorithms such as K-means, hierarchical and neural networks can be used to handle all the gathered data. This is followed by reviewing how the different data types can be stored, manipulated and accessed while comparing the different processing frameworks. This chapter focusses also on data mining by providing an overview of data mining and explaining how it can be used to extract, refine and make prediction on those data. It also highlights the different types learning that is associated with the algorithms and also mentioning the different industries where data mining is being used daily and why. The chapter then concludes with a summary.

3.2 Data Acquisition

Data gathering underwent drastic changes since the 1950s, where tools were being developed for identification of patterns and trends and to capture information faster than the human mind, which was referred as Analytics 1.0 in the mid-2000s when ‘Big Data’ was introduced [42]. During that time, modernized and robust technologies were developed in order to enable organizations turn data into insight and profit which therefore signified the switch to Analytics 2.0 [42]. Experts believe that we are now in the era of Analytics 3.0 which enable predictions and prescriptions of analytics to provide an insight to the probability of a potential event in the future and hence recommend possible courses of action [42].

Data mining techniques and algorithms used to handle gathered data have to be scaled up, to allow reasonably large datasets to be processed on a daily basis. The use of efficient transformation of data by analytical tools is made possible when the algorithms are scalable and can handle various velocity challenges associated with data coming from multiple individuals. Different techniques can be used; one example involve collection through a web based interface hosted on a remote server provided to the user, along with some existing and newly generated solutions that the user can choose from.

3.3 Data Storage

New processing frameworks, for example Hadoop and databases, for example NoSQL are required for storage and manipulation. Competencies in both analytics and information technology are required for Analytics 2.0 to better equip them for the upcoming technological advances. Non-Relational database, also known as NoSQL or Not only SQL database has been created to enable the support of applications on the cloud and to exceed scale, performance, data model and the drawbacks of relational databases such MS SQL. MongoDB is a commonly used option which allows data storage without defining a schema. The data is indexed on every attribute, and hence access to the information is relatively quicker than the relational database systems.

Numerous limitations such as performance are present in relational databases. Despite the fact that MS SQL provides a very good performance through indexes on the schema attributes, nevertheless more indexes have the ability to slower the insertion process. Another drawback is that the servers tend to require more space for both work and hard disk as data increases [43].

A comparative study between relational databases (MySQL) and NOSQL database for example MongoDB was conducted in order to identify the potential advantage offered by expanding NOSQL schema-free database systems. The following data types: JSON, BSON, XML and BLOBs with consistent access to all data with one interface are supported by MongoDB. All the documents stored in the system are converted into a detailed exercise of critical access to ease the process of joining data from varying sources for clear definition of the relationships between them. MongoDB's one-point access to various types of data and rapid speed makes it the best option for a vigorously varying structure of data especially when compared to the relational databases [44].

3.4 Data Mining

This section focuses on the extraction of implicit, previously unknown, and potentially useful information from data. Data mining is mainly about analysing and discovering patterns in data that is already present in the database in order to solve problems [45]. Data Mining Techniques are a set of algorithms (such as clustering) that help in the identification of information patterns that exist in the data being analyzed and then classify them so that the data elements can be put in groups for a better understanding.

The main purpose of data mining is to remove information from a large amount of data. Data Mining can be classified into 5 tasks:

1. **Exploratory Data Analysis (EDA):** EDA allows data to be investigated and evaluated through EDA techniques without any opinionated notions of what to expect [46].

2. **Descriptive Modelling:** Descriptive Modelling have the potential to construct a model that provides the user with a detailed explanation of the data. The later provides us with a comprehensive depiction of the data along with the data's global probability distribution, cluster analysis and segmentation and the relationship between variables [46].

3. **Predictive Modelling:** Predictive Modelling has the ability to foresee. The goal is to predict a value of a single variable based on the values of the other variables [46]. We have been using Neural Network Time Series Prediction to predict how many employees are leaving over a period of time.

4. **Discovering patterns and rules:** Using data mining together with discovering patterns and rules enable to aim for patterns and rules rather than constructing a different model itself. The aim is to look for frequent unions among items or features [46].

5. **Retrieval by content:** Similar patterns from the data set can be located from already given patterns.

3.5 Types of Machine Learning Algorithms

Machine learning algorithms can be used to predict outcome in a new situation, can also be used to explain how prediction is derived. These methods originate from Artificial Intelligence, Statistics and research on databases. Machine learning which is composed of multiple processing layers is enabling computational models to learn representations of data with multiple levels of abstraction in domains as speech-recognition, visual object recognition and many other such domains [47].

As people are more prone to make mistake by analysing data, it makes it hard to find solutions to problems [12]. This is where machine learning comes in play. One of the most common form of learning is Supervised Learning [47]. Supervised learning is where variables are being used to generate functions that map inputs to desired output. The objective of applying supervised learning is to approximate the mapping function so that output can be predicted for data with any new inputs, even if the inputs were not included when the mapping function was created. This is achieved through splitting of the dataset into training data, which is the data with input variables and their expected output value, and test or case data that is used to evaluate the accuracy of the produced prediction. If the mapping function does not produce the correct results, there are optimization techniques to tweak the mapping function so that error in the function can be minimized [12], [15], [47], [48].

A typical example of Supervised Learning is in the retail market where association techniques can help in identification that a customer will also buy product Y if he bought product X. On the other hand, Uunsupervised Learning is where people hope to discover unknown, but useful solutions to problems. Figure 3.1 shows an overview of unsupervised learning. Unsupervised is associated to clustering algorithm where grouping a set of objects (Events) in such a way that objects (Events) in the same group are more similar to each other that those in other groups; Figure 3.2 describes how unsupervised learning can be used to cluster data. Depending on the number of attributes for each entry in the dataset, clusters are modelled using many similarities measuring techniques such as Euclidean or probabilistic distance. One of the common types of unsupervised learning is K-Means algorithm [12], [15], [47], [48].

Another type of machine learning is the Reinforcement Learning where learning is conducted on the basis of trial and error to make accurate business decisions. Instead of telling the learner what actions to take, this type of learning makes the learner to discover which actions yield the best results, by trying each action in turn [48]. This review is about the creation of an Information System with Pattern Recognition algorithms to store, interpret, analyse events (objects) and propose measures to address the many events that occurs in an organisation while allowing organisations to learn from the events and adapt to changes using a reinforcement model to strengthen their business operations; Unsupervised learning algorithm is more appropriate in this case.

However, some of the commonly used clustering algorithms are Hierarchical Clustering, K-means Clustering, Gaussian Mixture Models, Self-organizing Maps and Hidden Markov Models. Clustering (K-Means algorithm) and Hierarchical Clustering algorithms are elaborated in more details in this thesis as it is more relevant to the Pattern Recognition System. A proof of concept is going to be built to implement the application of these classification of those mentioned techniques.

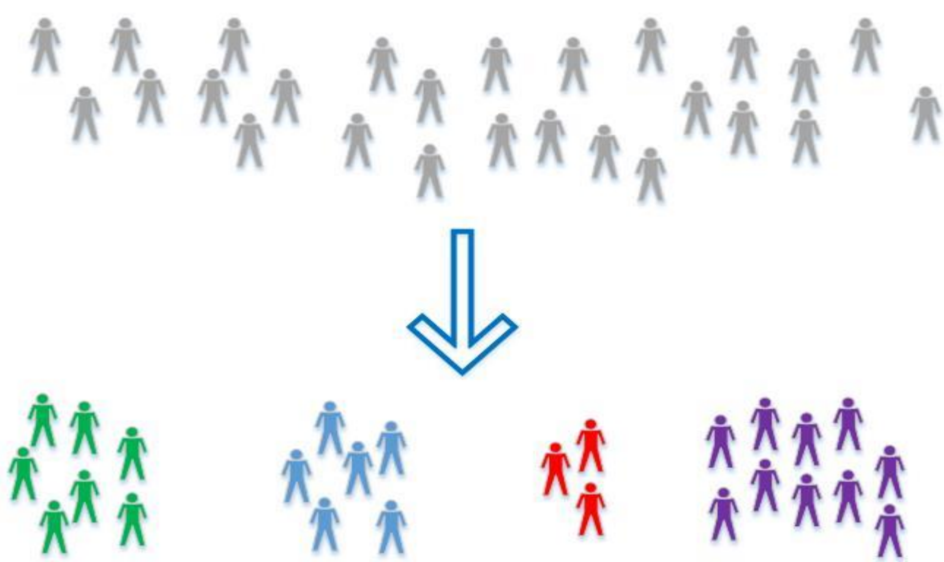


Figure 3.1: Overview of Unsupervised Learning [12], [15], [47], [48].

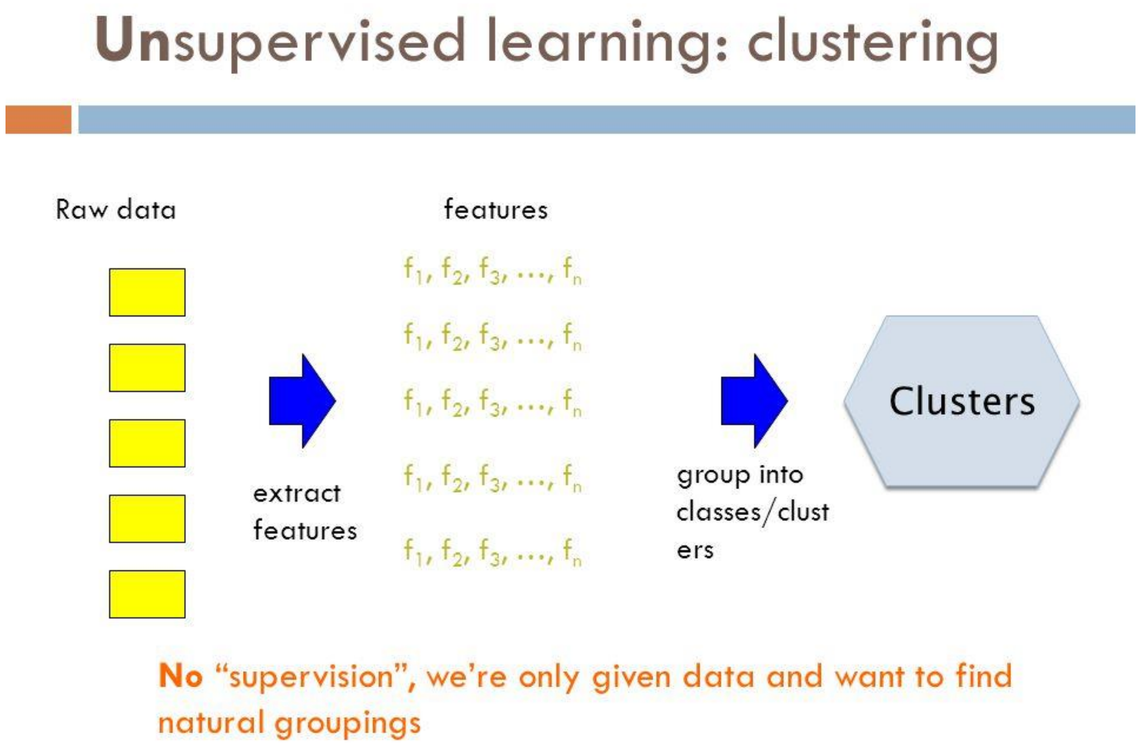


Figure 3.2: Unsupervised Learning: Clustering [12], [15], [47], [48].

3.6 K- Means Clustering Algorithm

K- Means clustering algorithm which is traditionally viewed as an unsupervised method for data analysis is a series of action of dividing or grouping a given set of patterns into disassociated clusters [49], [50], [51]. The similarity in the Learning Organisation Learning System can be based on Events. Different events happening in the organisation on daily basis; technical events, people events, career events. When all those events are logged, or saved into the database, clustering algorithm can be used to partition them so as differentiate between those events. Clustering algorithm identifies relationships in the dataset that are not visible through casual observation. However, it becomes very difficult to make such observations when there is insufficient data resulting in many data points for similar attribute values. The k-means clustering method will identify the relationship between these occurrences and look at each attribute that is being input to see which cluster a data point (event) should belong to.

3.6.1 K- Means Clustering for LOIS

K-means is a proper classification algorithm for compact cluster, however, it is sensitive to outliers and noise (example: bad data). It uses only numerical attributes where the input X is a set of feature vectors or points that can be defined from $x_1 ... x_n$ and K is the number of clusters that can be detected by the algorithm and lastly is the convergence threshold that can be explained in the following steps: 1). Starts by placing *C* centroids ($c_1 \dots c_k$) at random locations in multidimensional vectors space and then iteratively run through all the dataset and find the nearest centroid by computing the distance between $X_i ... C_j$ (example Euclidean Distance). 2). Pick the cluster that has the minimum distance (i.e the nearest centroid) and assign the point x_j to the cluster of that nearest centroid c_j. 3). Run over your clusters K centroids, and for each centroid, re-compute its position (i.e take all the data points that fall into that cluster and average them out) to get the new centroid. 4). Keep running all the points until no points change cluster membership. Figure 3.3 shows the iterations process to re-compute its position

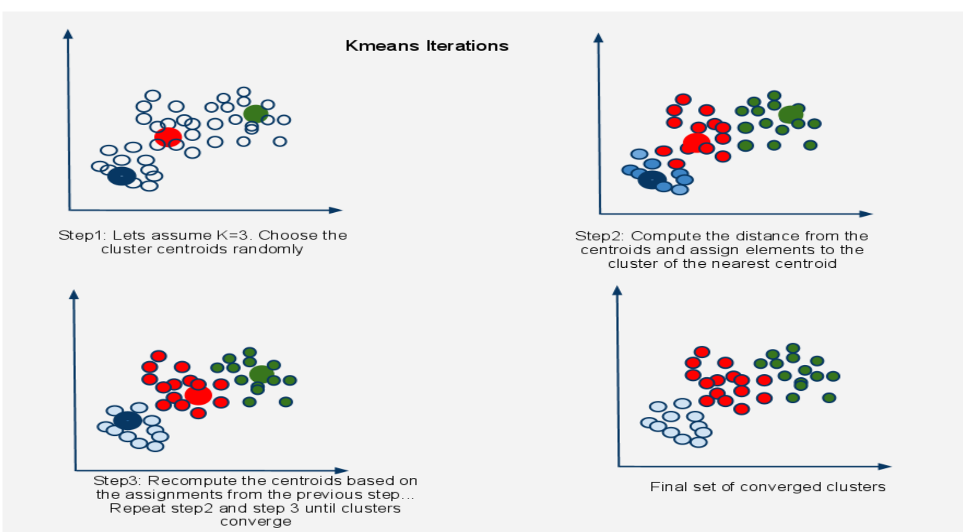


Figure 3.3: K- means Iterations [16][49][50][51]

3.7 Hierarchical Clustering

Hierarchical clustering can be classified using two different strategies; agglomerative and divisive. Agglomerative starts from the lowest level and only takes one object per cluster and hence combines two clusters at a time. Hence, the clusters are either fused together or separated into sub-clusters according to the affinities present in the varying clusters to construct a bottom-up hierarchy of clusters. In comparison, divisive produces a top-down hierarchy of clusters by beginning with all the data objects among a giant-cluster and constantly dividing into further cluster levels according to the connections and the clusters with more resemblance are held together on the same level and thereby divided according to the similarities between data points of each cluster.

An advantage of hierarchical algorithms is that it creates visual dendograms while allowing users to label their own clusters to increase their understanding. This is known as cluster labelling. Despite all the advantages in hierarchical clustering methods, once a decision has been locked in regards with either merging or dividing, the decision cannot be reverted which therefore makes it much less flexible. It also makes data processing very sluggish when different levels of attributes are present and each one of them relate to a large number of data instances. Despite that there is no accord; it is believed that K-means is better than hierarchical clustering algorithms regarding the quality of the final clustering solution [52].

3.8 Neural Network

The machine learning method called Neural Network first became popular in the 1990s and recently gained momentum by companies like Facebook, Twitter, YouTube etc that use versions of neural network called **Deep Learning**. Neural network is useful for forecasting both binary and numerical outcomes such as forecasting time series even though they were designed for cross-sectional data. Neural network which is said to be the most popular among all the machine learning algorithms are data-driven machine learning algorithms learns from patterns from data (big data) [53], [54].

Examples where NN forecasting has been used mainly, as they guide many important decisions [55]:

a. Tourism – Forecasting the number of tourists over a period of time
b. Financial Trading
c. Renewable Energy – Power Usage
d. Economics
e. Governments

The idea of the NN is to mimic the human brain while solving problems. A neural network is typically depicted as a network of connected nodes called neurons where each neuron is a variable. Specifically, we link the input information with the output information through a network of neurons where each neuron is simply a weight. The neurons activate other neurons by learning from each other.

Like any other machine learning algorithms, Neural Network can also be divided into two categories; Supervised and Unsupervised learning as discussed earlier where supervised learning requires historical data to train the network compared to unsupervised learning that formulate data by building its own model without known answers. There are different types of Neural Network such as:

- Artificial Neural Network
- Time Lagged Neural Network (TLNN) where the input nodes are the time series values at some particular lags.
- Seasonal Artificial Neural Networks (SANN) – predicting the performance of Artificial Neural Network (ANN) for seasonal time series data. The architecture does not require any pre-processing of any raw data.

Whether it is Supervised or Unsupervised Learning, Artificial Neural Net can be divided into 3 types of layers with a weight attached to every connection. The 3 different layers are connected by acrylic links.

1. **Input Layer:** Contains all the input variables also known as the input neurons
2. **Output Layer:** Contains all the output variables also known as the output neurons.

3. **Hidden Layer(s):** The Layer(s) between the input and output layer is called the **Hidden layer or hidden neurons/derived variables**.

Figure 3.4 and **3.6** describes a single hidden layer where the output from one layer is the input into the next layer [53], [54] whereas **Figure 3.5** shows a forecasting model with four layers cross-sectional data.

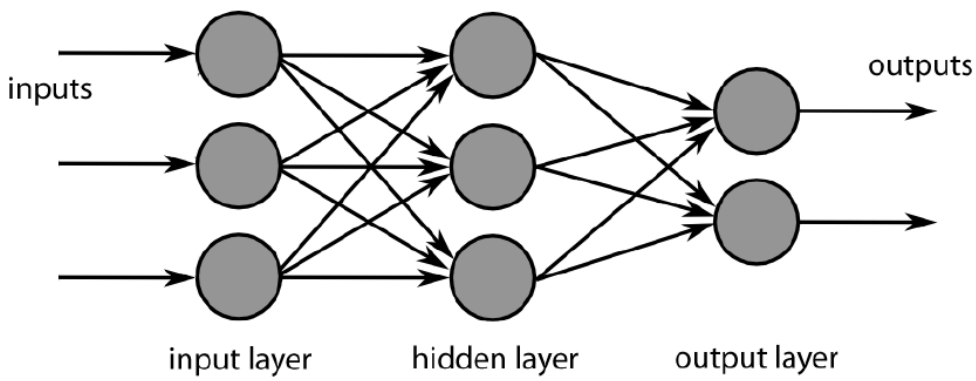


Figure 3.4: Neural Network Model – Cross Sectional Data (Three Layers) [53], [54]

It is the number of hidden layers that determined the results of the Neural Network. The more hidden layers and neurons the network can capture the more complicated the relationships are. Figure 3.5 below shows the complexity of the Neural Network where Xi is defined as the input nodes [53], [54], [56].

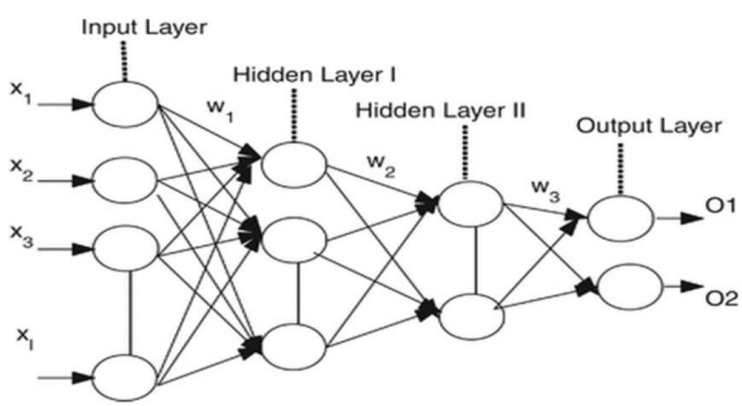


Figure 3.5: Forecasting Model – Cross Sectional Data (4 Layers) [53], [54]

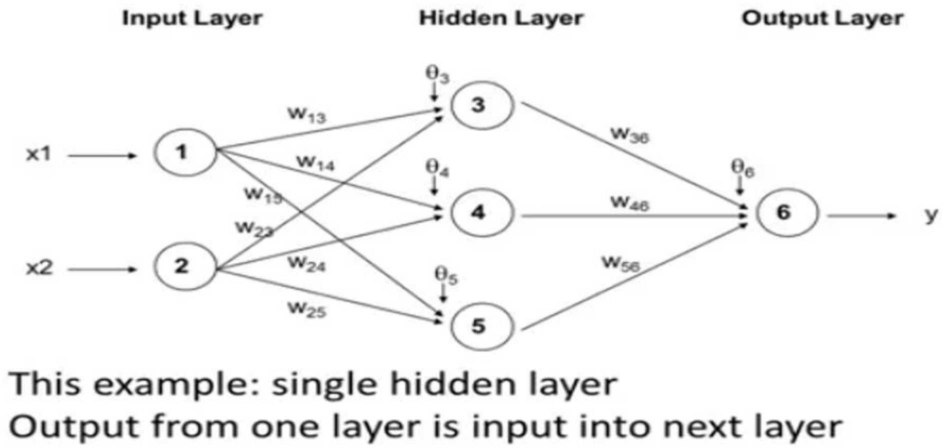


Figure 3.6: Forecasting Model –Single Layer output to calculate neuron output [53], [54]

3.9 Data Mining Applications

Even though data mining is a new technology that has not been fully developed yet, there are several industries that are currently using it on a daily basis. Some of the other organisations include retail stores, hospitals, banks, and insurance companies where data mining is being combined or integrated with elements such as statistics, pattern recognition, and other critical tools. With the help of data mining patterns and connections are less difficult to find [63] [64]. Business Intelligence and Search Engines are two successful application examples of Data mining that have shown great importance in research and development [57].

One of the many businesses that used data mining to overcome challenges was Soft map Company Ltd in Tokyo [63]. The company was experiencing difficulties to make hardware and software purchasing decisions that was delaying online sales. With the use of data mining their page views increased from 67 percent per month after the suggested engine went live as well as their profit tripled in 2001 as their sales increased by 18 percent within a year. [63]

Business Intelligence: It is critical for businesses to acquire a better understanding of the commercial context of their organization, such as their customers, the market, supply and resources and competitors [57].

Web Search Engines: Web search engines which are generally extremely huge data mining applications, are specially devised computer servers that search for information on the web. Several techniques including crawling, indexing and searching are used in all aspects of the search engines. Search engines present grand challenges to data mining. They have to handle a huge and ever-growing amount of data. Typically, such data cannot be processed using one or a few machines. Instead, search engines often need to use computer clouds, which consist of thousands or even hundreds of thousands of computers that collaboratively sort through the huge amount of data. Scaling up data mining methods over computer clouds and huge distributed data sets is an area that requires further researching [57].

3.8.1 Major Issues of Data Mining

In this sub-section, the major issues in data mining research, partitioning them into three groups are outlined: mining methodology, user interaction and efficiency and scalability. Many of these issues have been addressed in recent data mining research and development to a certain extent and are now considered as data mining requirements; others are still at the research stage.

1. **Mining Methodology**

   Issues such as data uncertainty, noise and shortfalls must be taken into consideration when applying mining methodologies developed by Researchers. Some mining methods explore how user specified measures can be used to assess the allure of discovered patterns as well as guide the discovery process [57].
2. **User Interaction**

   This section outlines how the user plays an important role in the mining process. It is important to consider the design of the user interfaces when building the system. User interfaces should be flexible and exploratory to facilitate the user's interaction with the system. Interactive mining should allow users to dynamically change the focus of a search, to refine mining request based on returned results [57].

3. **Efficiency and Scalability**

   Data mining algorithms must be efficient and scalable to effectively extract information from huge amounts of data in many data repositories or in dynamic data streams [57].

3.10 Learning Organization Machine Learning System

Modelling the business processes gives us a mechanism to understand how things work within an organisation. Once an understanding of how things work is gained, alterations can be carried out to allow better working situations. As the marketplace became more and more dynamic, companies needed to quickly adapt to enable changes in their processes. Therefore, rules were implemented to change those static decisions. Subsequently, re-engineering happened. The whole point of re-engineering was to get rid of some process steps like gathering information or validating information and automating them so that they can happen more efficiently. While rules are easy to change, they are also difficult to maintain by humans especially if the rules expand. We are beginning to replace those human generated rules by machine generated ones. This is done by machines that learn these rules automatically from data. One of the advantages of machine generated rules is that it can quickly adapt to continuous business environment [46].

Machine learning is used in many areas of the industry, but here we are considering four different areas where machine learning has been used in organizations to facilitate the task for human beings, 1). Machine Learning in Health Care, 2). Estimating effort in software development (while building projects), 3). Sales forecasting process and 4). Predicting employee turnover in an Organisation.

Due to the many factors that influence health, doctors will never be able to process all the information in the short time in which they see their patients. This is where machine learning come in place. Machine learning has greatly been used in health care to have better health outcomes and better precision medicine that will help to save massive amount of money due to its unique data insights leading to more targeted treatments.

Machine learning in health care comprises of different models such as the Classification model, where the model is being trained using a set of labelled data. An example is to find whether a person's mole is cancerous or not. The model is being fed with a huge amount of data, that represents a set of mole scans from 1000 patients that the doctor has already examined to determine if they show cancer or not along with other data such as gender, age, place of residence etc. **Figure 3.7** shows how the classification model works while using some sort of algorithms.

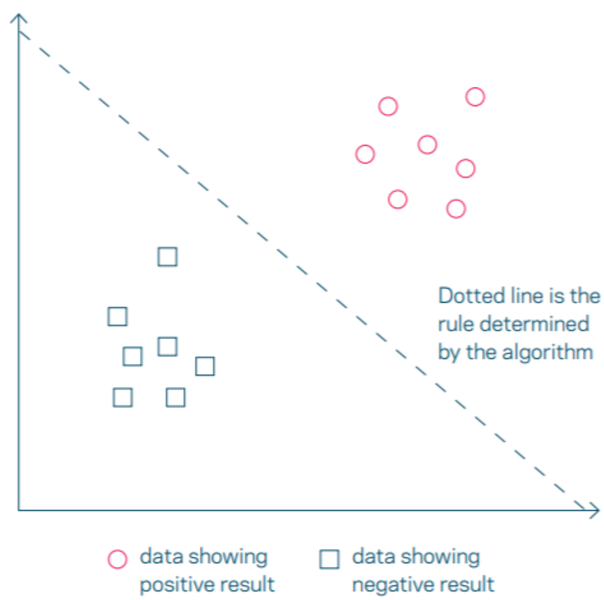


Figure 3.7: Use of clustering algorithm in Health Care

Another model that machine learning compromises is the Clustering model. The clustering model has been explained earlier. Clustering mainly looks for patterns in data and clusters the data in different sections where each section represents a different group [58].

Business to Business (B2B) sales forecasting process is one of the many other areas of the industry where machine learning was used to help the decision-maker. In many cases B2B was being conducted by grouping a large amount of data over a long period of time and based on that data, human judgement was taken into consideration to decide or plan a forecast. This method was proven to be inefficient and ineffective. With the aid of machine learning, an organisation model was put in place and evaluated in the company for a couple of months where users' sales forecasts were observed to be improving. The organizational model describes how machine learning was incorporated with the single and double looping learning explained below in Figure 3.9, *A proposed organizational learning based on ML model, enhanced with explanation methods*, and at the same time adopting a culture of acceptance by involving users. ADR methodology along with several cycles of the CRISP_DM methodology were being implemented to build the model in an organization point of view. Figure 3.8 represents a proposed organizational learning based on machine learning model, enhanced with explanations methods. ADR stands for Action, Design and Research. In simple words ADR is a methodology that consists of four different steps mainly: 1). **Problem formulation** which is identifying the class of which the specific problem is an instance 2). **Building, Intervention and Evaluation** that intents to support an iterative process at the intersection of the IT artefact and the organizational environment 3). **Reflection and Learning** formulates the learning in terms of all the theories selected. and 4). **Formalization of Learning** focuses on the results and communication of the outcomes. ADR was mainly chosen for this experiment as ADR enables users to be involved in all stages of the model development, testing and use. As shown in **Figure 3.8**, new insights generated are fed back into the system [59].

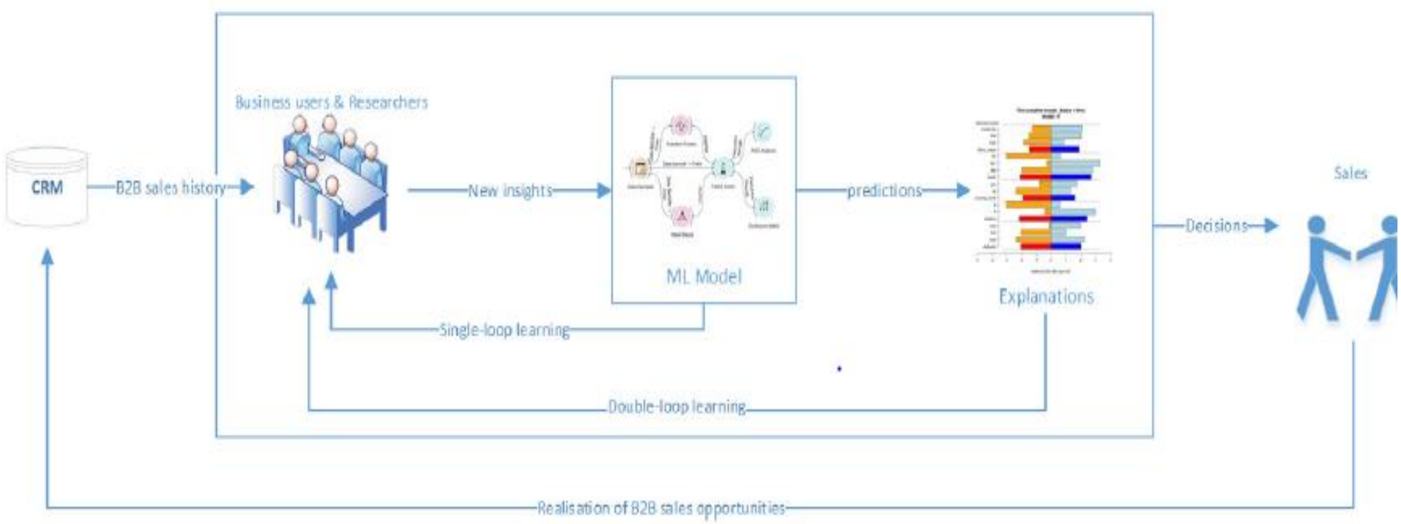


Figure 3.8: A proposed organizational learning based on ML model, enhanced with explanation methods [59].

Similarly, to the Learning Organization Information System (LOIS), users will be able to contribute to input data (Log Events and Input how they are feeling on a particular day or week), examine the results of the model and propose useful solutions. The model was being used for several months, data was being gathered by the company and some Machine Learning techniques were applied to those data where sales predictions along with their explanations were being generated. This was very useful for sellers as they were abled and encouraged to revise their initial forecast. In machine learning point of view, EXPLAIN or IME methodology were being implemented to construct the model. The EXPLAIN or IME method observes changes of one variable at a time.

Figure 3.9 shows how users changed their initial forecasts based on the generated sales prediction and learn from it from a group level as well as on an individual level.

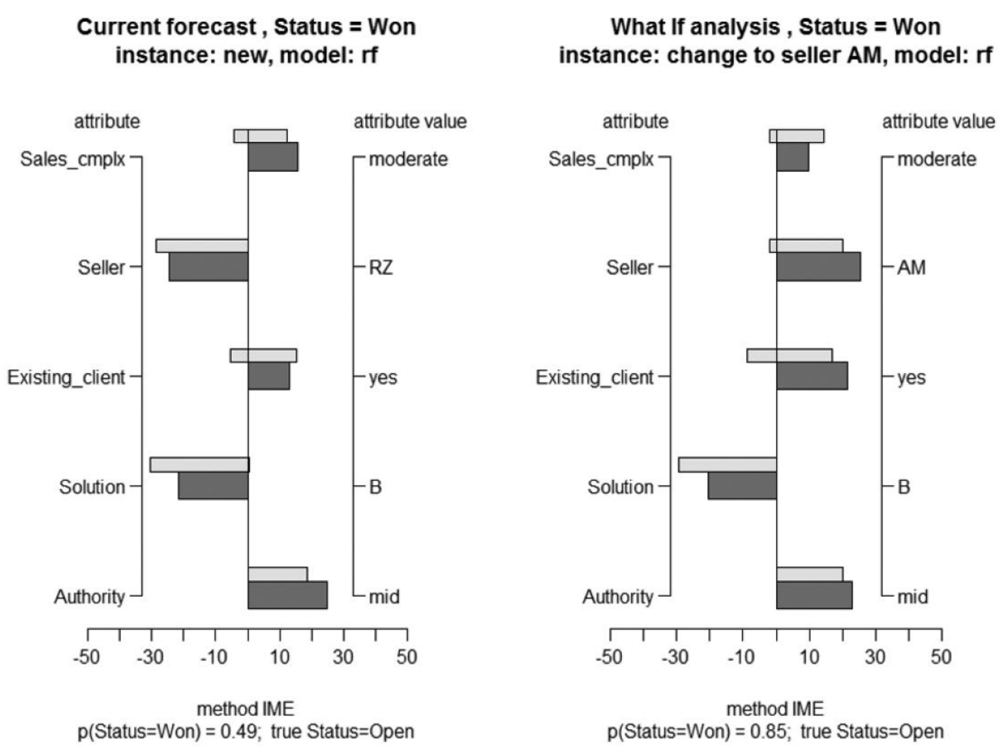


Figure 3.9 a) Explanation of a prediction a new sales opportunity b) “what-if” analysis for the new sales opportunity [60].

There is also the double looping as shown above (*Figure 3.9*), where learning is being done by revision of the users' beliefs and mental models. In this way, the process of model building and usage is contributing to improved understanding of the model and the B2B sales forecasting model.

Creating and building applications that produce the desired outcomes within a limited schedule and budget are one of the main objectives in software engineering. A project budget is always dependent on its effort factor. Therefore, effort must always be considered while developing projects. Often project failure occurs due to a miscalculation in the effort estimation as hiring too many people for a job results in a loss of income and less problem leads to an extension of schedule. To tackle this issue, a model that uses machine learning was put in place where software related data was collected in small and medium enterprises. **Figure 3.9.1** shows the Learning Model for Effort Estimation, where several methods were used as tools for the effort estimation using the COCOMO guidelines based on COCOMO and COCOMO II models including; back propagation multilayer perceptrons, regression trees, radial basis function (RBF) and support vector regression (SVR).

Constructive Cost Model (COCOMO) which is a procedural software cost estimation model is used to estimate size, effort and plan a new software activity based on the software cost.

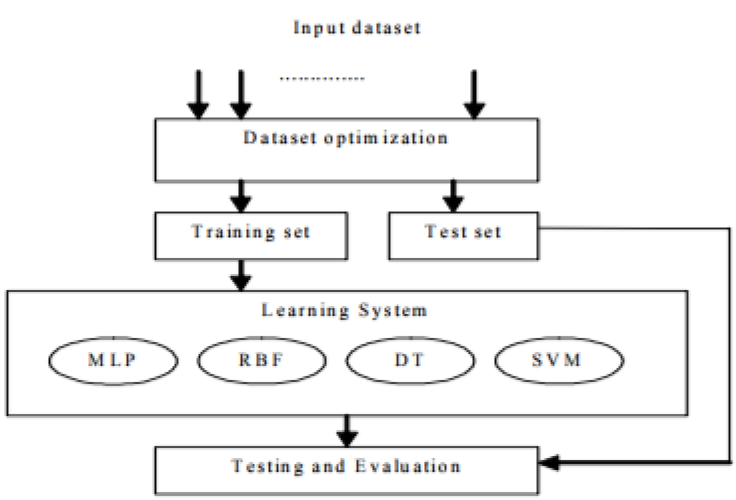


Figure 3.10**:** Learning Model for Effort Estimation [61]

Different datasets such as NASA, USC and SDR were used where machine learning methods mentioned above MLP, RBF, DT and SVM were applied. Based on the experiment carried out, it is observed that the parametric models are insufficient for measuring effort and more evolving system must be implemented or incorporated to address the issues rather than a static one. We have also noticed in the experiments that the COCOMO model is useful for effort estimation for the two datasets USC and NASA.

There are also some limitations when using those models. As most of the applications are built using Microsoft Visual Studio or some java-plugins, a high percentage of the codes are auto-generated. Therefore, SDR dataset fails when using COCOMO and COCOMO II considering the huge size values. The results for effort is also very high causing a huge inaccuracy.
As a future work, learning system different methods can be implemented or to test the system further. As we can notice here, this is a lack of work and knowledge in this particular area of the industry [61].

Bilge Başkeleş, Burak Turhan and Ayşe Bener [62] used machine learning algorithms and techniques to predict employee turnover in an organisation. In their research, they utilised the Extreme Gradient Boosting technique with data provided by Human Resources Information Systems. The main benefit of applying machine learning techniques is that it can allow organisations to take proactive measures to have a low rate of retention. However, one of the main disadvantages is that the techniques used to solve the stated problem has failed to account for the noise in the data received by the HR Information System. Noise in terms of inefficiency of capturing employee's data during his/her time in the company. Also, there is limited understanding of the benefits and cost and how return of investment can be calculated and measured in the HRIS. All these lead to noise in the data which in turn diminish the capability of the techniques to provide accurate algorithms [62].

3.11 Summary

Data Mining is a dynamic and fast-expanding field with great strengths. It is essential for Data mining process to consist of flexible user interfaces and an exploratory mining environment in order to enable the user to interact effectively with the system.

Many different types of data mining techniques were discussed that could be used to process the collected data and generate prediction models based on different dimensions of the data. The data is information, and it is converted to knowledge after manipulating through the application of intelligent machine learning techniques. If the data is collected from a system, and then the knowledge derived from this data is applied to strategic decision making and automation of the same system, it is bound to help in improving the service and operational excellence. Out of all the techniques mentioned and major area of their application, techniques like Clustering algorithms was discussed in more detail because of their use in existing pattern recognition systems.

The pattern recognition systems can be used to collect data from employees and then develop prediction and forecasting systems to improve their confidence and reliability of the service. With an automated integration of data mining techniques of patterns in the data, it can potentially change behaviors of the employees and the organization’s culture and the way of doing things itself as important data can be extracted for decision making. This highlights that data-driven decision making can help design and improve learning systems of the future. The next chapter talks about Organizational Learning where traditional IT is changing into a more digital era.

Chapter 4: Intelligent LOIS Architectural Framework

4.1 Introduction

Architectures show the structure of different components and how they are inter-connected and frameworks represent the foundation of the architectures. Instead of creating everything from scratch, some frameworks already provide pre-built modules so that the developers can easily use and extend. In this, the LOIS framework will adopt Model-View-Controller (MVC) [65] as an architectural pattern to make it easier to implement database connectivity, sessions etc. MVC framework also provides us with the ability to add different plugins, work on different languages, connect to different services, and host the application on a cloud platform and will be used as a deployment platform for the design of the LOIS framework. The framework has also adopted a service driven architectural style in order to increase its extendibility, scalability, pluggability, interoperability and other quality of service factors. MVC has been greatly embraced by companies over the last few years whereby the architecture contains a server-side programming component that enables building of Web-based applications. Java, C#, Angular JS, PHP and Javascript and many others are the languages that can be used on the architectural framework where it provides users with many advantages such as easy to manage complex applications with the divisions of Model, View and Controller, better support for Test Driven Development (TDD) and code reusability. The Model is the layer that communicates with the database to retrieve data, structure the data in a logical way and also stores data that is retrieved from the Controller and sends it to the View to display as information; The View is mainly the display layer. A representation of information that handles the display of data and also generates new output to the user based on changes in the MODEL (most often the views are created from the model data itself) and lastly the Controller, accepts input and converts it to command for the Model or the View and can also send commands to the Model to update the Model's state [65].

This chapter considers in detail the Learning Organisation Information System and how an organisation can connect with an application so that the Organisation can learn and grow. It also shows how an adaptable learning system can be very efficient and effective within an organisation. This is achieved by integrating several components, which deliver different functionalities such as the analytics component, data storage, management and transformation components, and visualisation components with frontend and backend layers.

The chapter starts with an overview of the proposed System Architecture while describing every component of the architecture and their functionalities. It also considers the advantages of having such an architectural framework in place. Then, the process flow of having both the framework and the architecture incorporated using MVC is presented, while describing all its key features. This is followed by the presentation of a deployment architecture based on MVC including the justification of using MVC and the way it works. The Organisational Framework Process Flow on how the organisation interacts with the system is then presented. Finally, some conclusions are drawn.

4.2 Overview of the Architectural Framework

This section presents an overview of the framework and how different components, that provide different services and elements of automation, are inter-connected to produce results that can help organisations to learn and grow. A simple definition of architecture is how we can separate work into components and construct them in such a way that they are re-usable, able to solve complex problems, reliable, adaptable and most importantly cost effective. **Figure 4.1** depicts how different components of the architecture are separated into different layers where each layer is responsible for a selection of related tasks but at the same time dependent on the other layers to be able to function. This architecture consists of various components or services such as System Communication, Visualization, Analytics and Data Storage, Management and Transformation Components etc. The Visualization and Data Storage, Management and Transformation components are designed in such a way that they need to work together to be able to function properly and most probably deployed together as well. No graphs can appear on the screen without the database reading the data. For example, if any schema changes in the database are implemented without changing the business layer, then the software will crash on its own. On the other hand, the Analytics (Machine Learning) components can be deployed separately and work independently. It needs only the data from the Business Layer to function properly or even data from a third-party component. The service component is created in such a way that any re-work carried out will not impact the rest of the architecture.

The architecture consists of different components starting with the Wireless Clients component where the tools that a user can use to interact with the system are defined. Then, the Data Storage, Management and Transformation Components deal with how the data is being read and stored. Analytics consider the entire machine learning components including patterns and trends analytics, and it is about making predictions on data. It also describes the connection to the clients, which can be wireless or desktops. The visualization components are used to view the data, which can be analysed, and measures to address any issues are formulated.

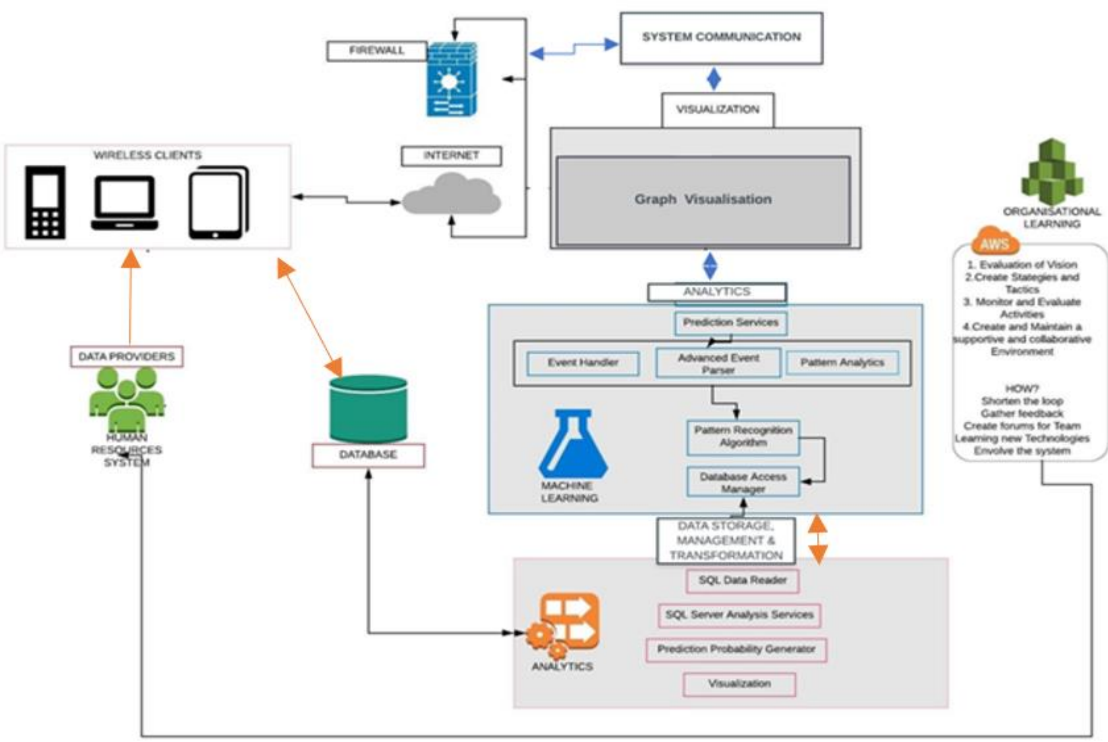


Figure 4.1: System Architecture Overview

WIRELESS CLIENTS

This LOIS system will be a web-based application that can be hosted on Cloud platforms so that internal users can connect to it. Devices such PC (Personal Computer), tablets, mobile phones, laptops, palmtops and a good internet connectivity should be enough to connect to the application. The only drawback of such an application is that it can be accessed only via VPN or by the Organisation's ethernet cable as the only users that will be using the applications are going to be employees (internal users).

SYSTEM COMMUNICATION COMPONENTS

System Communication components mainly consist of components where clients can communicate with the system and to where the system can communicate to other different components. It is where all our Object-Oriented languages interacts with a database server and then to another web server for the user to see the information. It serves as a link among various components of the system such as Visualization, Web Server, Database Server, Analytic components etc.

VISUALIZATION

The Visualization component consists of the UI Layout, which must be simplified for easy use by the employees for them to quickly adopt the tool. The Visualisation component gets data from the Pattern Recognition Algorithm and displays it in a graphical form for the users to analyse and make decisions. The Visualization Component is a critical part of the architecture as this is where all the stored data (read, clustered etc.) is being displayed as visual information for the user. The Visualization is directly related to other components such as the Data Storage, Management and Transformation Components and Analytics Components. This component represents the "**View**" of the architectural pattern. Each View is related to a Controller in the Advanced Event Parser and each method in the Controller file is linked to a Model in the Business Layer.

ANALYTICS COMPONENTS

The Analytics components englobe Event Handler, Advanced Event Parser and Pattern Analytics. The Event handler allows the user to record an event through an Interface (Example: mood or issues on a weekly or daily basis) which then stores the event into a defined structure by communicating to the DB core through the DS Access Manager. The data is then read by the Data Storage, Management and Transformation Components and then logged into the database. The Event Handler also consists of the Events Trend component that holds the data concerning trend of events that's happening in the Organisation. The data is then passed to the Pattern Analytics that holds the algorithm to look for Trends in data, stores the patterns and pass the data to the Advanced Event Parser component to apply some machine learning algorithms (K-means and Time Series Prediction Algorithm). The Advanced Event Parser which holds the algorithm that takes data from the Pattern Analytics and parse the data in specific format and according to the parser instructions to the Pattern Recognition Algorithm component. Parsing involves applying a regular expression to values and setting them to event attributes. The Advanced Event Parser represents "**Controller**" of the architectural pattern. Pattern Recognition Algorithm component consists of Machine Algorithm Agents that uses K-Means to cluster data and Time Series Prediction algorithms to predict on those clustered data. The output of the parsed algorithm is provided back to Advanced Event Parser and then to the Presentation Layer (Visualisation Component) as information for the user. The Pattern Recognition Algorithm represents "**Model**" of the architectural pattern.

DATA STORAGE, MANAGEMENT AND TRANSFORMATION COMPONENTS

The Data Storage, Management and Transformation is where data is logged, read, accessed, managed and transformed. Data Storage is how data is being stored in the database. Microsoft SQL Server will be adopted in the implementation as it provides us the stability and the adaptability to connect with other Microsoft platforms such as migrating our SQL Server databases to the Azure SQL database without having to change our application. SQL Server also provides us with many other plugins options that we can use to cater for our needs. One of the options is SQL search that gives us the ability to search for objects in an entire database.

Data can be logged into the database through the Event Handler that holds the interface and other components. The SQL Data Reader component then reads the data that is being fed into the database and then pass it to the Database Access Manager so that it can be accessed and manipulated by the Analytics Component. Data Access Manager conducts all the communication and CRUD (Create, Read, Update and Delete) operations to the DB Core, which is the main database of the software application for the learning organisation system. The SQL Server Analysis Components is an in-built component used as an analytical engine to provide with enterprise-grade semantic data models for business reports and client applications such as Power BI, Excel and some other data visualisation tools. It was not implemented for this research project but can certainly be used in the Future to have a more refined quality of data.

4.3 The Framework Architectural with MVC and Process Flow

Figure 4.2 depicts how MVC is being used to illustrate an overview of the process flow of the architectural framework. It shows how the Controller is responsible for getting data from the Model and passing those data as information to the Presentation Layer. It also shows the flow of how the Controller captures information from the Presentation layer to the Model and how the Model sends the data to be updated in the database. Moreover, it demonstrates the flow on how the stored procedure fetches data from the database and returns it so that is can be clustered and predicted using K-means and Time Series Prediction algorithms respectively in the Business Layer.

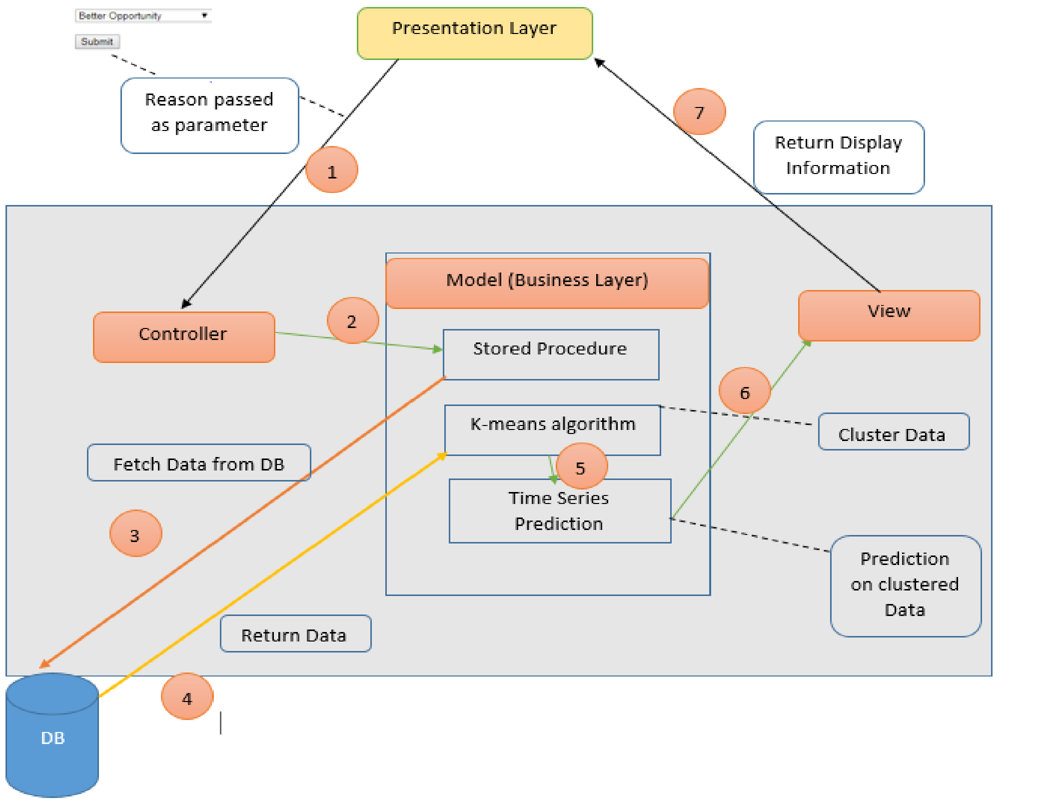


Figure 4.2: Framework Architecture Process Flow with MVC

The following steps represent a generic flow through the architecture:

1. The user chooses an option from the drop down and the option is sent from the presentation layer to the controller as a parameter on submit.

2. To query the database for data, the controller accesses the Business Layer (Model) and passes that same parameter to the stored procedure.

3. The stored procedure method then connects to the Database through the DAC (Data Access Layer) to retrieve data.

4 The data obtained from the stored procedure is sent to the Machine Learning Algorithm Agents. The date is then clustered into 3 main categories – Low, Medium and High (Minimum to Maximum number of employees that left to the sum of years of service) through one of the two agents; K-Means algorithm and Time Series Prediction.

5 Time Series Predictions are then applied on those clustered data to forecast the number of employees that can leave for each month.

6 Thereafter the data is sent to the View.

7 All the display information is returned to the user.

Figure 4.3 is a flow chart on how a client interacts with the system and the flow how different components of the system respond accordingly. It clearly shows how does the system react in cases where the client is feeding/updating data or if the client is using the system to view information only.

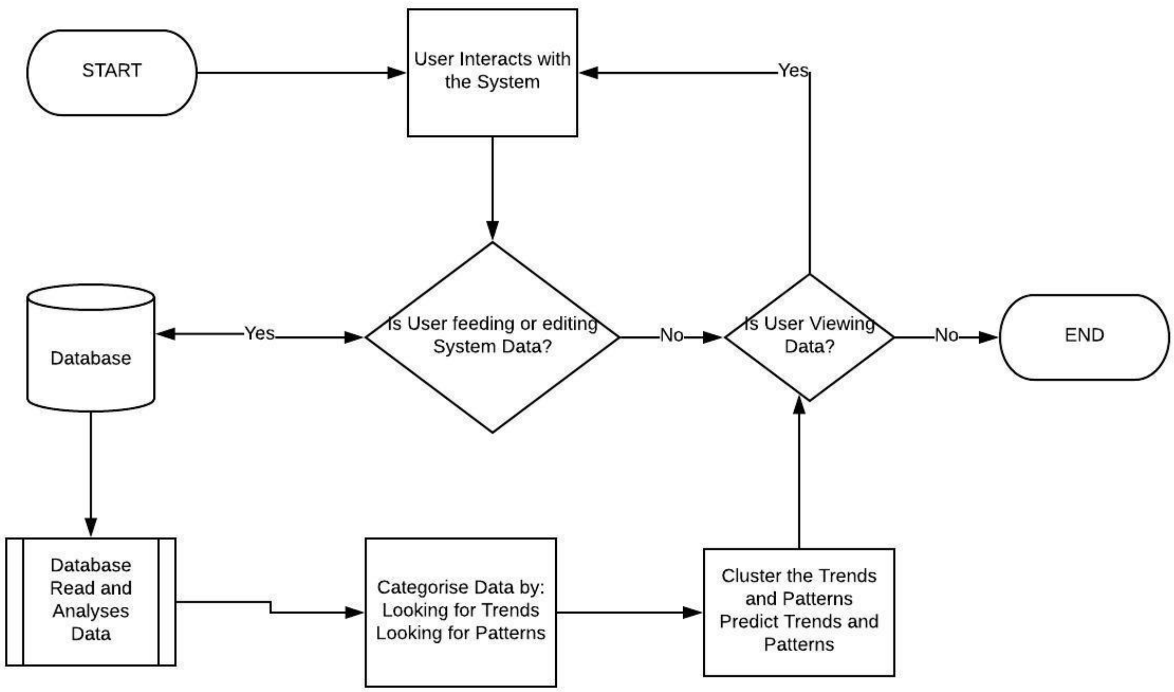


Figure 4.3: Overview of the Architecture Process Flow

4.4 Deployment Architecture – MVC

The Model-View-Controller known as the MVC is an architectural pattern that has greatly been embraced by companies over the last few years. This framework was first introduced in the SmallTalk-80 programming environment. The architecture contains a server-side programming component that enables building of Web-based applications. This architectural pattern divides an application into 3 main components: The Model which contains all the data and all the major functionalities of the website. The Model also communicates with the Database Access Manager that fetches data from the database. The View that provides the user with information and the Controller is the one who handles all the input that the user makes on the View. The user interface compromises mainly of the View and the Controller.

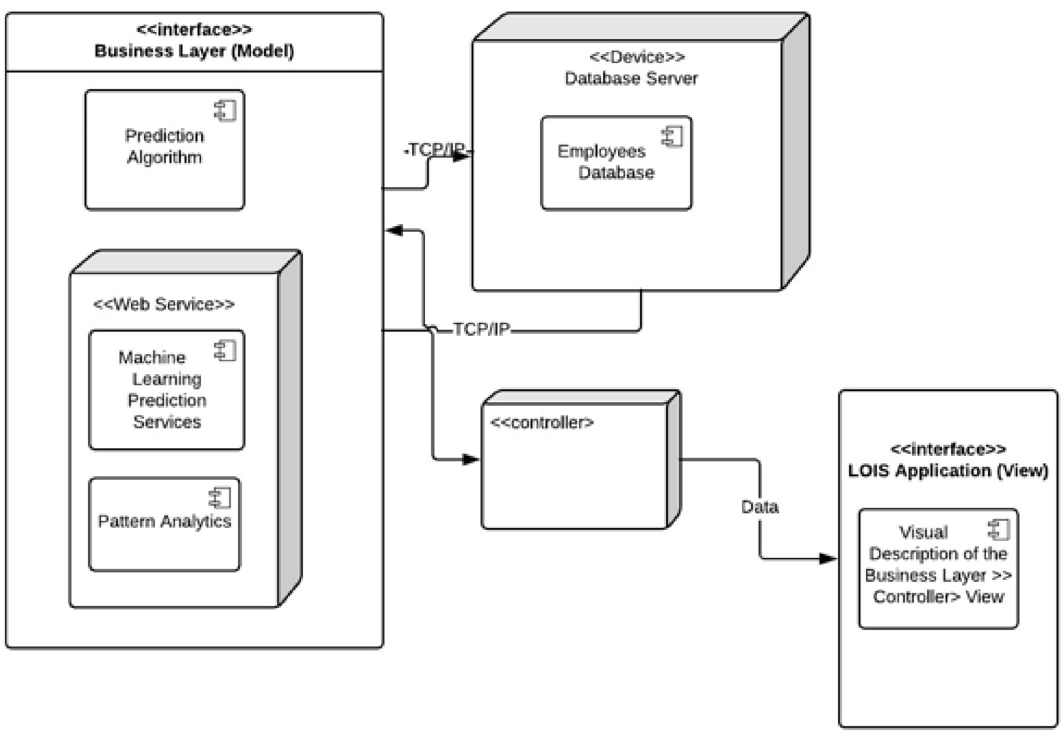


Figure 4.4: Simple Deployment Diagram based on MVC

A simple deployment diagram based on MVC is depicted in **Figure 4.4**. It shows different components and what does each component holds. It demonstrates the relationship between components and the nodes. Moreover, it shows the devices and the nodes that is unique to the system and identifying the nodes that represent the system's client and the server processors.

Figure 4.5 illustrates the functionality of each layer in the MVC architecture. In summary, **V**iews that display information to the user obtain data from the **M**odel. Only one model can be used to formulate multiple **V**iews where each view is associated with a **C**ontroller component (a method in the controller class). The **C**ontroller receives input from the user as mentioned above and each event is translated to service requests for the **M**odel or the **V**iew. The interaction between the system and the user is only through the controller. If ever any changes happen to the **M**odel through the **C**ontroller of one **V**iew, all the other **V**iews that are dependent on the modified **M**odel should reflect the same changes [65].

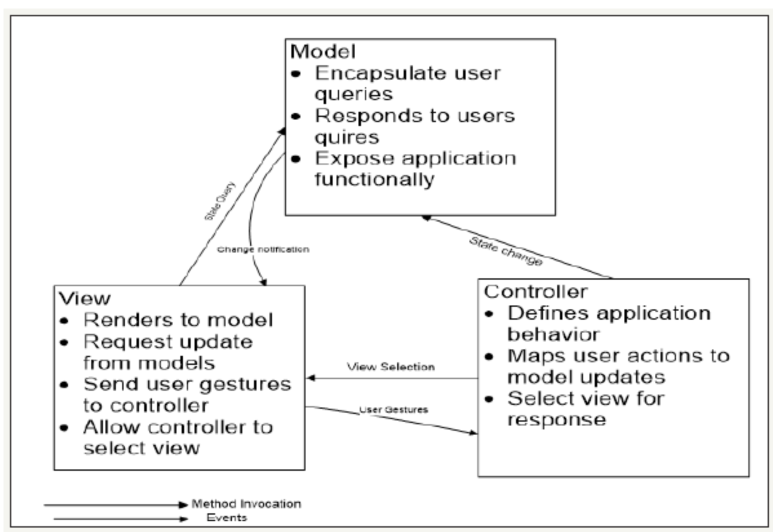


Figure 4.5: The Functionality of each layer in the MVC architecture [65].

MVC has been used to manage and control the complexity of the application by dividing it into the three main components (**M**odel, **V**iew and **C**ontroller). This has also helped to reuse the codes repeatedly instead of writing new lines, hence, making the application less bulky.

4.5 Organisational Framework Process Flow

The Framework Organisational Process flow diagram for the software solution of automating the learning organisation, LOIS, is depicted in **Figure 4.6Error! Reference source not found.**. The diagram describes the steps how the Organisation Management System or HR uses the framework to monitor the attention and retention rate in the company. It shows the flow how data is being fed and retrieved from the database. Moreover, how data is being passed into our Machine Learning Model to provide results, useful results that can be cascaded to managers where they can formulate necessary measures or plans to retain employees in the organisation.

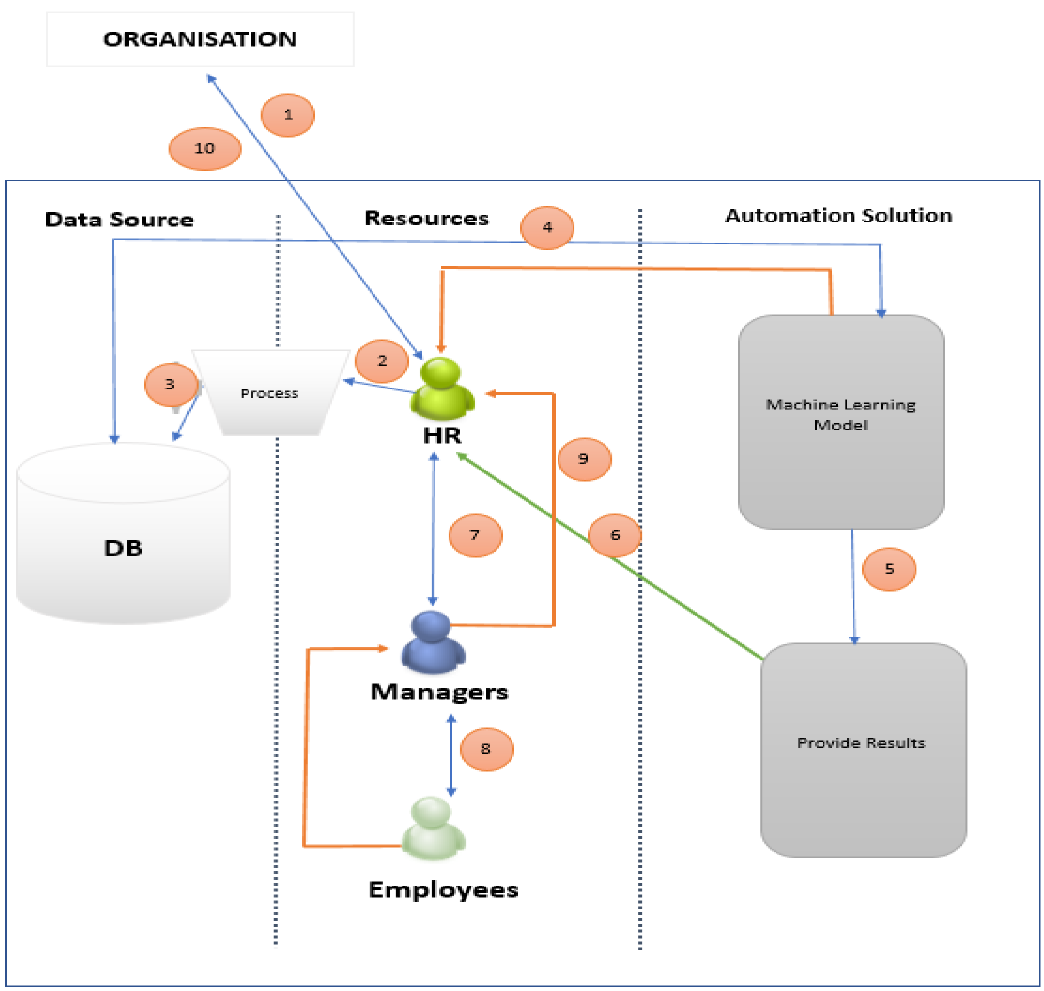


Figure 4.6: The Framework Organisational Process Flow

The below is a step by step demonstration of a Case Study where by an HR or Organisation Management System uses the system to feed data into the database, analyses results, cascade useful information to managers where measures can be formulated. Furthermore, it shows how this application acts as a facilitator between HR and different managers across the organization. It is also a platform whereby employees can express their concerns and issues so that they can be addressed. It clearly shows the flow of processes how the Organization can use the system to retain employees and address concerns:

1. Attrition and retention are conducted by Human Resources (HR) also known as the Organisation Management System on a monthly basis. The latter obtain and filter useful information that is happening in the organisation.

2. The Organisation Management System input all the information in an Excel sheet and upload it using the interface provided, which however for that model, the information was not accurate. This is because every single piece of information provided originated from the HR Information Systems (HRIS) where data are kept and maintained using different sorts of artefacts.

3. All the information is then processed and embedded into the Database.

4. The Machine Learning Model takes data from the database and trains the model to predict the number of leavers per month.

5. The Machine Learning Model then provides useful graphical information.

6. The information is reverted to the Organisation Management System or HR so that necessary measures can be taken.

7. HR cascades the information to respective managers for analysis and feedback.

8. Managers then relay the information to respective employees so that they find solutions that will improve work satisfaction in the workplace thus retaining employees.

9 The evaluation is thus cascaded back to Human Resources to act.

10 Ultimately, the Organisation Management System update the system with new data to monitor the progress of the organisation.

11 New graphs will be generated based on the new set of data. We can also track if there is any improvement being made based on the new set of data in comparison to the old set of data.

12 Useful information can be gathered more easily and quickly and made available to the Organization.

13 Organization can improve existing processes and work on better effective strategies and tactics based on all the feedback gathered.

14 Lastly, with such a system put in place, the organization will have the ability to create and maintain a supportive and collaborative environment.

4.6 Conclusion

This chapter has focused mainly on the framework while explaining its functionality, usage and connection between components. A brief introduction of the framework was provided followed by an overview of the process flow by explaining all the components and the benefits of the proposed architecture. The framework architecture was explained in detail in relation to MVC along with a deployment diagram also based on MVC have also described. There are several benefits of the proposed architecture. As the application will be hosted on a Cloud Platform, it will be easily accessible and highly available while providing an increase of performance of the platform. It will also allow admins to access the database and make instant modifications to the schema and the data. The architecture will help to build a solid foundation for the software project while making it easier for developers to create and enhance different modules of the application. Moreover, code reusability will be catered so that less time is needed to implement new features, hence reducing the development cost. The framework along with MVC as architectural pattern will provide developers with a better code maintainability where developers will find it easier to maintain the application, as the structure will be documented, known and made visible. Consequently, a higher adaptability will be easier to achieve as the architecture will provide a clear separation of concerns. In this manner, bugs and anomalies can easily be found and fix, thus providing clients with an increase in quality of the application and developers with an increase in quality of the platform.

Chapter 5.0: Implementation and Evaluation

5.1 Introduction

The main purpose of this chapter is to present the implementation of the proposed framework and to evaluate it using a real-life case study. A Learning organisation system is built to reflect the main functionalities and components of the framework. It also describes how a user can interact with the built system and hence assessing the results of the built prototype. It also considers each component of the application and how particular features can help to improve organisations.

The aim of implementing the framework is to make it possible for organisations to learn and adapt to changes of the new digital marketplace. It enables learning organisation to adapt and become non-intrusive and easy to use and propagate within the operational dynamics of the organisation. Also, it is important to mention that one of the best ways of achieving such result, is to automate the method of the learning organisation, wherever possible.

In this chapter a case study based on how employees in an organisation can be retained while enhancing the work environment as well as how to keep and improve employees' satisfaction in the company. Employees' attrition, retention and satisfaction have become critical aspects in an organisation where the organisation itself does not have any specific tool(s) to monitor or track those key aspects. Employees resign due to multiple reasons and therefore, organisations must invest heavily on their recruiting resources to look for new talents and cater to train them according to their different positions to be held in various departments across the company. In order to have better results and productivity, it is very important to keep the employees satisfied. Thus, we have come forward with this framework as explained in Chapter 4, whereby HR or Organisation Management System will not only be able to track the number of employees leaving the company, but also monitor on a daily, weekly or monthly basis how many employees are satisfied with their day to day job and whether they have any concerns or issues hindering them from performing or increasing their levels of productivity.

This chapter starts with a brief description of the case study, including the main issues and the potential solution. Then, a software tool which is constructed based on the proposed framework, is presented together with its main functionalities. The tool is used for the evaluation of the framework and the results are then presented. Finally, some conclusions are drawn.

A Learning Organisation Information System Tool has been built to automate and digitalise the core disciplines of the learning system to enable Organisations to learn from it and improve many processes of the business. Our tool will be used mainly by HR admins or Organisation Management System, Managers and Employees across the business.

5.2 The Case Study

The case study is based on HR or Operation Management System requirements to have a predicted number of leavers for the whole year and therefore to learn the reasons and how to improve retention. HR requires to know the number of employees predicted to leave at the end of the year or for a particular month based on new data and hence to analyse that information to formulate measures. The HR admins will have full access to all features of the system so that they can feed data, monitor and track different key aspects of the business while managers will have restricted access to certain features. The designated features will help managers to better communicate and facilitate their employees' tasks and address any concerns. On the contrary, employees will have limited access to the system where they can only monitor their mood on a daily, weekly and monthly basis and log any work-related concerns.

The application of the Learning Organisation Information System 'LOIS' framework is based on two vital aspects; Attrition and Retention. The goal is to allow the organization to learn and grow by potentially decreasing the Attrition and increasing the Retention rates. We shall now move forward by applying some machine learning techniques as discussed in the literature review to help the organization predict the number of leavers in a month regarding the Attrition rates. Subsequently, for the Retention rates, interfaces such as surveys and monitoring of the employees' mood on a weekly or daily basis are implemented. Both agents will cohesively create a prototype to facilitate and enhance the use of the learning organisation.

As mentioned before, the application will consist of two important machine learning algorithm agents (explained in more details in Chapter 3.0) namely the K-means algorithm and Time Series Prediction algorithm. K-means algorithm will cluster and classify the data into three different categories; Low, Medium and High to formulate graphs on the number of people leaving per month to the sum of number of years of experience of all leavers for that month. Time Series Prediction will forecast how many employees can leave over a certain period while taking measures to retain the leavers and thus enhancing work satisfaction for the current employees in the organization. Measures to address the events will be formulated by the users through analysing the patterns produced by the algorithms. The mentioned algorithm will be the core aspect of the solution and will be vital to eliminate the need for the manual effort to analyse the events, thus making the solution for the learning organisation less intrusive. It has been proven that data-driven companies in their top third of their industries are on average, 5% more productive and 6% more profitable than their competitors [44].

The proposed solution will be based on the following steps:

1. Building an information system prototype just like the Human Resource Information System (HRIS) mentioned above, that will allow employees to record events (mood on a daily and weekly basis and other concerns) through a UI, and the events will be structured and stored in a database.
2. Input data into the database using an Interface.
3. Use algorithms as mentioned above to identify from the list of events/data logged and categorise or cluster the patterns with the appropriate names.
4. Provide an intuitive UI for the user to analyse and assess graphs on the number of employees leaving over a period of time so that they can formulate the measures or solutions to be implemented to retain employees and enhance employees' satisfaction in a company.
5. The prototype is simple, user friendly and non-intrusive enough for the employees to repeat the whole process.
6. The system supports high level of accessibility i.e. web based for easy entry to all employees of the organisation.

The flow on how HR can use the proposed LOIS to formulate the identified earlier course of actions and measures is shown in Figure 5.1.

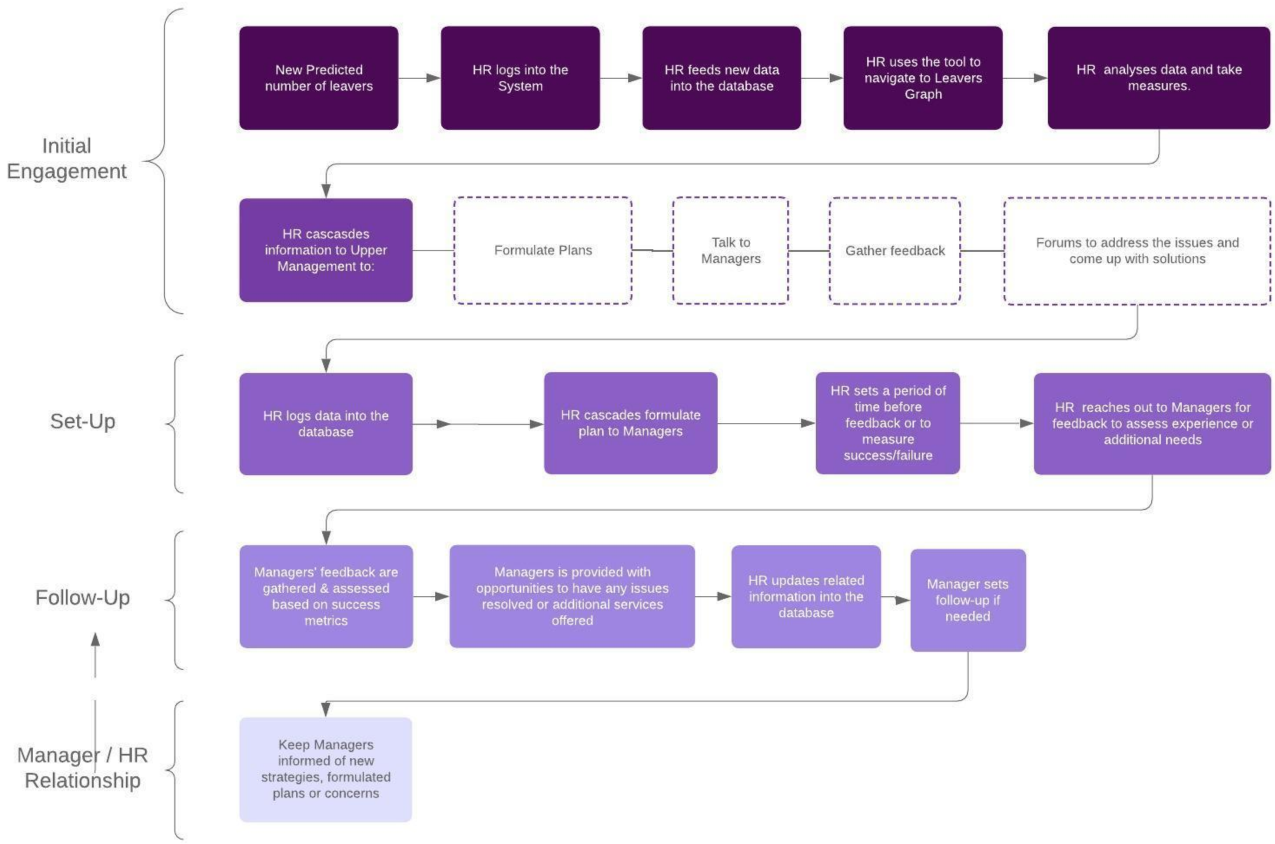


Figure 5.1: Using LOIS to formulate measures based on predicted number of leavers.

5.3 LOIS Tool - MVC

LOIS will automate and digitalised the disciplines of the learning organisation and is built as an instance of the proposed framework and aims to include its main components (Figure 5.2). The application will embed different components and layers including the Presentation Layer that contains the UI/UX Components and MI Dashboard; the Event Handler, the Clustering Algorithm Agent, Predictive Analytics, Configuration and Common Utilities, Advanced Event Parser, DB Access Manager and DB Core.

VIEW

Presentation Layer: This component of the architecture holds the UI Layout which has to be simple and easy to use for the employees to quickly adopt the tool. As MVC (Model-View-Controller) will being used as the architectural pattern for building the LOIS tool, the View represents the presentation layer and will contain all the ".html" files.

UI/UX Components: This component of the architecture handles of the UI construct and UI workflow required to manage the UI transition as the user interacts with the system. The User Experience UX has to be intuitive so as to encourage and attract employees to use the tool. The UI/UX Components form part of the Presentation Layer where different components of the UI/UX can be used within the Views' files itself. The UI/UX Components will hold all the ".css" files.

MI Dashboard: The dashboard which also forms part of Presentation Layer provides analytics on the usage, utility, user adoption rate and the historical data of the CRUD learning organisation application. The analytics is vital to validate if the tool is being used correctly and repeatedly and helps to show the progress of the organisation to learn and adapt.

CONTROLLER

Event Handler: This component of the architecture provides the capability for the user to record an event using the Presentation Layer, and then stores the event into a defined structure by communicating to the Model. The Event Handler represents the Controller.

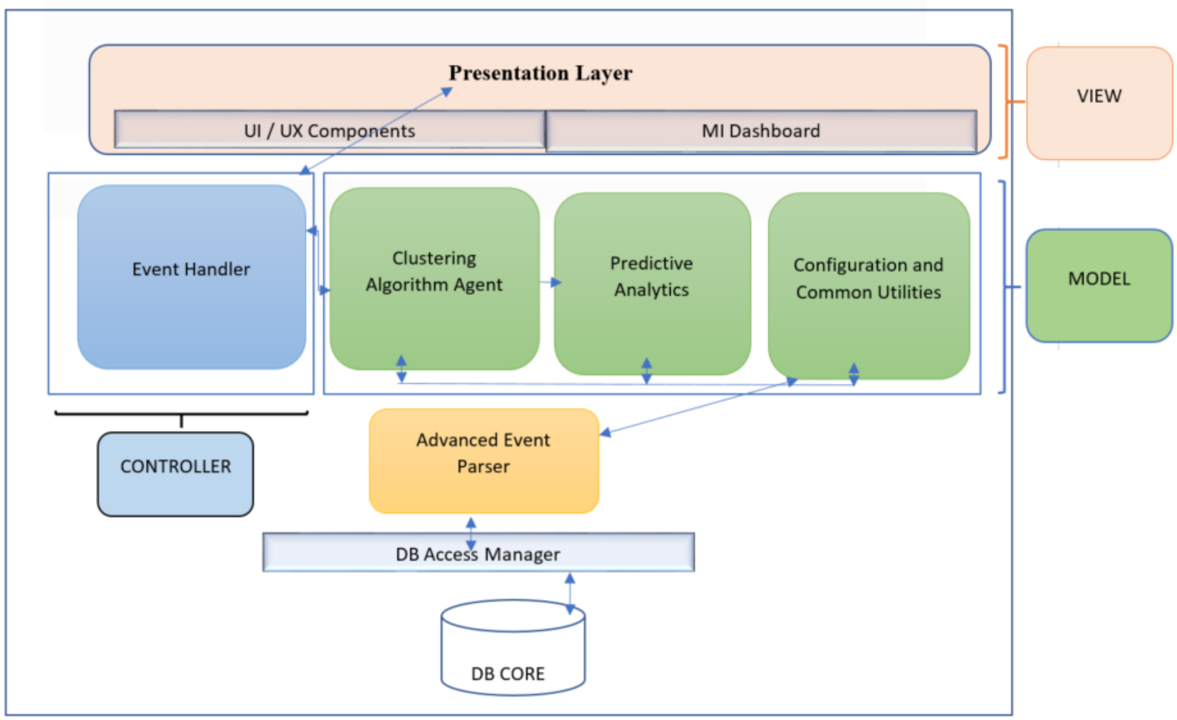


Figure 5.1: Architecture of the Solution proposed for LOIS

MODEL

Clustering Algorithm Agent: This component of the architecture holds the algorithm to identify keywords that defines the common properties of the events and clusters them into groups. The clustering recognition algorithm agents can access the new events from the Presentation Layer to the Event Handler or existing events from the DB Core to the Advanced Event Parser and then clustered the data into groups and passes them to the Predictive Analytics component.

Predictive Analytics: This component of the architecture uses clustered data from the Clustering Algorithm Agent and make prediction on those data. The data is then passed to the Configuration and Common Utilities Component.

Advanced Event Parser: This component of the architecture is a parser that employs algorithms that parse through the events that is already stored in the DB core, and it accessed the DB core by communicating through the DB Access Manager. The output of the parsed algorithm is provided to the Clustering Algorithm Agent. The Advanced Event Parser also get data from the Configuration Utilities.

Configuration and Common Utilities: This component of the architecture handles all the utilities required to configure the parsers and other parts of learning organisation software tool. It includes files that have different methods that are re-usable throughout the application. It also gets data from the Predictive Analytics Component to save into the DB and can also sends data back to the Event Handler Component.

DB Access Manager and DB Core: The DB Access Manager, handles all the communication and CRUD (Create, Read, Update and Delete) operations to the DB Core. The DB Core is the core database of the software application for learning organisation.

5.3.1 User Interaction

User interaction describes the many features that LOIS contains and how a user can use the tool as described below in section 5.4 LOIS Tool chapter 5. The features make use of different components and are described as follow: 1). Follow up, 3). Issues, 4). Leavers, 5). Mood and 6). Import to Database use the Presentation Layers including the UI/UX Component, Event Handler, Configuration and Common Utilities, Advanced Event Parser and DB Access Manager and Core whereas the 2). Live Graph feature tab uses all the components listed and the Clustering Algorithm Agent and Predictive Analytics.

The Main Menu:

The Main Menu as stated above contains different sections that a user can use to navigate the application or tool, including; 1). **Follow up**: This is where a manager and an employee can follow up or view conversations that have already been discussed between them, 2). **Live Graph**: This is where an HR person can view Attrition/Retention Graphs based on actual data from the DB and formulate measures to retain employees, 3). **Issues**: This is where an admin person can log an Action to be taken and can also be used by an employee to log any issue(s) happening, 4). **Leavers**: Is where an HR can view all the leavers per department across the company and why are employees leaving based on five already pre-defined reasons, 5). **Mood**: Where an employee can measure and track his or her mood on a weekly/daily basis. This tab can also be used by a manager to export the list of results in a PDF format, 6). **Import to Database**: Is where an admin can import data directly into the database from an Excel Sheet.

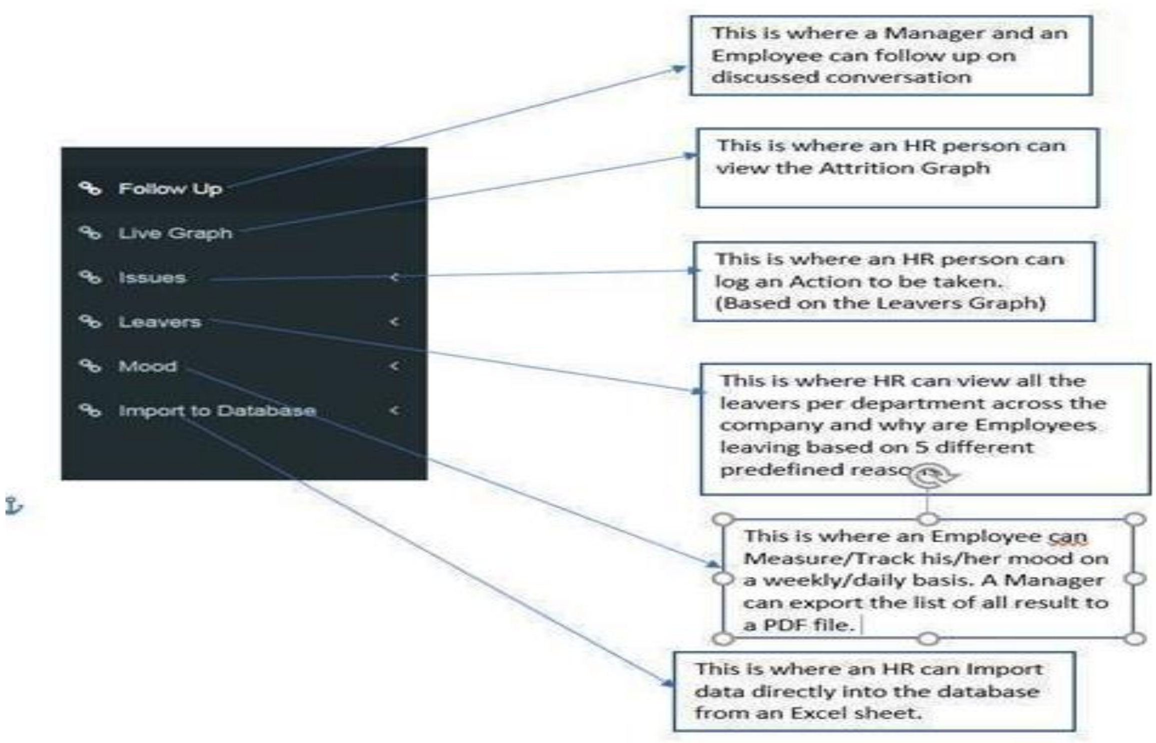


Figure 5.3: The Menu and Features

<u>Logging an Issue or a Concern:</u> This is shown in figure 5.4 which shows the interface that provides HR admins with a Create button where they can add any new observation while exploring and analysing the graph.

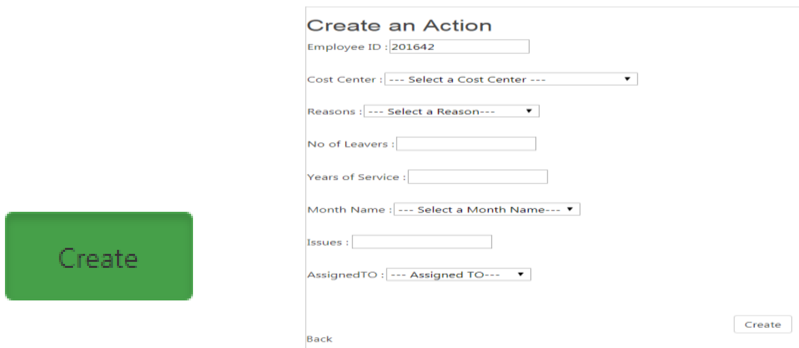


Figure 5.4: Create an Action

<u>View, Edit & Delete Action Events:</u> Figure 5.5 show the screen that allows a user to View, Edit and Delete all the Action Events. Moreover, they can mark all resolved events using resolved check box. Furthermore, they have the 'Assigned To' option where an administrator can assign a Task to himself/herself or someone else on the Team.

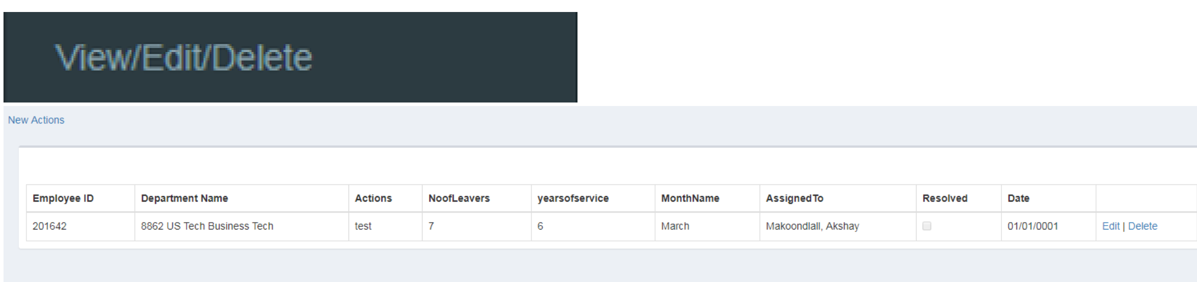
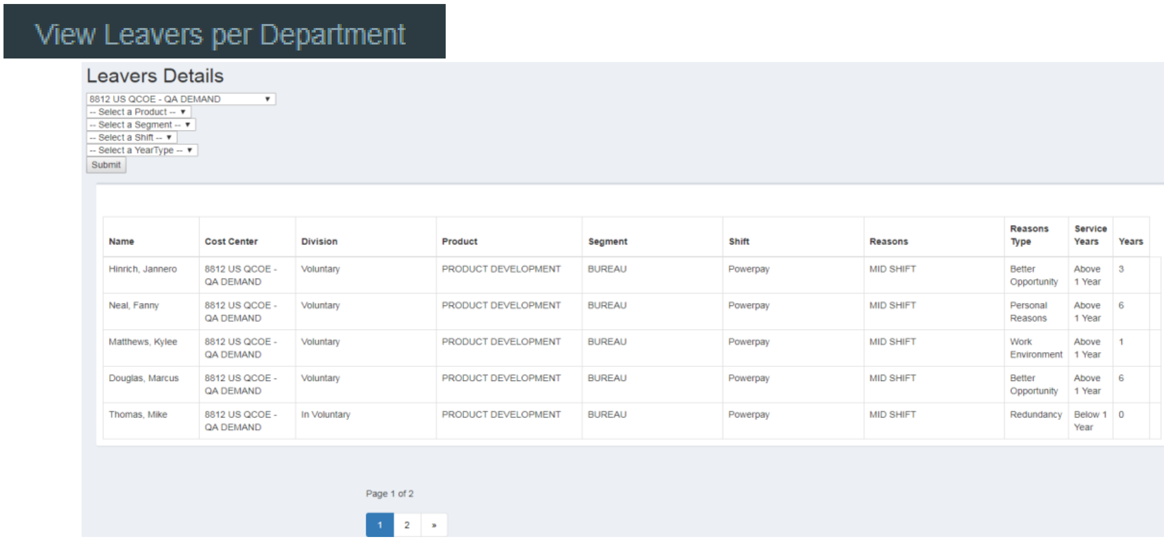


Figure 5.5: View, Edit & Delete Action Events

<u>The Leavers Tabs:</u> This is shown in Figure 5.6 is the interface where the Organisation Management System or someone with access rights to this feature, can use to explore the number of people leaving per department, per product, per segment, per shift and per year type. Based on that, the person will be able to formulate measures accordingly.



Name	Cost Center	Division	Product	Segment	Shift	Reasons	Reasons Type	Service Years	Years
Hinrich, Jannero	8812 US QCOE - QA DEMAND	Voluntary	PRODUCT DEVELOPMENT	BUREAU	Powerpay	MID SHIFT	Better Opportunity	Above 1 Year	3
Neal, Fanny	8812 US QCOE - QA DEMAND	Voluntary	PRODUCT DEVELOPMENT	BUREAU	Powerpay	MID SHIFT	Personal Reasons	Above 1 Year	6
Matthews, Kylee	8812 US QCOE - QA DEMAND	Voluntary	PRODUCT DEVELOPMENT	BUREAU	Powerpay	MID SHIFT	Work Environment	Above 1 Year	1
Douglas, Marcus	8812 US QCOE - QA DEMAND	Voluntary	PRODUCT DEVELOPMENT	BUREAU	Powerpay	MID SHIFT	Better Opportunity	Above 1 Year	6
Thomas, Mike	8812 US QCOE - QA DEMAND	In Voluntary	PRODUCT DEVELOPMENT	BUREAU	Powerpay	MID SHIFT	Redundancy	Below 1 Year	0

Figure 5.5: View Leavers per Department

The import Tab: Figure 5.6 is the screen that allows the Organisation Management System to import any excel sheet to the database to be able to feed new data.

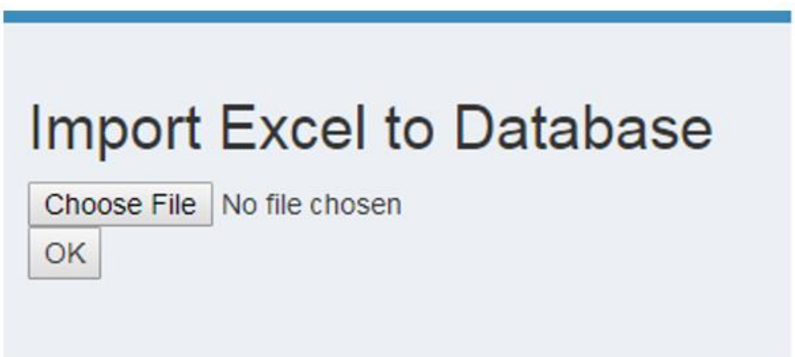


Figure 5.6: Import to Database

The Mood Tab: Figure 5.7 is the feature that allows a manager or the Organisation Management System person to view the mood results of all his/her employees. We have also added an "Export to PDF" option where the result can be exported to pdf, especially for presentation purposes, shown in Figure 5.8.

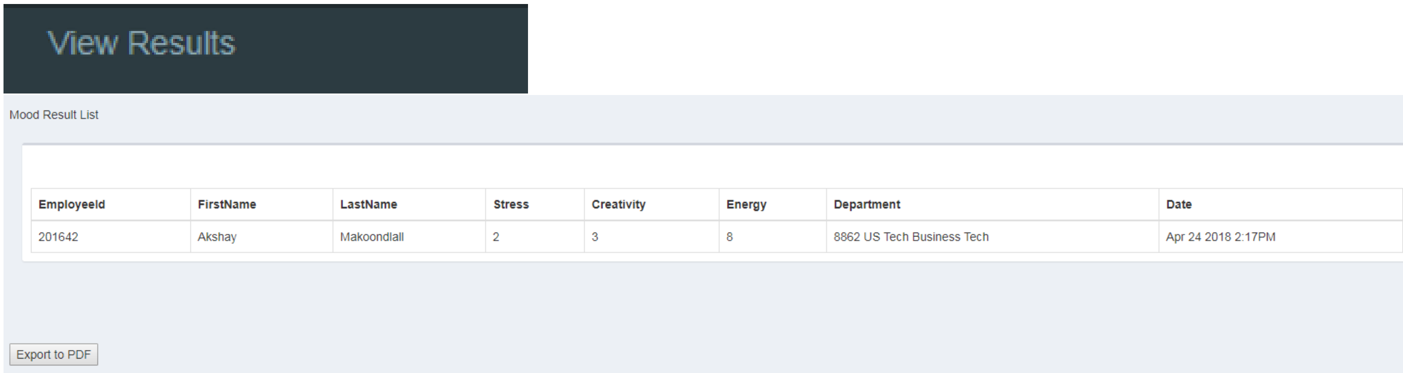


Figure 5.7: View Mood Result

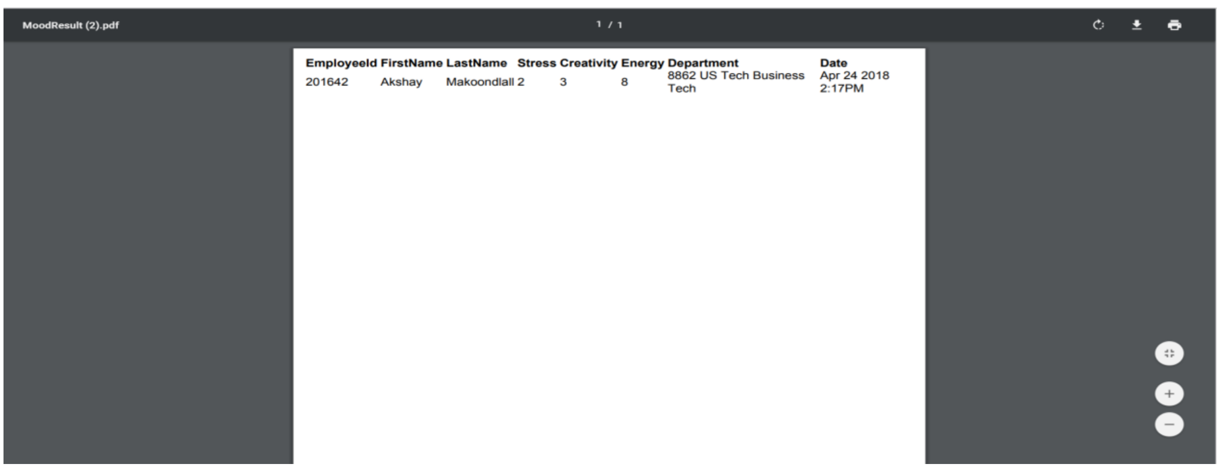


Figure 5.8: View Mood Result on PDF format

5.3.2 Feature to measure mood in a Workplace

The tool will provide users with an interface in form of a questionnaire that they will be encouraged to fill on a daily and weekly basis. The result will be monitored and communicated to their direct manager and thereafter, measures will be formulated to work on a plan according to the mood index of the employee (Figure 5.9).

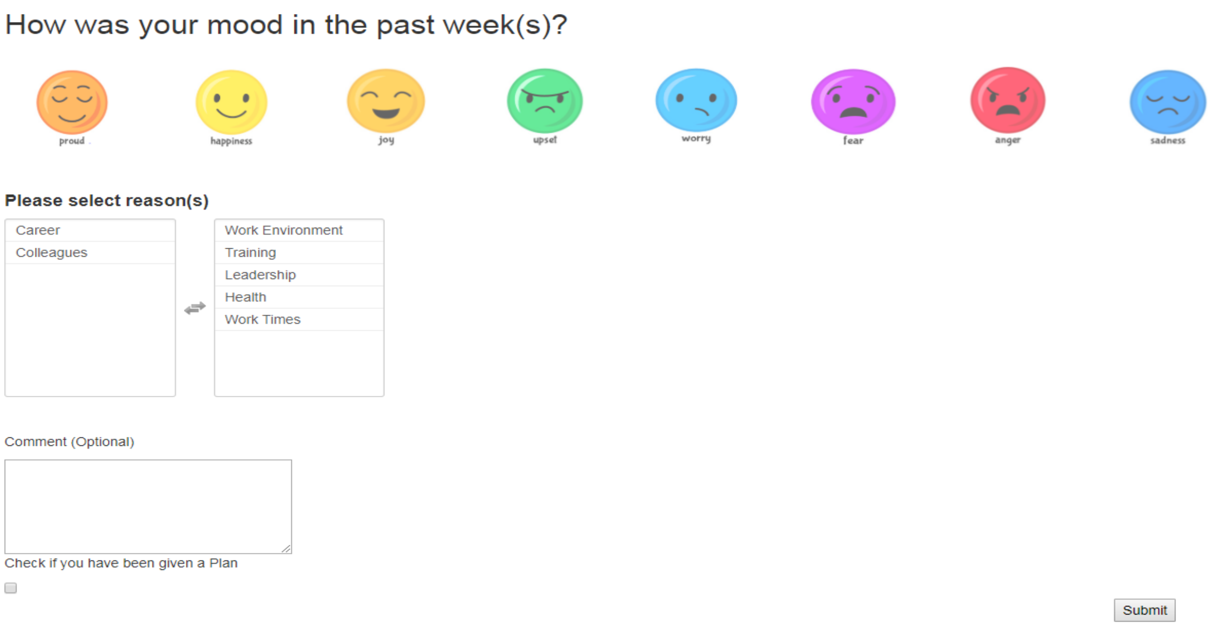


Figure 5.9: Capturing Employees' mood on a Weekly basis.

Reasons to reflect the person's mood on a designated day are included and a comment text area is also provided, whereby a user can give their feedback on the matter (Figure 5.10).

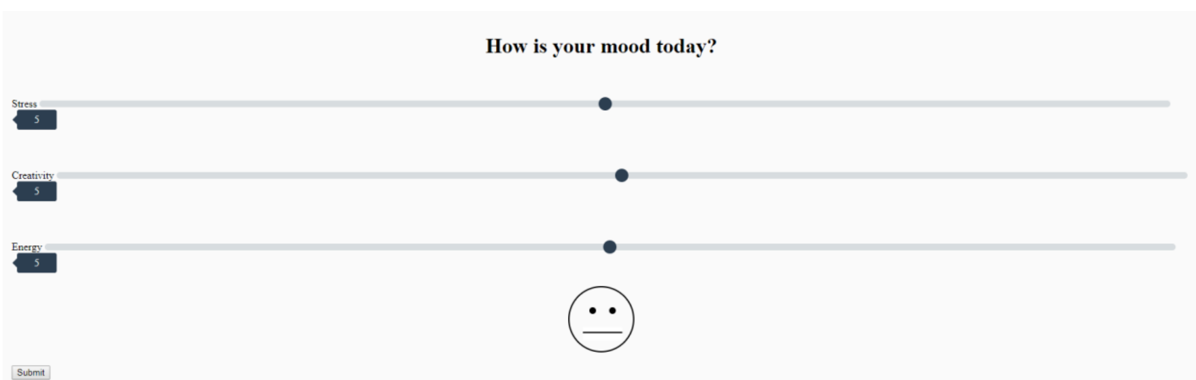
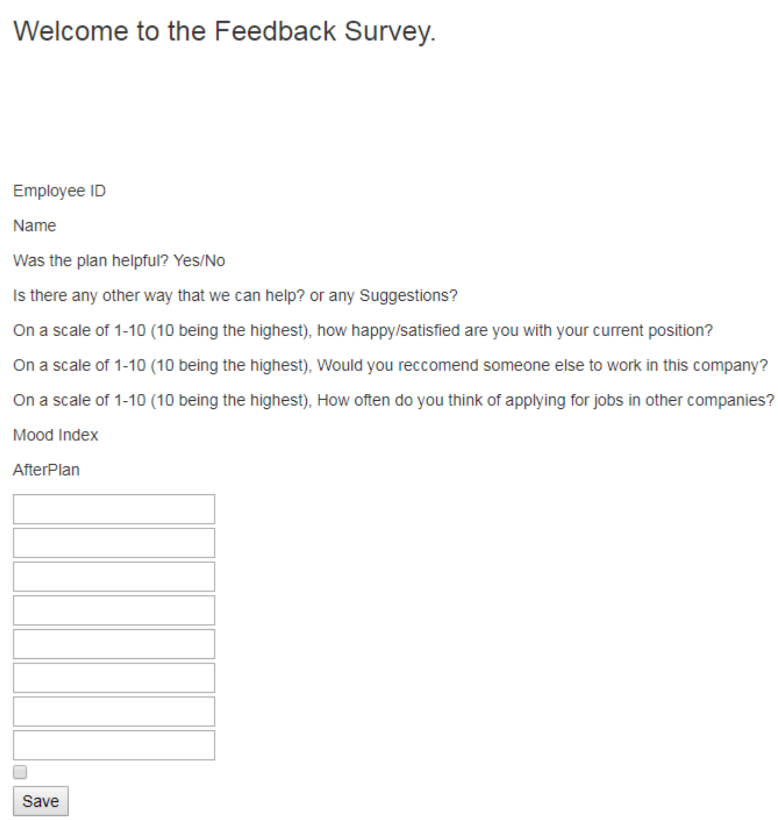


Figure 5.10: Capturing Employees' mood on a daily basis.

The Organisation Management System will also be able to monitor the number of people leaving and for which reasons (The reasons are pre-defined already: Better Opportunity, Limited career progression, Personal Reasons, Redundancy, Work Environment, Work Life Balance) per department. Graphs will be formulated to know how many people are resigning per month per reasons and how many people are predicted to leave over a period of time that will help to work on different actions plan.

The data obtained will be used to explore the effects between the mood of an employee in an organization and the number of employees that are unhappy in their current position, hence resulting in retaining employees in an organization and enhancing a work life balance, at the expense of productivity.

It is said that a good mood results in improving productivity in the workplace. Companies heavily invest on employees' mood in different ways such allowing more time off, flexible working hours, team building outside the work areas, office celebrations and events. However, no proper tool is available to monitor the employees' mood and to track how they are feeling on a daily (Figure 5.9) or weekly basis (Figure 5.10), hence enabling to work on different plans to cater for their needs.


Welcome to the Feedback Survey.

Employee ID

Name

Was the plan helpful? Yes/No

Is there any other way that we can help? or any Suggestions?

On a scale of 1-10 (10 being the highest), how happy/satisfied are you with your current position?

On a scale of 1-10 (10 being the highest), Would you reccomend someone else to work in this company?

On a scale of 1-10 (10 being the highest), How often do you think of applying for jobs in other companies?

Mood Index

AfterPlan

Save

Figure 5.11: Feedback Survey Questionnaire

After a period of time, the employee will be provided with a feedback survey page as shown in Figure 5.11 below to monitor if the plan that was provided was efficient and thus a graph will be formulated as well.

Following table shows Employees Survey Details

Click here to create a new Survey!!.

Employee ID	Name	Was the plan helpful? Yes/No	Is there any other way that we can help? or any Suggestions?	On a scale of 1-10 (10 being the highest), how happy/satisfied are you with your current position?	On a scale of 1-10 (10 being the highest), Would you reccomend someone else to work in this company?	On a scale of 1-10 (10 being the highest), How often do you think of applying for jobs in other companies?	Mood Index	AfterPlan	
2016421	Akshay Makoondlall	Not yet given	Not yet	2	0	8	5	False	Update Delete
2016421	Akshay Makoondlall	Yes	None yet	7	0	3	8	True	Update Delete

Figure 5.12: Feedback Survey Details

Figure 5.12 shows the feedback survey details before and after a formulated plan was provided to the employee. The "False" value under the "AfterPlan" column is when a plan was not given to the employee while the "True" value is after the plan has been given to them. The weightage for the other questions on the form can be used to calculate other index such as Engagement Index, Employee Engagement Index etc. As we can see the mood changed from 5 to 8 after a plan was formulated (Figure 5.13).

Figure 5.13**:** Mood Index

An update survey details interface, Figure 5.14, where an employee will be able to update his details.

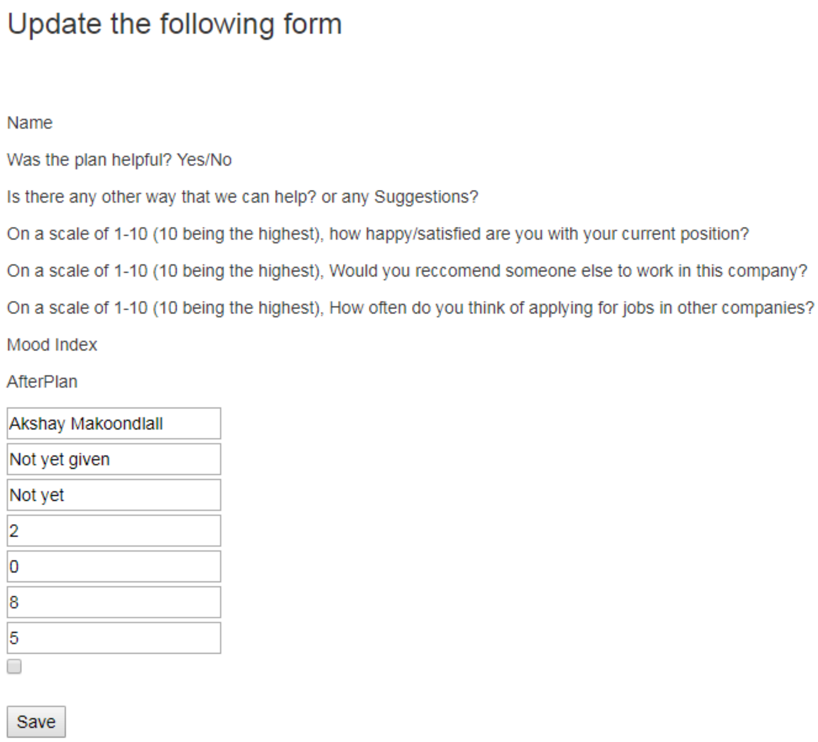


Figure 5.14: Update Survey Details

Figure 5.15 is the screen that uses machine learning algorithms such as K-Means algorithm combined with Time Series Prediction to explore the number of people leaving the company and predict how many employees are about to resign over a series of time per reasons (The reasons are already pre-defined as mentioned above).

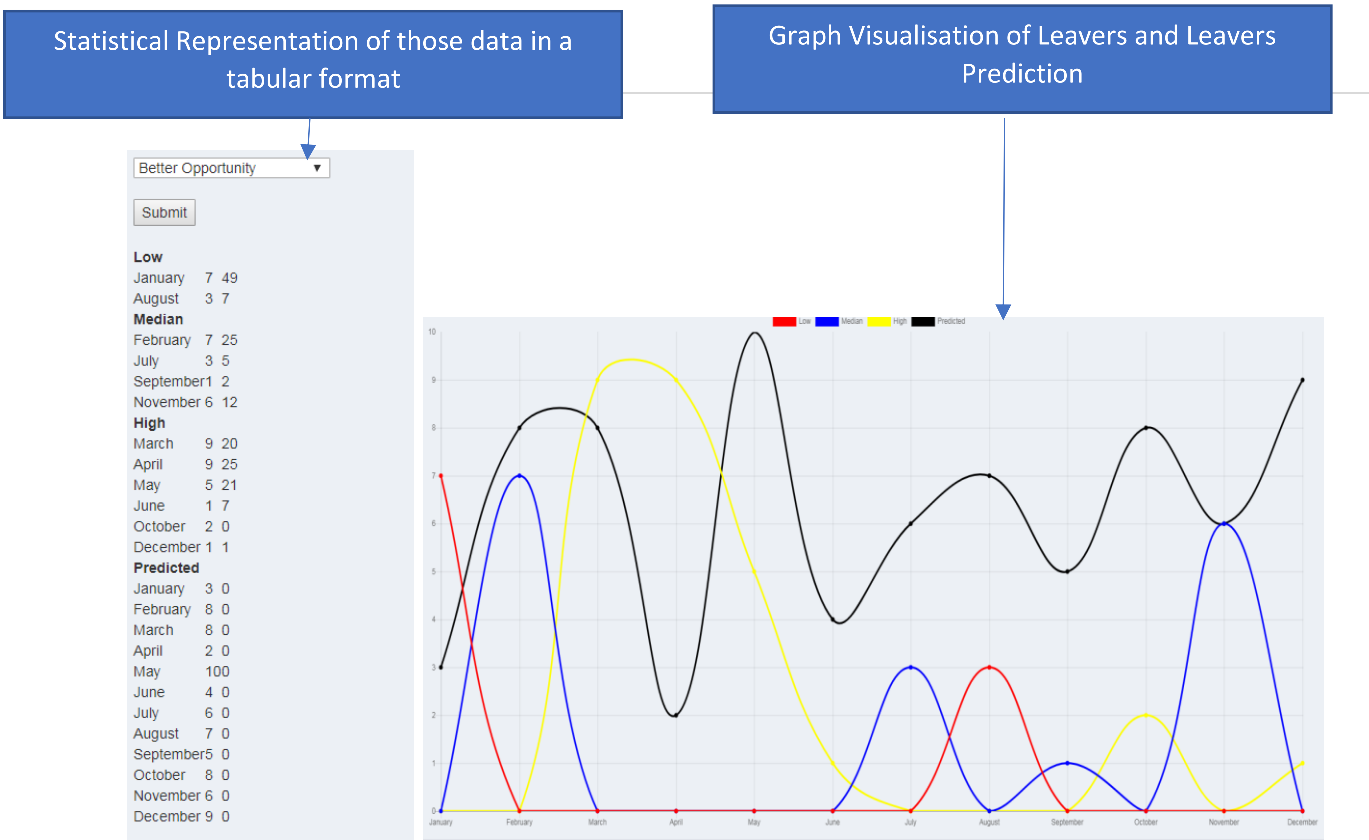


Figure 5.15: View number of predicted leavers per reasons

5.4 Results Analysis and Discussion

In the following experiments we have four sets of data including: 1. Better Opportunity, 2. Personal Reasons, 3. Work Environment, 4. Work Life Balance. The dataset depends on the reasons why the person is leaving. We have tested the data by variating the number of hidden layers starting from 1 to 5. As you can see below, the predicted number varies accordingly. The system only calculated the predicted number based on the number of leavers and the combined years of service is not taking into consideration while doing the prediction. The combined years of service will be impossible to predict in this particular scenario as it will be difficult to make prediction on the combined years of service of employees. Example: An employee can leave after 5 years and 5 employees can leave after one year. The years of service will be counted as 5 in both scenarios but will not reflect the number of leavers.

After clustering the data into three different categories: Low, Medium and High, we have used the Time Series algorithm to make prediction on those data. The system takes the number of leavers as input and the outcome number comes out as the predicted number. In between the Input and the output, we have from 1 to 5 nodes (Hidden Layers) as explained in **Section 3.7 Neural Network Chapter 3** above. It is the number of nodes that determine the accuracy of the outcome. The higher the number of node the more complex the system get and the less accurate the outcome can be. Below is some graphical reasons of the K-means algorithm and the Time Series Prediction algorithm put together.

Number of Hidden Layers: 1

Reasons for leaving: Better Opportunity

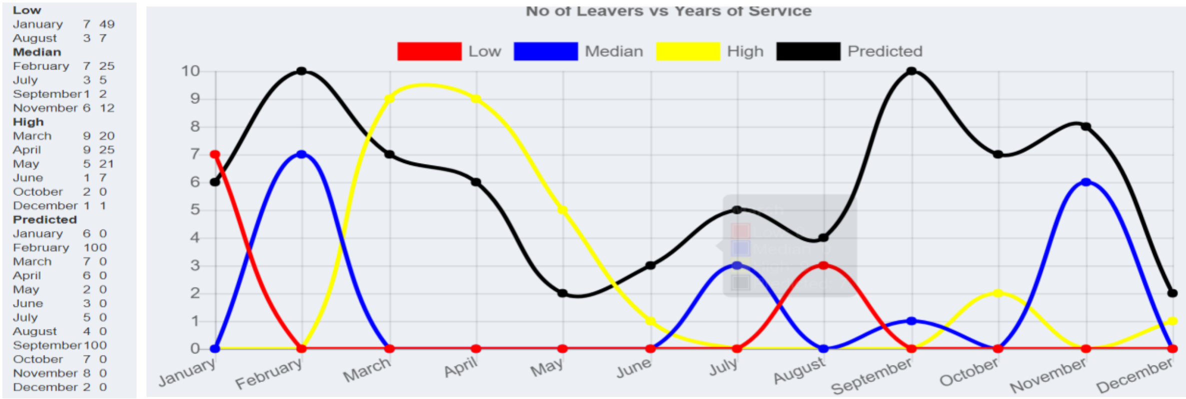


Figure 5.16: Number of Leavers v/s Years of Service for 1 Hidden Layer and Better Opportunity as Reason

Number of Hidden Layers: 1

Reasons for leaving: Personal Reasons

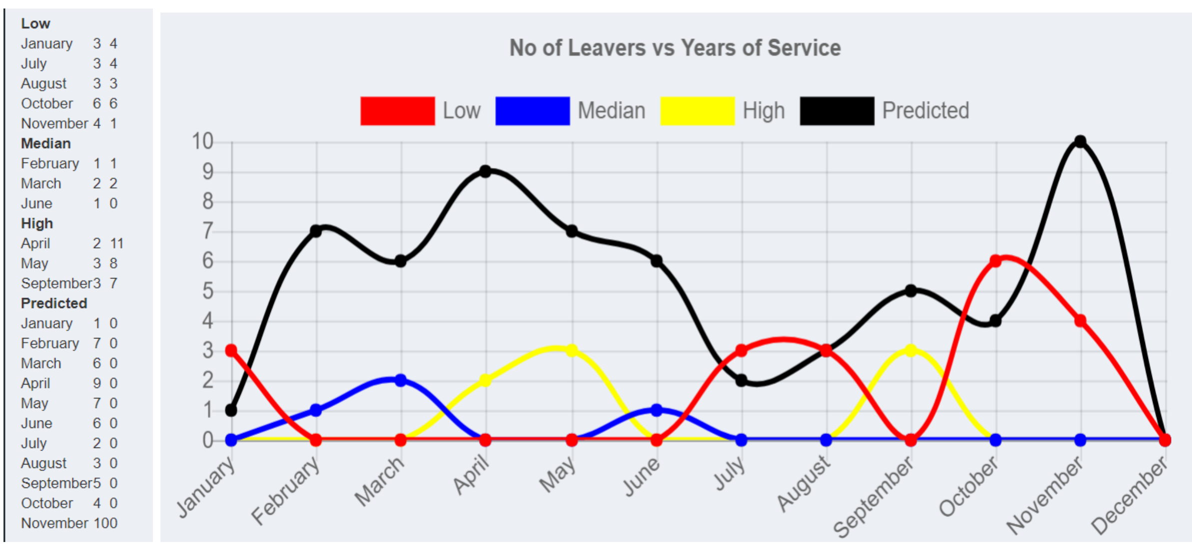


Figure 5.17: Number of Leavers v/s Years of Service for 1 Hidden Layer and Personal Reasons as Reason

Number of Hidden Layers: 1

Reasons for leaving: Work Environment ▾

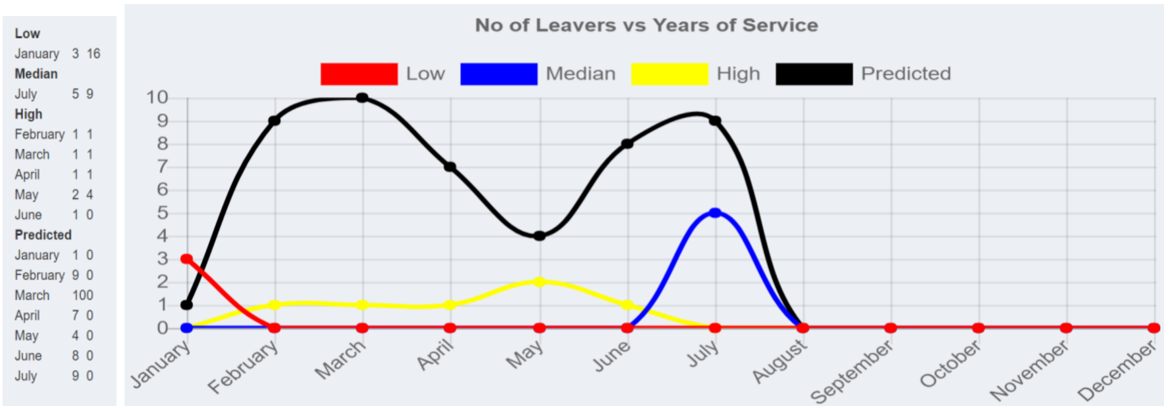


Figure 5.18: Number of Leavers v/s Years of Service for 1 Hidden Layer and Work Environment as Reason

Number of Hidden Layers: 1

Reasons for leaving: Work Life Balance ▾

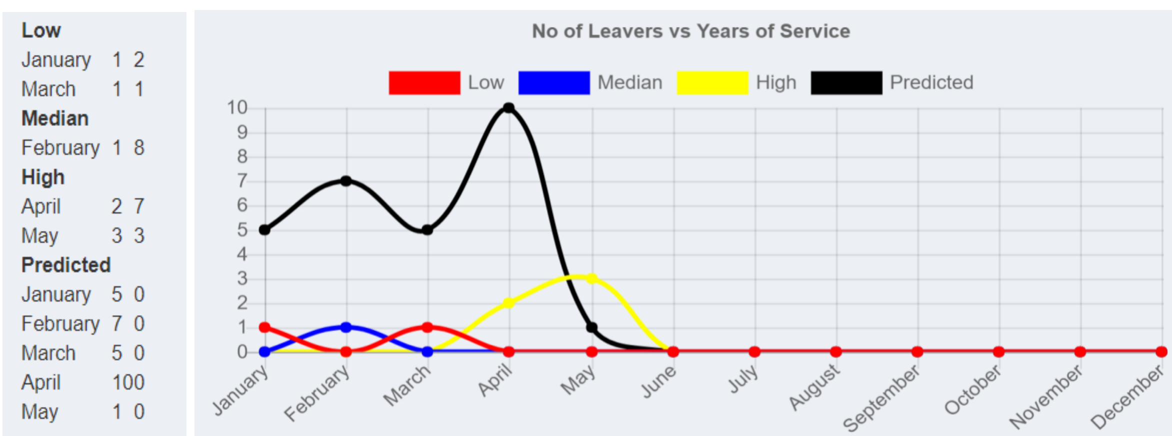


Figure 5.19: Number of Leavers v/s Years of Service for 1 Hidden Layer and Work Life Balance as Reason

The application has been trained to use only 1 hidden layer and different reasons for leaving where each reason represents a specific set of data compared to the other reasons. The next scenario is to increase the number of hidden layers to 2 but use the same set of reasons (data) as the first scenario.

Number of Hidden Layers: 2

Reasons for leaving: Better Opportunity

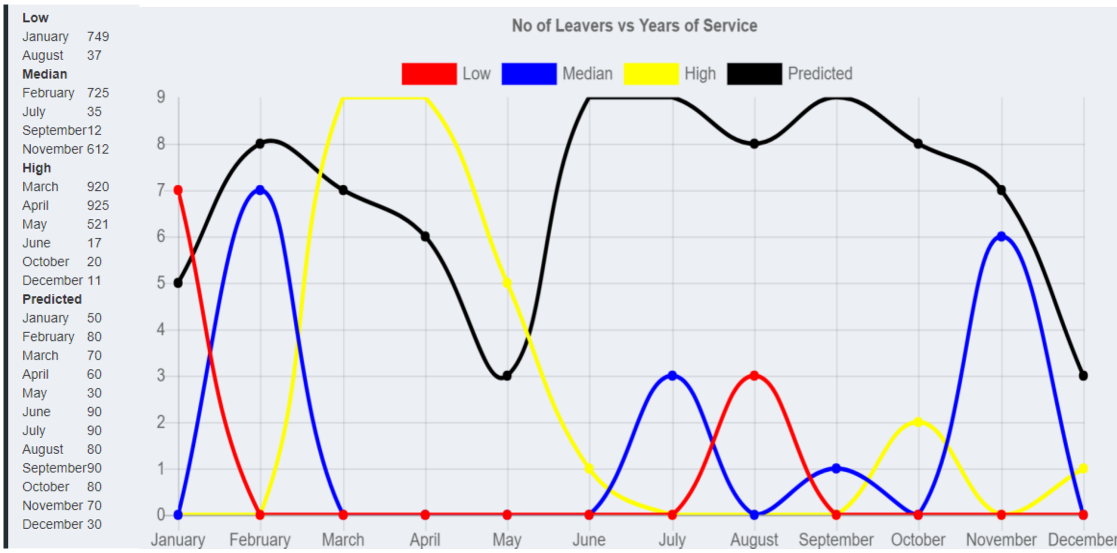


Figure 5.20: Number of Leavers v/s Years of Service for 2 Hidden Layers and Better Opportunity as Reason

Number of Hidden Layers: 2

Reasons for leaving: Personal Reasons

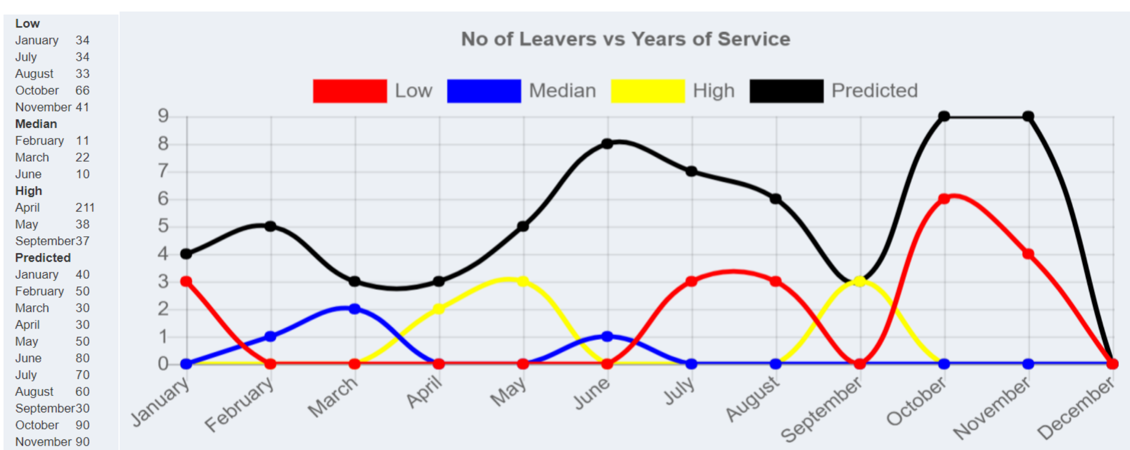


Figure 5.21: Number of Leavers v/s Years of Service for 2 Hidden Layers and Personal Reasons as Reason

Number of Hidden Layers: 2

Reasons for leaving: Work Environment

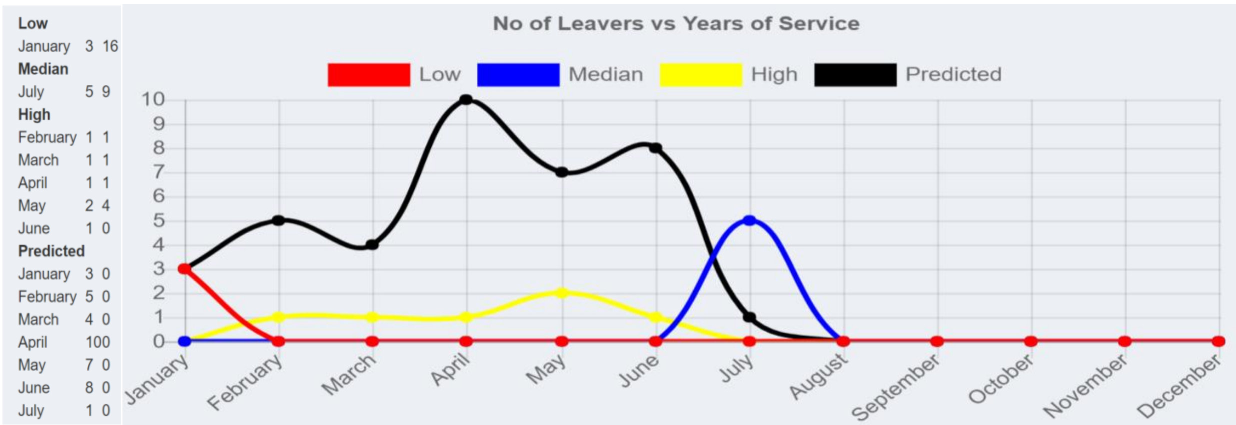


Figure 5.22: Number of Leavers v/s Years of Service for 2 Hidden Layers and Work Environment as Reason

Number of Hidden Layers: 2

Reasons for leaving: Work Life Balance

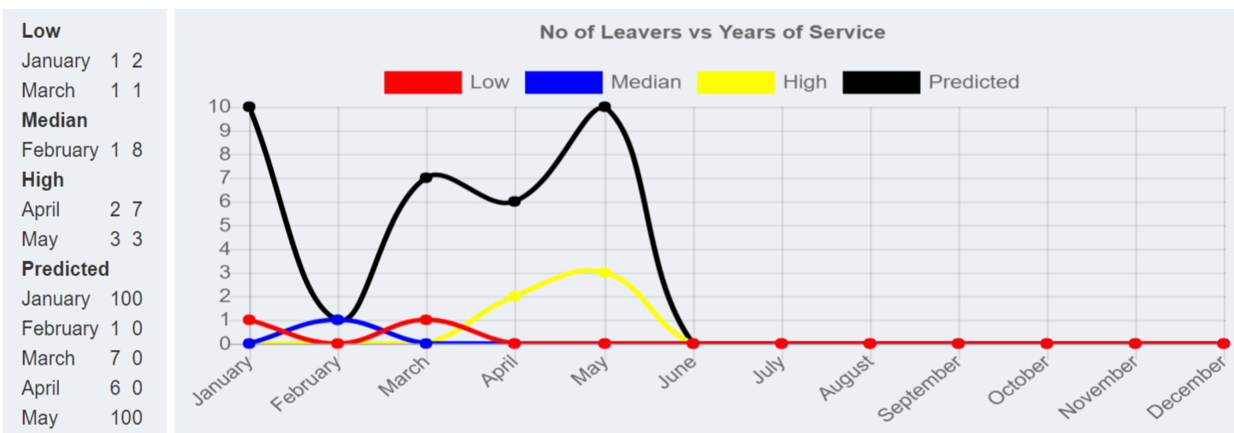


Figure 5.23: Number of Leavers v/s Years of Service for 2 Hidden Layers and Work Life Balance as Reason

The application has been trained to use 2 hidden layers and different reasons for leaving where each reason represents a specific set of data compared to the other reasons. The next scenario is to increase the number of hidden layers to 3 but use the same set of reasons as the first and second scenarios.

Number of Hidden Layers: 3

Reasons for leaving:

Figure 5.24: Number of Leavers v/s Years of Service for 3 Hidden Layers and Better Opportunity as Reason

Number of Hidden Layers: 3

Reasons for leaving:

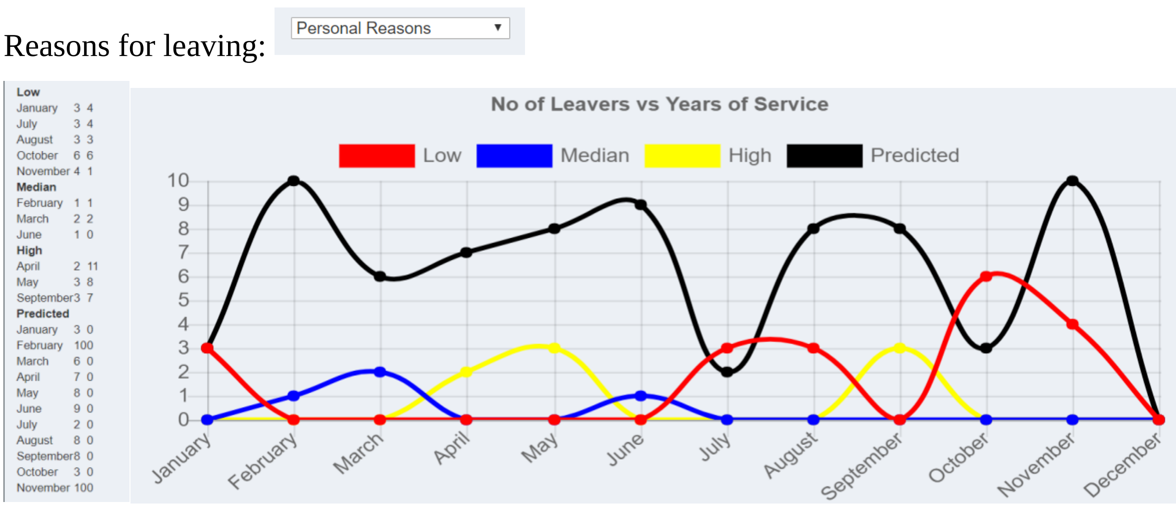


Figure 5.25: Number of Leavers v/s Years of Service for 3 Hidden Layers and Personal Reasons as Reason

Number of Hidden Layers: 3

Reasons for leaving: Work Environment

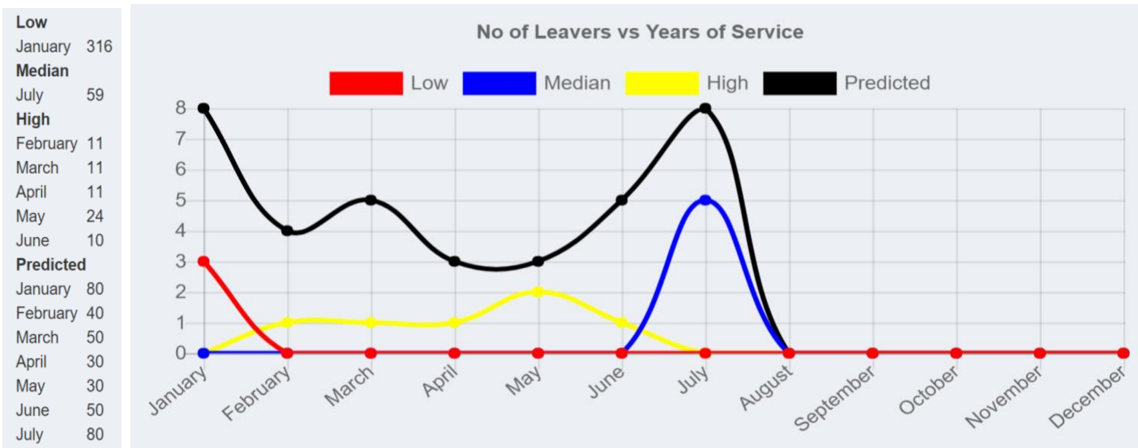


Figure 5.26: Number of Leavers v/s Years of Service for 3 Hidden Layers and Work Environment as Reason

Number of Hidden Layers: 3

Reasons for leaving: Work Life Balance

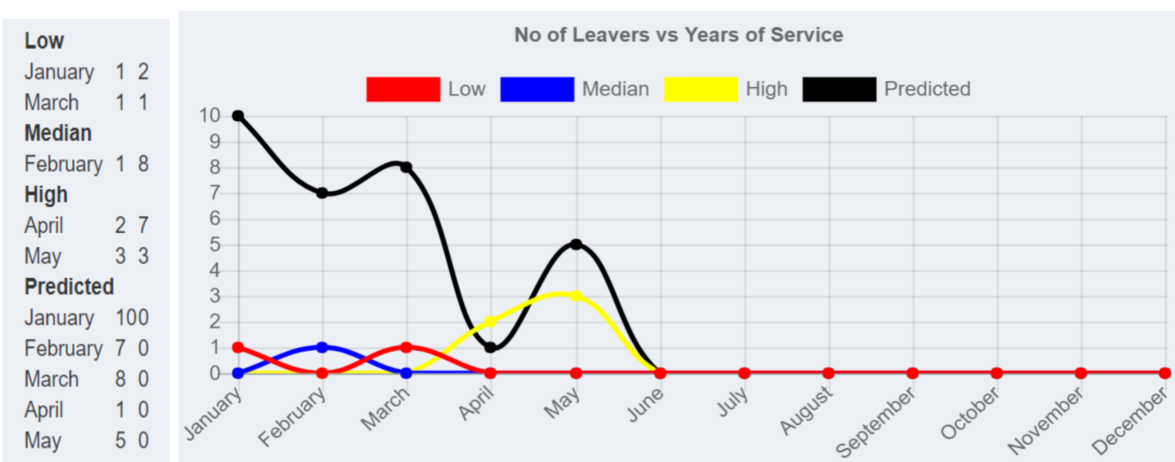


Figure 5.27: Number of Leavers v/s Years of Service for 3 Hidden Layers and Work Life Balance as Reason

The application has been trained to use 3 hidden layers and different reasons for leaving where each reason represents a specific set of data compared to the other reasons. The next scenario is to increase the number of hidden layers to 4 but use the same set of reasons as the previous scenarios.

Number of Hidden Layers: 4

Reasons for leaving: Better Opportunity

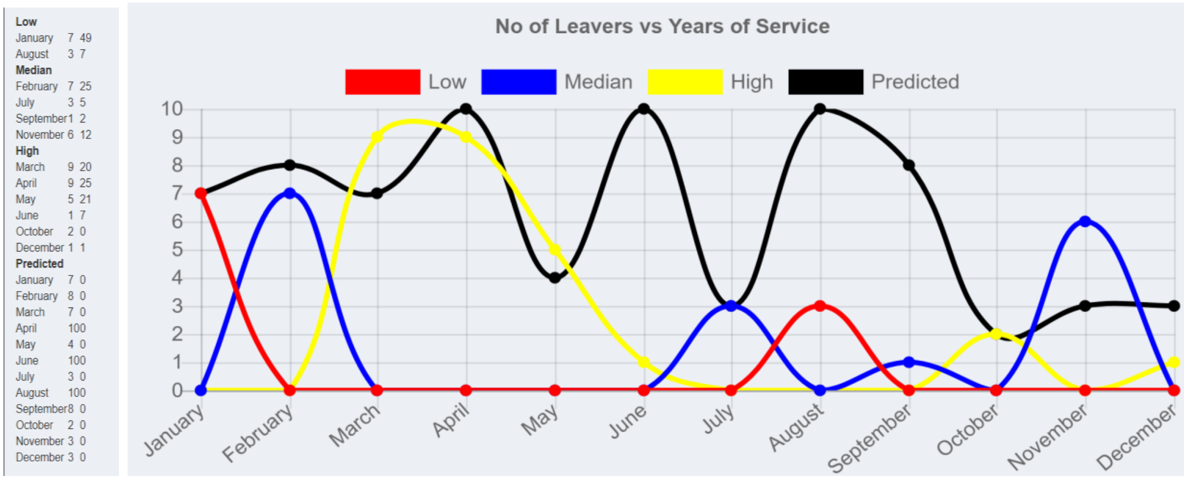


Figure 5.28: Number of Leavers v/s Years of Service for 4 Hidden Layers and Better Opportunity as Reason

Number of Hidden Layers: 4

Reasons for leaving: Personal Reasons

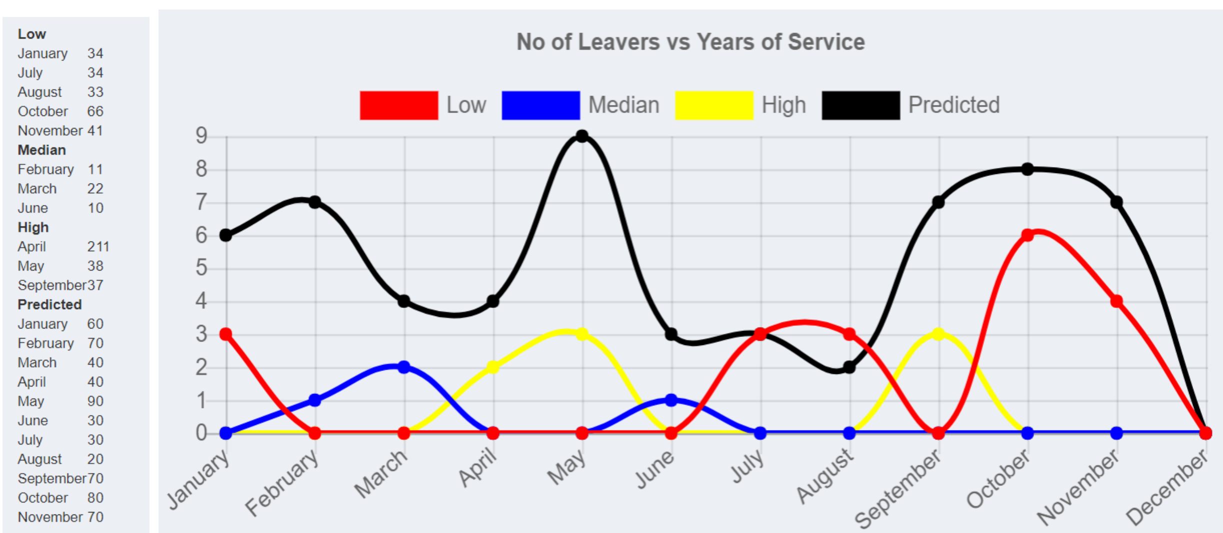


Figure 5.29: Number of Leavers v/s Years of Service for 4 Hidden Layers and Personal Reasons as Reason

Number of Hidden Layers: 4

Reasons for leaving: Work Environment

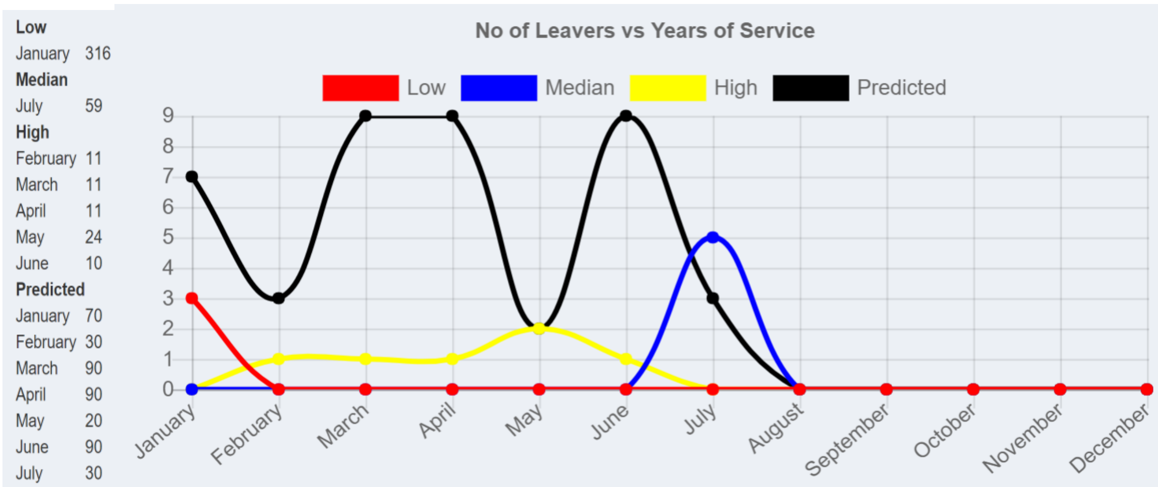


Figure 5.30: Number of Leavers v/s Years of Service for 4 Hidden Layers and Work Environment as Reason

Number of Hidden Layers: 4

Reasons for leaving: Work Life Balance

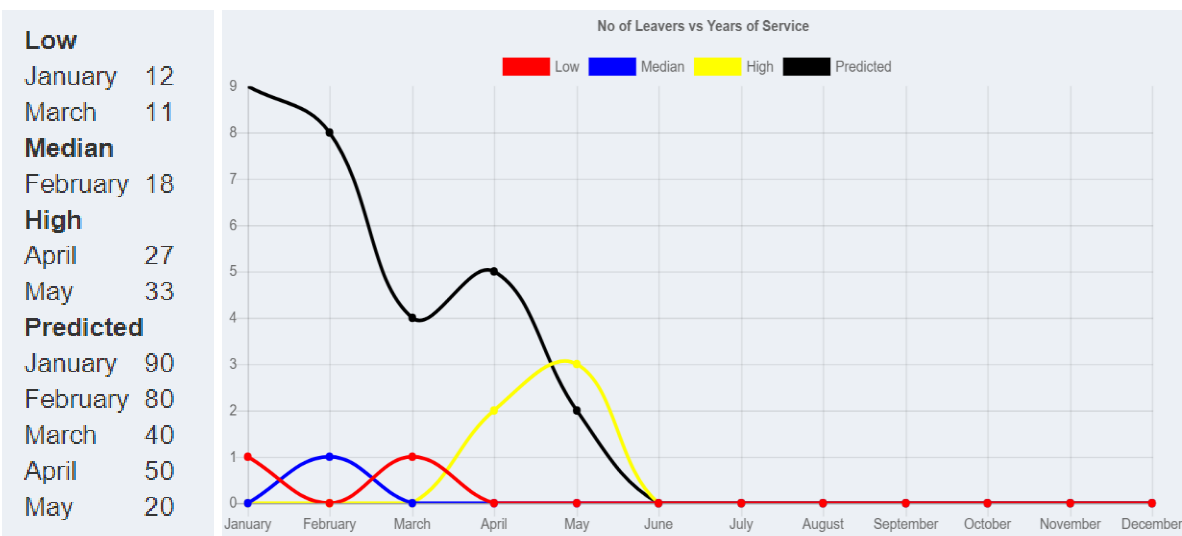


Figure 5.31: Number of Leavers v/s Years of Service for 4 Hidden Layers and Work Life Balance as Reason

The application has been trained to use 4 hidden layers and different reasons for leaving where each reason represents a specific set of data compared to the other reasons. The next scenario is to increase the number of hidden layers to 5 but use the same set of reasons as the previous scenarios.

Number of Hidden Layers: 5

Reasons for leaving: Better Opportunity ▼

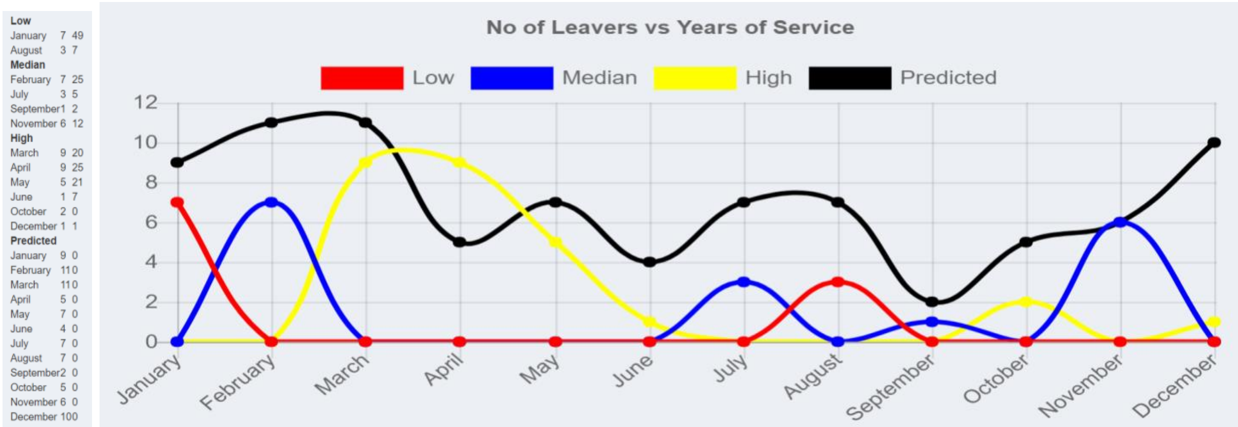


Figure 5.32: Number of Leavers v/s Years of Service for 5 Hidden Layers and Better Opportunity as Reason

Number of Hidden Layers: 5

Reasons for leaving: Personal Reasons ▼

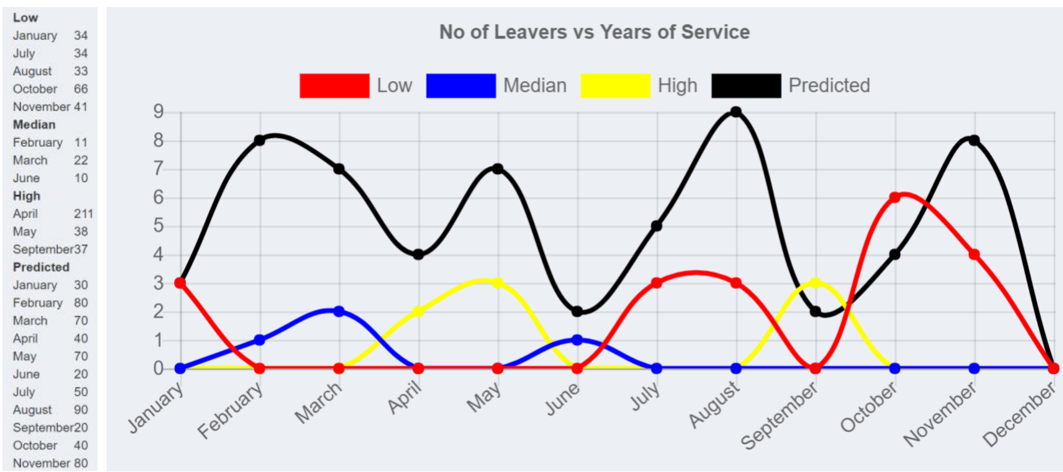


Figure 5.33: Number of Leavers v/s Years of Service for 5 Hidden Layers and Personal Reasons as Reason

Number of Hidden Layers: 5

Reasons for leaving: Work Environment

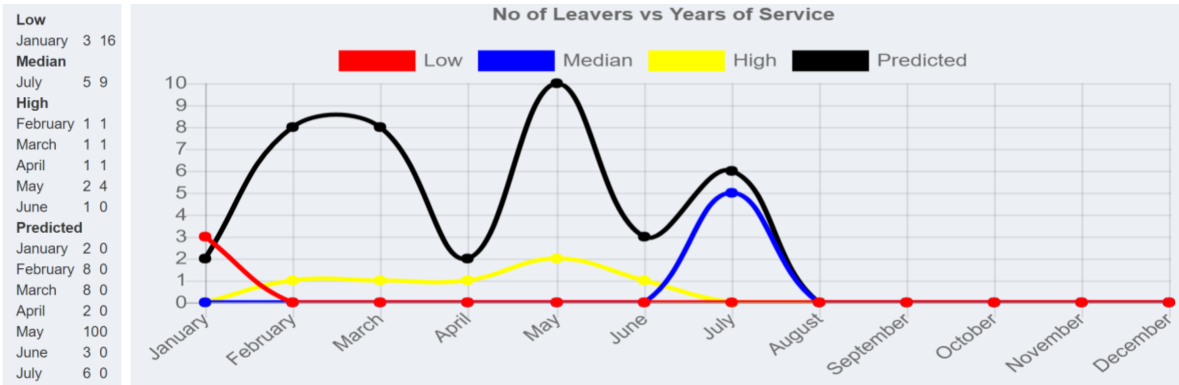


Figure 5.34: Number of Leavers v/s Years of Service for 5 Hidden Layers and Work Environment as Reason

Number of Hidden Layers: 5

Reasons for leaving: Work Life Balance

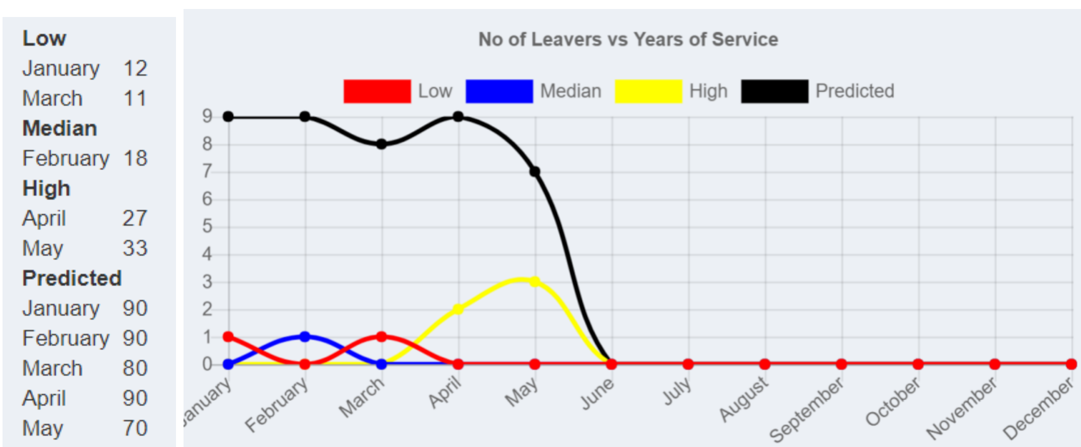


Figure 5.35: Number of Leavers v/s Years of Service for 5 Hidden Layers and Personal Reasons as Reason

The application has been trained to use 5 hidden layers and different reasons for leaving where each reason represents a specific set of data compared to the other reasons.

Layers	Actuals	Predicted
1	14	14
2		13
3		24
4		29
5		23

Table 1.1: Actual v/s Predicted Results

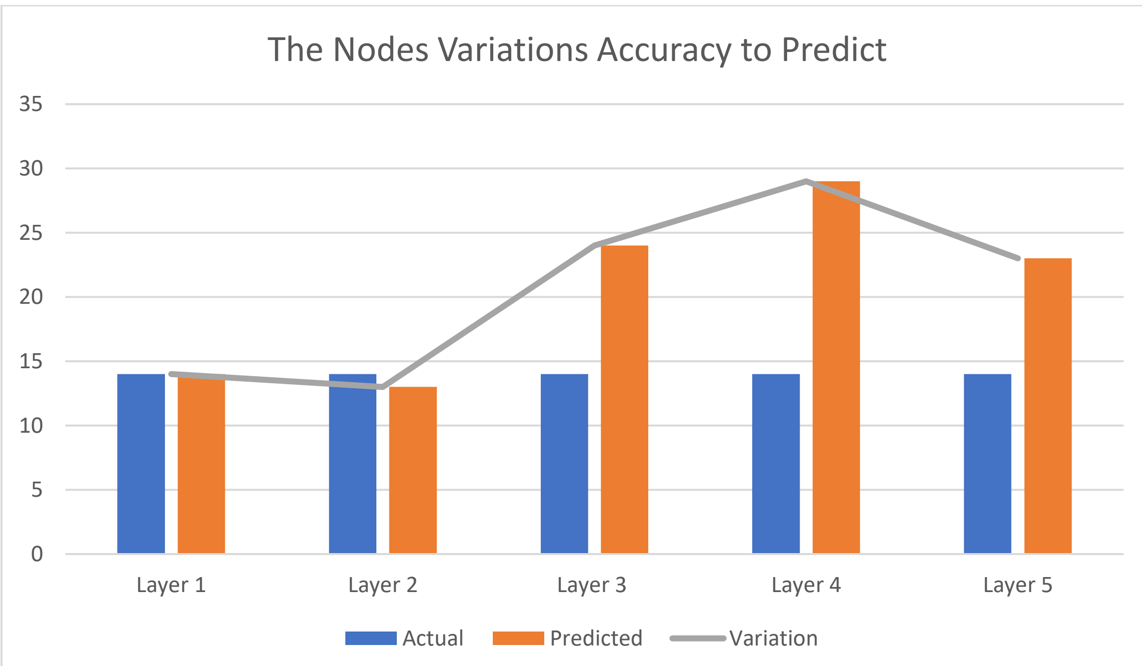


Figure 5.36: The Nodes Variations Accuracy to Predict

Table 1.1 above shows the overall accuracy used to train the neural networks ranging from 1 layer to 5 layers. **Figure 5.34** shows a no clear performance gain from 3 Layers to 5 layers; in fact, performance decreases when the number of layers exceeds 3. For networks with more than one layer, pre-training is used for each layer to decrease the training time.

In a Neural Network, one single hidden layer can fit most of the set of observations, and the need to add more hidden layers do not really arise. However, as you can see from table above that one hidden layer can approximate any function that contains continuous mapping from one finite space to another. It has always been a good practice to train our data with **Two Hidden Layers** whereby the second layer can represent a decision border or boundary to arbitrary accuracy and can approximate any smooth mapping to any accuracy.

Going by Table 1.1 above, the accuracy improves as the number of hidden layer increases from 1 to 2. We cannot generalise that accuracy will increase *proportionately* with increase in number of hidden layers. As mentioned before, we do not require more than One Hidden Layer to have the maximum accuracy. Having said that, no question arises whether to go for more or more hidden layers as ***Back-Propagation*** algorithm will be less effective. The set of errors can go up if you use more and more layers although you can have perfect accuracy for your train data sets.

5.5 Conclusion

This chapter has focused mainly on the implementation of the framework that was discussed in Chapter 4: Intelligent LOIS Architectural Framework, while explaining and evaluating the set of results. A brief introduction of the proposed framework was provided followed by a Case Study based on how an HR person or Operation Management System can use the application to predict the number of leavers for a whole year and therefore, formulating different measures to improve on retention. The Case Study also highlights the use of machine learning algorithm agents into the system. The tool was described in more details while explaining all the different components of the framework and the importance of each component. The tool was mainly described in relation to the architectural pattern used, that is, MVC. Screenshot of the main menu was provided to explain the interaction between the user and framework and how the user can navigate the application. Furthermore, each feature of the application was highlighted and briefly described. As we have adopted Neural Network as the architecture and is data-driven and self-adaptive, it makes it easy for us to make predictions as opposed to various traditional approaches. Neural Network can adapt to data being incomplete, erroneous or fuzzy which makes our prediction more accurate. NN is best to be using only one single hidden layer but the application was trained using layers from 1 to 5 along with various data sets where screenshot was provided for each layer and each set of data (reason) to determine the best hidden layer to be used. K-means clustering was also used to group data together before making prediction on those data. To conclude, we have clearly showed in the Case Study section the role of an HR admin, Managers and Employees in our framework and how they can use the tool to perform specific actions. Moreover, we have shown the organisational side on how such a framework can be used to enhance employee' productivity and help employees to log issues so that managers can address them. Additionally, employees will be able to evaluate their mood on a daily or monthly basis which will be tracked and monitored by managers. On the other side, how the machine learning was used as a foundation to increase the retention rate in an organisation and at the same time, how an organisation can learn from such a framework.

Chapter 6: Conclusion and Future Work

6.1 Conclusion

The primary aim and contributions of this thesis are the design, implementation and evaluation of a Learning Organisation Information System (LOIS) using essential views and system driven entities such as historical data, logs such as system logs, security logs, user logs as well as date of problem identification and its critical tendencies and other statistical information. The work which was carried out to achieve these aims, as well as the results of the work, was reported in the previous chapters of this thesis. In this section the challenges, achievements and conclusions which have been previously drawn will be summarized.

The project had challenging goals that were set at the starting time itself, however, all the project deliverables were achieved where algorithms were effectively implemented and developed along with some theoretical work. The system does not use any third-party tool and is fully stand alone and independent, however, there is an element of uncertainty when the software model is adapted initially in any new environments and using different sets of data.

There was two of the main challenges to build this project. The first was to obtain useful information concerning retention rate of employees and the actual reasons why they are leaving as the implementation of the project was based on an actual organisation facts and figures. Secondly, many companies are reluctant to implement new technologies into the organisation, trying to incorporate this pattern recognition prediction system for the automation of learning organisation framework into the Organisation’s routines was another challenge faced.

The study began with an overview of learning organisation and how important it is for an organisation to adapt, learn and grow. This thesis has presented the organisation including the different types of learning within the organisation, followed by the different types of machine learning and how can we incorporate machine learning in to the organisation. This thesis has then introduced and presented a framework with a number of component including the ones that were build using the idea of K-means and Time series prediction algorithm. The use of K-means algorithm was introduced to cluster data while Time Series prediction was used to make prediction on those clustered data. Information was collected across the organisation and fed into the system by the Organisation Management.

As a result, each time a new set of data is entered into the database, the data is being clustered again and passed to the Time series algorithm. Once the K-means specifies the number of clusters to be used and the node number for the Time Series prediction algorithm, accurate prediction can now be made on those data. In this way the system can reflect the new changes so that the organisation can evaluate the trend and see if there is any improvement being made.

The system provides a full cycle while trying to involve all level of employees in the organisation to use this framework. The framework involves the Organisation Management that feed data into the system; to the managers that can find why their employees are leaving them and taking the right actions; and for the employees to express their concerns and be retained and eventually going back to the organisation to formulate measures. While developing the project we found that to be able to retain employees in the organisation, it is also very important to track their mood on a daily or weekly basis and provide the employees with a platform to express their concerns that all issues can be tackle from the beginning itself. Finally, the main goal of the framework was achieved by helping the organisation not only to retain employees but also to learn and improve.

6.2 Future Work

Based on the work presented in this thesis, there are several areas that can be further improved and carried forward. The case study has other aspects of business which was ignored in this work like the using social medias' API to consume data such as employees' hobbies, interests, likes and dislikes etc to have a better understanding their behaviors and link it to our mood feature that we have created in our learning tool. Furthermore, with the use of machine learning, the UI provided to the user to monitor their mood can be a key aspect for the solution. Predictions of someone's mood can be made based on data, trends and patterns. The user or employee can be provided with graphs and more details concerning their current mood and things they can do to improve.

Natural Language Processing (NLP) can be added to the framework where pattern recognition algorithm can be used to formulate and identify patterns in textually written events or more precisely pattern recognition applied to NLP. This implied that NLP algorithms can be used to interpret events and employ keywords as part of an ontology to find common properties to characterise a group of events together, wrapped into a pattern. Then, measures to address the events will be formulated by the users through analysing the patterns produced by the pattern recognition algorithm. This algorithm can be the core aspect of the solution and can be vital to eliminate the need for the manual effort to analyse the events and create patterns, thus making the solution for the learning organisation less intrusive.

The case study discussed in this report is limited to only one type of industry (IT), it will be very interesting if we can expand the scope to other types of industries as well as other applications which form part of the whole business. The results from using LOIS within different types of industries can be compared and results can be used as a repository for all businesses where further adaptation of LOIS can be made using huge data for analysis and improvement of the model. Future work can be added by making LOIS available as a mobile application where users can easily download for free. Moreover, factors affecting reactive and proactive approaches in areas such as shared services, cloud computing, web security need to be explored extensively. To conclude, it would be almost impossible to retain and measure employee satisfaction within a workplace without having a tool in place to help.

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