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Human Cognition and Emotion using Physio Psychological Approach : A Survey

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ABSTRACT

A soldier's responsibility in the military includes his physical and mental attitudes which makes him to support the army in a full-fledged manner. This type of human dimension recognizes Soldier readiness from training proficiency to motivation for the Army's future success. It introduces the concept of holistic fitness, a comprehensive combination of the whole person, including all components of the human dimension as a triad of moral, cognitive and physical components. The human dimension concept is directly related to the human mind and memory system. In this research, a system which will be capable of recognizing human emotions based on physiological parameters of a human body is discussed. The data from the system is fed to a computer where it is stored. Stored information regarding human parameters is retrieved and classified using support vector machine to generate a data set about the various emotions the human poses at a specific situation. The emotion, thus calculated is grouped to generate a grade for his present status. This grade is used to recommend the suitable working environment for the person.

Keywords: Human cognition and emotion, support vector machine, physiological parameters, ECG, skin conductance

1. INTRODUCTION

This research work is an attempt to provide a descriptive survey on the cognition level associated with human emotions in the military domain. This system detects and classifies the emotion of soldiers from the various physiological parameters including human body temperature, pressure such as systolic and diastolic, pulse rate, skin response and ventilator rate. A resultant grade for emotion is generated and it suggests the environmental condition or work profile suitable for soldiers.

Burger[1] details the development of human brain which is not natural using electrical circuits. The work is based on connecting the pulses between the neurons with electrical signals[1]. Bernard & Mozziyar[2] depicts on methods to build an artificial memory system alike human memory. A memory system was developed and partitioned into various blocks where we can store visual functions, sound factors affecting the sense of touch, smell etc. Each segment has its own auto associative neural network for handling, storing and retrieval of information[2]. James & Dimitrijev[3] describes about the memory system which does not have any cross functional attributes. The interpretation levels shows that there is no complexity involved in the memory design. Liu[4], explains about various techniques to access EEG signal. Wavelet transformation with digital processing techniques were used for analysing EEG.

Homma[5], *et al.* key out the design of long term memory. It deals with the control signal which was generated on cognitive results that was obtained during experimentation. The model developed speaks about the results obtained from long term memory. Using the results, feeding a given input can be memorable or not was detected[5,17,18]. Guangzhou[6], *et al*. explained about the cognitive architecture defined by Canadian Association of University Teachers (CAUT) that deals with human brain organisation and the cognition level with neuron activities.

The brain stores the data which it receives through various sensory organs of our body. Different information is stored in different parts of the brain and in different format. Moreover, the brain uses various voltage levels and timing signals for storing this information. As a result, the emotions of human also change with change in environmental parameters. In the existing literature, these environmental parameters are not taken into consideration and least importance was given for the surroundings while assigning a job profile for soldiers. It is decided to design a system which collects the physiological signals using bio-sensors, and feed into a microcontroller to generate the emotion classification using support vector machine (SVM) classifier. This classifier generates a data sheet and is used to calculate the grade for various emotions. This grade is used to suggest the suitable environment for soldiers' task.

2. PROBLEMS FACED BY SOLDIERS

The problems faced by the soldiers are commonly found as mental stress and tension, depression, post-traumatic stress and psychiatric disorder, insomnia, decision-making and mismatch negativity. Cognition relates people to function socially with

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the neural substrates which are associated with EEG signals which suggests that how to extract the needed electrical signal from the mean of EEG readings[7]. Zhang[8], *et al.* proposed that EEG is a prime signal classification mechanism used for analysis and interpretation. Duque[9], *et al.* established a virtual laboratory where brain signals are modeled according to the characteristics of human.

3. COGNITIVE MEMORY SYSTEMS

The cognitive memory system is the memory which stores information appropriately through the ways in which a human can sense the real world information. Human memory cannot be equated to a microprocessor or a microcontroller where people tried to simulate the human brain with millions of artificial neurons which are connected with each other for retrieving needed information[10]. The space through which the information retrieval from the artificial human brain is dependent upon the developed size of the memory and the complex roles through which the neurons have to be connected in the appropriate manner to recall a particular information in the appropriate time when it is required[11]. Cognitive memory is a human like memory which will work in a simulated environment. A perpetual system acts to get inputs continuously from the working environment. The cognitive analyzer analyses the input received from the perpetual system and sends the decision to the active memory. It also sends the same information to the dynamic controller where in emergency situations spare decisions have to be taken by the human. The overall information is realised by the cognitive analyser and the reactive system functions as well with the inputs received from the environment.

If the memory part of the brain accommodates the right information in the right place, there is no mismatch and mental disturbance. Otherwise, it leads to psychological disturbance. The psychological signal variation has an impact on physiological disturbance. This can be detected as a parametric examination and a solution is provided based on the circumstances the person is working. It is also decided to go for a post analysis, whether the working environment change makes a transformation in the person's psychological signals by observing the physiological signals periodically.

3.1 Salient Features of Cognitive Memory

i. Memory pattern storage such as textual, visual, auditory information[12].
ii. Garbage memory locations can be used to store other pattern information.
iii. Real world scenarios with storage particulars can be stored in the relative binders[13].
iv. Data recovery is done with the base as the respective input patterns.

The army monitoring system with a known set of input parameters and analyses the human emotions using the SVM classifier was dealt[14]. The concepts on learning with emotion's influence on memory, attention and perception, dispensation of emotion and the varying emotional reactions, the grading was done on SVM classifier, which suggests the suitable environment for the soldiers to work without mental disturbance[15,16].

4. PHYSIOLOGICAL AND PSYCHOLOGICAL OBSERVATIONS

The observations of individual emotions from an Individual soldier with a maximum percentage differs from emotion to emotion. The observations also depicts the emotions from an Individual soldier of age 25-36 with the variations of heart rate, respiratory rate, skin conductance and body temperature. Combinatory logic is used to identify different emotions such as anger, happiness, tension, fear, relaxed and excited. The values of emotions are depicted in percentage. Table 1 and 2 describes the five parameters observations made with different age groups of soldiers.

5. FIVE PARAMETER ANALYSIS

A partially observable Markov decision process (POMDP) is the Markov's Partially Observable property which is used in our research as seven Parameter analysis with the dynamics in the human's behaviour determined by the Markov's Decision Process. As the physiological signals can be measured directly from the human body, it must maintain a probability distribution over the set of possible behavioural states, based on a set of observations which are emotions and observation probabilities, and the underlying Markov decision process. The exact solution to a POMDP provides the optimal action for each possible combination of the physiological signals of the human over his behavioural states. The optimal action is his behavioural aspect at a particular situation that his emotion must be maximised or minimised and the expected reward of the human over a possibly infinite prospect. The sequence of optimal actions is known as the optimal policy of the human for interacting with the given environment in a pleasant manner as expected, as shown in Fig. 1.

5.1 Mathematical Modelling

A discrete-time partially ordered Markov decision process (POMDP) is utilised to model the relationship between the human and his environment. A POMDP is a tuple (S, A, T, R, Ω, O, γ), where the human's perspective system as per the problem is considered as,

- S is a set of states- environmental variations
- A is a set of actions- behaviour
- T is a set of conditional transition probabilities
- $R : S \times A \to \mathbb{R}$ iis the reward function- change of behaviour
- Ω is a set of observations- psychological signals
- O is a set of conditional observation probabilities- from physiological signals
- $\gamma \in [0,1]$ is the discount factor- long term change of behaviour

At any given point of time, the environment is in some state $s \in S$. The human takes an action $a \in A$, based on his emotional variations Ω, which causes his state S in the environment, transition to state s' with probability $T(s' \mid s, a)$. Simultaneously, the human receives an observation $o \in \Omega$ which is his physiological signal that depends on the new state of the environment with probability $O(o \mid s', a)$. Then human receives a reward equal to $R(s,a)$. After that the process repeats. The goal is, the human has to behave in a manner that

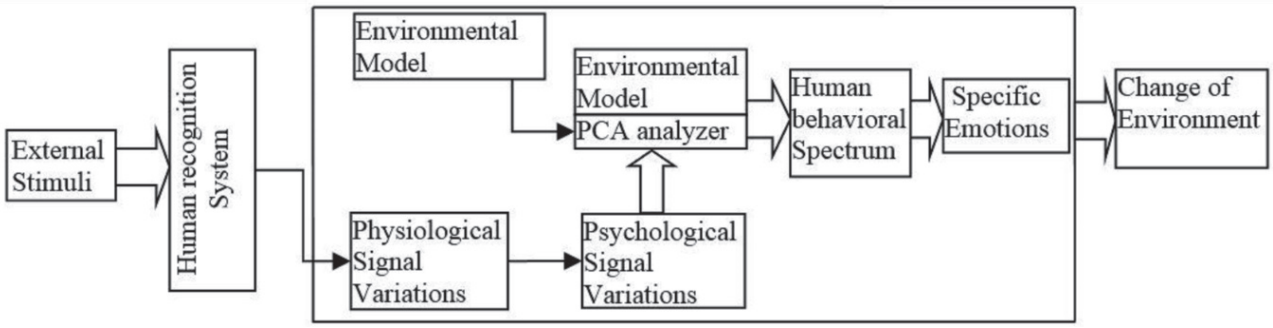

Figure 1. Framework of human parameter analysis for physio-psychological signals

Table 1. Soldier parameters analysis (male)

Parameters	Emotions	Age			
		22-35	**36–45**	**46–55**	**56–60**
Heart rate (bpm)	Normal	71-74	71-75	72-76	72-75
	Anger	73-76	75-77	75-80	78-84
	Tension	74-77	75-79	75-82	76-86
	Happy	66-70	67-72	69-73	70-76
	Relaxed	71-74	71-75	72-76	72-75
	Fear	74-77	75-79	76-82	79-86
	Excited	65-68	67-71	67-74	69-76
Skin conductance (μ Siemen)	Normal	.02-1	.5-5.5	1.6-3	2.5-5
	Anger	.02-.5	.3-1.5	1.2-2.4	1.8-3
	Tension	.01-.8	.6-1.2	1-1.8	1.5-2.2
	Happy	2.8-3.4	3.4-3.9	3.9-4.4	4.3-5.2
	Relaxed	1.8-2.4	2-2.8	2.6-3.4	3-4
	Fear	3.8-4.4	4.4-5	5-5.6	5.4-6
	Excited	4-4.7	4.6-5.2	5.2-5.7	5.6-6.2
Respiration rate (Bpm)	Normal	11-14	13-16	15-18	16-20
	Anger	17-20	19-22	20-25	22-26
	Tension	19-21	20-23	22-25	22-26
	Happy	9-12	11-13	12-15	14-18
	Relaxed	7-10	8-10	8-10	8-11
	Fear	16-19	18-20	19-21	19-22
	Excited	7-9	8-10	8-12	9-13
Blood pressure (mm Hg)	Normal	120-122/79-81	122-125/81-83	125-130/83-86	131-134/86-87
	Anger	120-123/69-73	122-126/70-75	124-127/72-77	127-131/75-82
	Tension	122-128/60-67	127-133/65-73	130-136/69-77	133-141/73-80
	Happy	110-113/75-79	111-117/79-83	114-119/83-88	115-120/85-91
	Relaxed	110-114/75-79	115-119/77-83	117-121/80-87	120-125/83-90
	Fear	120-131/70-77	129-137/75-81	133-141/77-83	140-147/81-85
	Excited	110-117/60-67	117-121/65-71	121-126/69-75	140-147/81-85
Temperature (°F)	Normal	98.6	98.6	98.6	98.6
	Anger	98.6-99.4	98.6-99.4	98.6-99.4	98.6-99.4
	Tension	98-99.8	98-99.8	98-99.8	98-99.8
	Happy	98.4-99	98.4-99	98.4-99	98.4-99
	Relaxed	98.6	98.6	98.6	98.6
	Fear	98-99	98-99	98-99	98-99
	Excited	97-98	97-98	97-98	97-98

Table 2. Soldier parameters analysis (female)

Parameters	Emotions	Age			
		22-35	**36–45**	**46–55**	**56–60**
Heart rate (bpm)	Normal	73-76	74-78	74-77	74-77
	Anger	73-78	75-80	78-84	79-86
	Tension	74-78	75-81	77-82	78-88
	Happy	68-72	70-75	73-77	75-78
	Relaxed	69-72	70-74	70-76	74-78
	Fear	73-78	75-80	77-84	80-88
	Excited	66-70	68-72	70-76	74-80
Skin conductance (μ Siemen)	Normal	.02-1	.5-5.5	1.6-3	2.5-5
	Anger	.02-.5	.3-1.5	1.2-2.4	1.8-3
	Tension	.01-.8	.6-1.2	1-1.8	1.5-2
	Happy	2.8-3.4	3.4-3.9	3.9-4.4	4.3-5
	Relaxed	1.8-2.4	2-2.8	2.6-3.4	3-4
	Fear	3.8-4.4	4.3-5.1	5-5.6	5.4-6
	Excited	4-4.7	4.6-5.2	5.2-5.7	5.6-6.2
Respiration rate (bpm)	Normal	11-14	13-16	15-18	16-20
	Anger	17-20	19-22	20-25	22-26
	Tension	19-21	20-23	22-25	22-26
	Happy	9-12	11-13	12-15	14-18
	Relaxed	7-10	8-10	8-10	8-11
	Fear	16-19	18-20	19-21	19-22
	Excited	7-9	8-10	8-12	9-13
Blood pressure (mm Hg)	Normal	120-122/79-81	122-125/81-83	125-130/83-86	131-134/86-87
	Anger	120-123/69-73	122-126/70-75	124-127/72-77	127-131/75-82
	Tension	122-128/60-67	127-133/65-73	130-136/69-77	133-141/73-80
	Happy	110-113/75-79	111-117/79-83	114-119/83-88	115-120/85-91
	Relaxed	120-122/79-81	122-125/81-83	125-130/83-86	131-134/86-87
	Fear	120-123/69-73	122-126/70-75	124-127/72-77	127-131/75-82
	Excited	122-128/60-67	127-133/65-73	130-136/69-77	133-141/73-80
Temperature (°F)	Normal	98.6	98.6	98.6	98.6
	Anger	98.6-99.4	98.6-99.4	98.6-99.4	98.6-99.4
	Tension	98-99.8	98-99.8	98-99.8	98-99.8
	Happy	98.4-99	98.4-99	98.4-99	98.4-99
	Relaxed	98.6	98.6	98.6	98.6
	Fear	98-99	98-99	98-99	98-99
	Excited	97-98	97-98	97-98	97-98

maximise his expected future discounted reward: $E\left[\sum_{t=0}^{\infty}\gamma^t r_t\right]$ at each time instant.

The discount factor γ determines how the long term change of his behaviour is favored over more distant rewards. γ=0 indicates, which action will be chosen as his immediate behaviour to yield the largest expected reward; when γ=1, human cares about the long term change of behaviour which maximizes the expected sum of future rewards. The population experimented for observing sample data measurements was sixteen and the classification was done over that.

5.2 Application Scenario and Findings

S → Set of States which defines the environmental aspects in the sample space. These aspects are depicted in Fig. 2 such as,

S1. Army support task (rescue)
S2. PAN army task (army education)
S3 Army medical corps (medical team)
S4. Army farm service (agriculture)
S5. Army postal service (mailing)
S6. Army service corps (delivery).

Out of sixteen subjects, we measured the five biological parameters temperature, skin conductance, blood pressure,

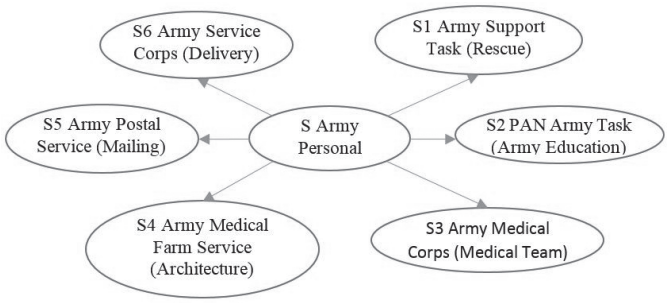

Figure 2. Sample space environment.

respiration rate and heart rate from 16 the samples in the age group of 22-35, 36-45, 46-55, and 56-60 integrating 4 sample in each age group. Out of 6 basic emotions, the emotions which most importantly affect our mind are fear, anger and tension. Other emotions happy, relaxed, excitement are not harming ourselves and the environment also. From the findings it is concluded that, based on the emotional aspects, the environment which is suitable for the soldiers can be allotted. The work profile of the soldiers can be changed from the state S to any one of the suitable states which are mentioned as sample working spaces [S1-S6]. Instead it can be decided by the higher authorities of the Army after our analysis.

For statistical modeling and analysis, the parameters of the soldiers in the age group of 22-35 years are considered. The heart rate varies from 65-77 for the basic six emotions. These Values are pertaining to male soldiers. Even though female soldiers are available in the military, they are given supportive tasks only.

In Fig. 3, X axis indicate the emotion and y axis indicate the normalised physiological signal level. It was done for all the five parameters. From the observations made, the transition probability for the change from normal behaviour to abnormal behaviour is estimated for respiration rate. Normal to abnormal behaviour of the soldier can be estimated from the deviation of the abnormal value in either above or below the normal value.

T: S^*A_{RR} ($11 \leq X \leq 14$) for the behavioural aspects of normal, happy relaxed, and excited.

T: S^*A_{RR} ($14 < X \leq 21$) for the behavioural aspects of anger, fear and tension.

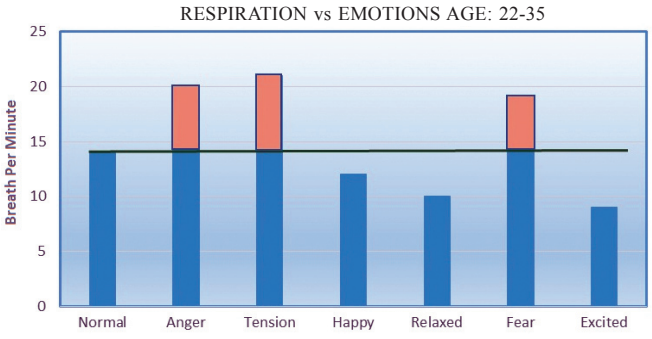

Figure 3. Respiration rate vs human emotions.

Oservation: If the respiration rate starts increasing from 14, the soldier has to be given proper counselling and guidance to change his attitude towards the betterment of his behaviour.

From the observations made, the transition probability for the change from normal behaviour to abnormal behaviour is estimated for heart rate, as shown in Fig. 4.

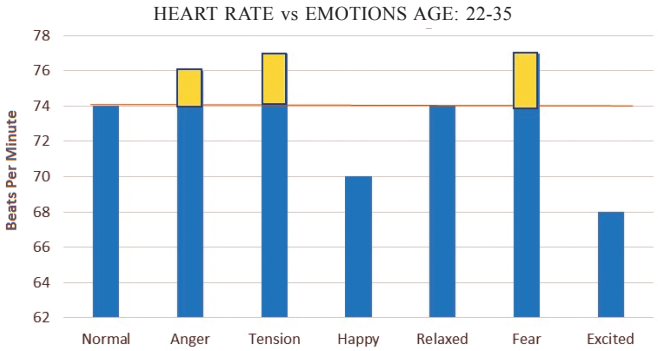

Figure 4. Heart rate vs human emotions.

T: S^*A_{HR} ($71 \leq X \leq 74$) for the behavioural aspects of normal, happy relaxed and excited.

T: S^*A_{HR} ($74 < X \leq 77$) for the behavioural aspects of anger, fear and tension.

Observation:At the normalised rate of 74, his heart rate should be ideal. It should not be increased beyond this limit as it arouses wrong behaviour and leads to apply wrong decisions in the environment.

From the observations made, the transition probability for the change from normal behaviour to abnormal behaviour is estimated for skin conductance, as shown in Fig. 5.

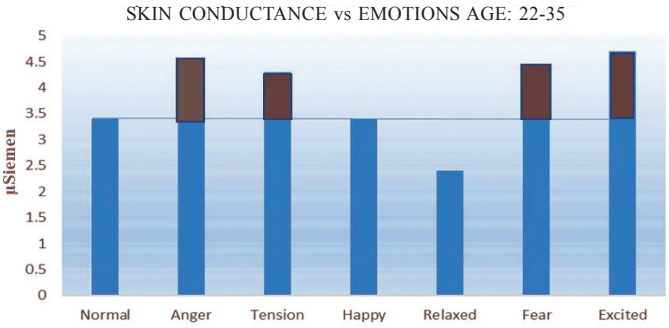

Figure 5. Skin conductance vs human emotions.

T: S^*A_{SC} ($1.8 \leq X \leq 3.5$) for the behavioural aspects of normal, happy, relaxed.

T: S^*A_{SC} ($3.6 < X \leq 4.7$) for the behavioural aspects of anger, fear and Tension, and excited.

Observation: At the normalised rate of skin conductance is 3.5, happy and relaxed emotions will occur. When it goes beyond the normal value, anger, tension and fear appears. But from our observation, with a very small sample set of 16, excited emotion reaches the normalised value of 5. As the graph shows, it may be treated as over excitement and the implications of skin conductance must be concentrated on.

From the observations made, the transition probability for the change from normal behaviour to abnormal behaviour is estimated for blood pressure - systolic, as shown in Fig. 6.

T: S^*A_{SYSBP} ($110 \leq X \leq 122$) for the behavioural aspects of normal, happy relaxed and excited. We did not concentrate on hypertension.

T: S^*A_{SYSBP} ($120 < X \leq 131$) for the behavioural aspects of anger, fear and tension.

Observation: At the normalised rate of systolic blood pressure 120, happy, relaxed and excited emotions occur. When it goes beyond the normal value, anger, tension and fear

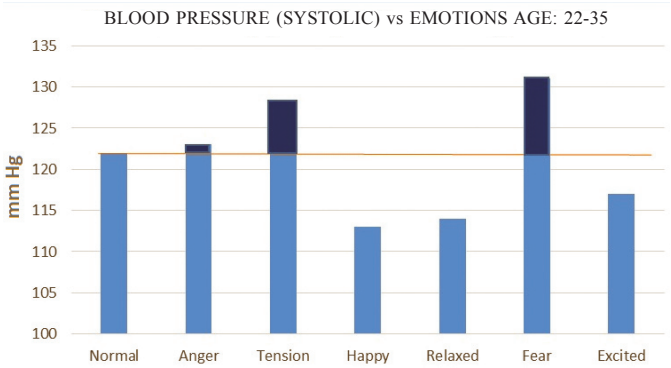

Figure 6. Blood pressure- systolic vs human emotions.

appears. Hypertension is not considered in this research. As high BP problems are severe in nature, immediate solution is essential for the soldiers.

From the observations made, the transition probability for the change from normal behaviour to abnormal behaviour is estimated for blood pressure – Diastolic, as shown in Fig. 7.

T: S^*A_{DIASBP} ($75 \leq X \leq 81$) for the behavioural aspects of normal, happy, relaxed and excited.

T: S^*A_{DIASBP} ($60 < X \leq 77$) for the behavioural aspects of anger, fear and tension.

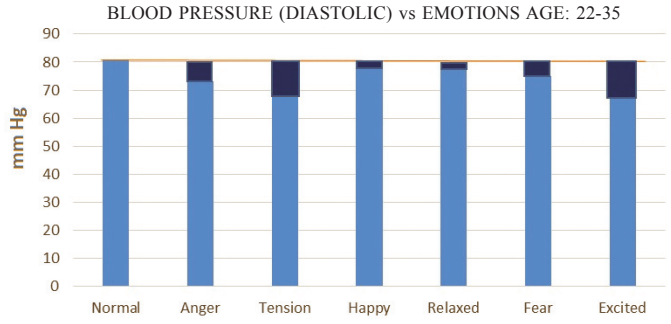

Figure 7. Blood pressure- systolic vs human emotions.

Observation: As it is low BP, the measurements which are low from the normal values have been considered as abnormal. From the values 75-77, there is a misconception of normal and abnormal behaviours. Choosing a big sample size, selecting different environments, observing different measurements from the soldier may provide lot of insight into separating normal and abnormal values. Hidden Markov Model can be applied in this kind of scenario.

From the observations made, the transition probability for the change from normal behaviour to abnormal behaviour is estimated for temperature, as shown in Fig. 8.

T: S^*A_{TP} ($97 \leq X \leq 98.6$) for the behavioural aspects of normal, happy, relaxed and excited.

T: S^*A_{TP} ($98.6 < X \leq 99.8$) for the behavioural aspects of anger, fear and tension.

5.3 Observation

Measurements of body temperature provides distinction between normal and abnormal values. From the normal set of values 97-98.6, the pleasant emotions fall in. When the body temperature goes high, it affects our health developing anger,

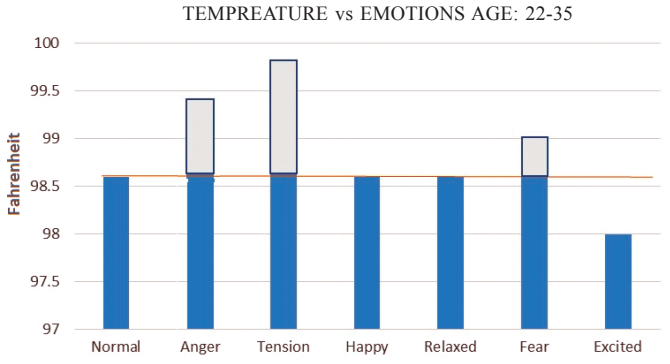

Figure 8. Temperature vs human emotions.

fear and tension. High body temperature has to be controlled by controlling emotions and vice versa.

This is a preliminary study about the soldiers' body parameter analysis. Increasing the sample size is an option for a detailed analysis. When the soldier is given proper counselling and guidance after many trials, his behavioural aspects can be changed. Environment change is one of the options, as most of the physicians suggest that for freeing from mental illness.

It is decided to combine the five vital parameters of the human body, where the combination of these parameters provide different causes to man. These parameters are chosen as their impact is expressed in terms of human emotions. The influence of combining one parameter with another parameter and combining all the five parameters with the expected return of rewards have been analysed in this research. The notion of identifying the suitable environment for the affected soldier from this study can be possible, only when it is made as a real time work in a real world scenario.

As mentioned, $\gamma \in [0,1]$ is the discount factor which provides the long term change of behaviour, the soldier who is under mental agony, can be recovered from his state when he is allotted to work in a new environment. The soldier receives a reward equal to $R(s,a)$ which indicates when he changes from his current state to a new state through his action. G is the reverse value of R. The goal is the human has to behave in a manner that maximize its expected future discounted reward.

Case 1: $\gamma = 0$

When the soldier is in an abnormal condition, he will be immediately recovered to normal condition as per the advices given through proper counselling. His location has to be changed to acquire the value of $\gamma=0$. The largest expected reward is R, R(s,a). The abnormal states due to tension, anger , fear due to his environment or work pressure which affects his physiological parameters in turn reflects in psychological parameters even. When the soldier cooperates after counselling, environment change will provide him a better working atmosphere to work enthusiastically.

Case 1: $\gamma = 1$

The soldier's future rewards will become countable, as how he behaves after coming to the new environment.His behavioural aspects have to be analysed to maximize the value of R, which in turn make him to acquire more rewards in future.

6. CONCLUSIONS

The human's physiological parameters were analysed and the physiological signals are grouped and classified using support vector machine to generate the emotion of human. Emotion thus generated is classified and ranked to find the environment suitable for soldiers. A matrix performing a permutational analysis was made to support Physiological signals with Psychological signals and with the given environment. A policy of defining the human's action selection with respect to the changes in the environment is required for further analysis. As POMDP is used to map from the state space to a distribution over the action space, the realistic environment with different states and actions will be analysed with lot of permutations and combinations. Principle component analysis will be done over the set of observations of possibly correlated variables based on physiology into a set of values of linearly uncorrelated variables which are emotions, called principal components. We can also introduce the notion of non-deterministic policies on MDPs to deal with sets of actions in the future work.

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