SIMULATION MODEL FOR THE RECOGNITION OF HUMAN EMOTIONS BY FUZZY LOGIC

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Abstract

This paper is a simulation model to determine the human emotions by computer system. This study is an experimental design using MathLab, has two variable inputs the Heart Rate and Skin Temperature. Fuzzy Logic is also used to determine the membership functions and solve the vagueness of the inputs. This paper focuses on idea to define emotion from different perspectives and explore possible causes and variations of different parameters. This study has been implemented using Mamdani type relational model. Physiological sensors were found to be the best approach to recognize emotional changes of the human being, as they provided information about changes that take place physiologically and are out of a person's control.

Keywords: *the simulation model, fuzzy logic, physiological sensors, Mamdani type model, human emotions*

1.0 Introduction

Emotions play a vital role in people's everyday life. It is a mental state that does not arise through free will and is often accompanied by physiological changes. Therefore monitoring these changes is important as they perceptions of emotional changes and can help in identifying matters of concern at an early stage before they become serious.

Human-computer intelligent interaction (HCII) is an emerging field of science. The interaction between human beings and computers will be more natural if computers can perceive and respond to human non-verbal communication such as emotions Quraishi et al. (2012).

According to Ghosh et al. (2013), most of the time human being used non-verbal communication such as gesture, pruning, facial expression to express their feelings and emotions. However, our human-computer interfaces are unable to understand this kind of non-verbal communication and failed to take full benefits of the interaction to the users, this is a drawback of modern computer based system. If computers could recognize the emotion of the user from his physiological attributes, then human interaction with computers can be improved and react in a friendly manner according to the user's need.

This research deals with investigation of the different knowledge representation techniques in developing a framework of multiple cooperative agents' activities to recognize the prediction criteria of diagnoses of the emotional situation. This study attempts to present a model so that the computer can understand the reasoning of the human along with the emotion (Ekman 1999).

The objective of this simulation model is to determine the four basic human emotions i.e., happy, sad, angry and relax. Finding relationship between emotions and actions has been an important topic for philosophers, psychologists, and neurobiologists. Monitoring the changes of emotional states is vital as they help in identifying behaviors at early phase. This simulation gives the avenue for further study on the application for the person with a disability.

In order to acquire numerical values that can be used to infer about individuals' emotional states, sensors that measure variables such as PPG (Photoplethysmogram), and SKT (Skin Temperature) will be used.

2.0 Literature Review

In 1969, study on emotions in different cultures using facial expressions. It was able to find six basic emotions i.e. happiness, sadness, fear, surprise, anger, and disgust (Ekman and Friesen 1976).

Various methods have is proposed for modelling emotions. For instance, Damasio (1995), suggests somatic-marker mechanism for modelling emotions. TABASCO architecture is based on the emotion appraisal theory. OCC theory of emotions is another popular model.

McCraty (2004), in his research, a dramatic change in the pattern of heart's rhythm due to changes in autonomic activity was observed. Emotions such as anger, frustration or anxiety caused the heart rhythms to get more erratic and disordered as compared to highly ordered heart rhythms observed from positive emotions such as love, appreciation or compassion.

In average adult, the heart goes through full cardiac cycle 70 times a minute. It means that a healthy heart rate at rest 60-80 beats per minute. The heart rate data in this study is on the principle of photoplesthysmography (PPG). Table 1 illustrates the heart rate matrix from the findings of Quazi et al. (2012).

Skin temperature is an effective indicator when it comes to evaluating human sensations. The temperature of the surface of the skin varies with the environment temperature, with the temperature of the body and the conditions in the skin in the structures lying beneath it. In comfortable environment, the temperature of the skin surface of the trunk usually varies between

33.5 and 36.9 Celsius (Bierman 1936). While the temperature of the skin surface is lower over superficial veins than it is over superficial arteries.

Kataoka et al. (1998) investigated the relationship between stressful tasks and the skin temperature. They found that skin temperature falls when stress, tension or other sensation occur because blood flow decreases due to factors like blood vessel constriction.

Study by Shoemaker (1996) and Srivastava (2003), that temperatures vary from morning to evening, person to person, child or adult, male to female, before and after physical activity, before and after food intake.

Heart rate affects body temperature. A linear fit shows that for every four beats per minute increase in the heart rate, there is a 0.1 F rise in body temperature (Srivastava 2003 Mackowiak et al. 1992).Table 1 shows the heart rate matrix as one of the input variables.

FL, which was first introduced by Zadeh(1965), is used to handle uncertainty, ambiguity and vagueness. It provides a means of translating qualitative and imprecise information into quantitative (linguistic) terms. Fuzzy set theory and fuzzy logic provide powerful tools to represent and process human knowledge in the form of fuzzy IF.

3.0 Methodology

The study made use of an experimental design using simulation modeling. The input variables are heart rate and skin temperature.

Mamdani type model was applied to find the relational matrix human emotions. At the last centroid rule is used to define specific facial features for a given degree of human emotion.

Various equipment and instruments is used in the past skin temperature measurement. Shown in Table 2 is the skin temperature matrix as one of the input variable.

Fuzzy Logic is a "weapon" to solve the problem: it allows using logic if-then rules to describe the system's behavior. Key reasons for using Fuzzy Logic is conceptually easy to understand ,and tolerant of

Table 1. Heart rate matrix as input variable for fuzzy logic

Heart Rate	State
60-80	Normal
75-95	Above Normal
90-110	Moderately Fast
100-120	Extremely Fast

Table 1. Heart rate matrix as input variable for fuzzy logic

Degrees Centigrade	Status
29-30.5	Normal
30-32.5	Moderate
32-34.5	High

imprecise data and based on natural language ended with conventional control techniques.

Rather than looking for an accurate model of an emotion process, it is suggested modeling it from a behaviorist viewpoint. Use of fuzzy logic for modelling emotional behaviors has a number of advantages (Mobahi 2012):

1. It is straightforward to implement software for a fuzzy system.
2. It provides a convenient means for triggering multiple emotions.
3. Changes occur smoothly, resulting in natural and life-like behaviors.

Since a fuzzy system is on linguistic variables, the design and understanding is convenient. It focuses on achieving the desired behavior, which is the main concern in human-robot interaction, unlike other emotional models that focus on accurate internal modelling. Fuzzy is a model free approach. Thus, there is no limitation imposed by model like other approaches. Designer can easily add or remove rules and watch their effect until achieving the desired behavior.

Figure 1 shows the min-max fuzzy inference system, that uses fuzzy set theory to map inputs to outputs (classes in the case of fuzzy classification).

In the membership functions of the input variable Heart Rate in Figure 2, the Gaussian membership function is used. A Gaussian MF is determined by c and σ; c represents the MFs centre and σ determines the MFs width The heart rate is divided into 4 normal, above normal, moderate fast, and extremely fast.

For input variable Temperature, Trapezoidal membership function is used and divided into three regions namely; normal, moderate, and high.

Rules:

1. If Heart Rate is Normal and Temperature is Normal the, Emotion is Relax.
2. If Heart Rate is Extremely Fast and Temperature is High then, Emotion is Angry.
3. If Heart Rate is Above Normal and Temperature is Moderate then, Emotion is Happy.
4. If Heart Rate is Moderate Fast and Temperature is Moderate then, Emotion is Sad

The define rules are tested in the simulation using MathLab Simulink.

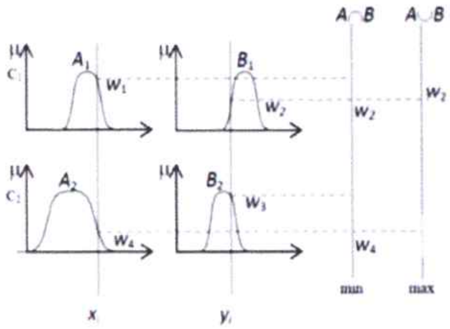

Figure.1 Min-Max fuzzy inference system

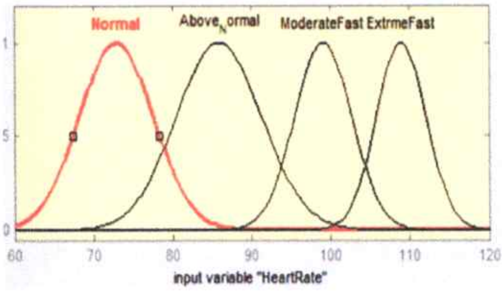

Figure. 2. Membership function for heart rate

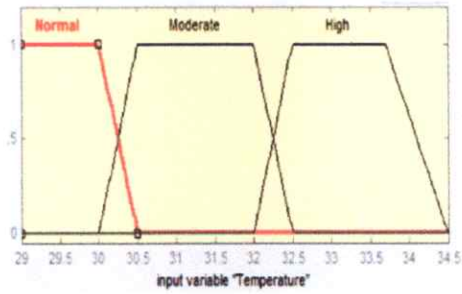

Figure 3. Membership function for temperature

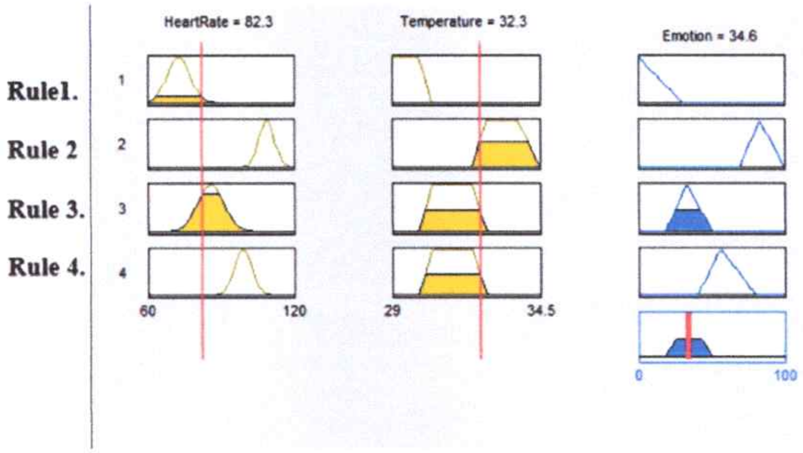

Figure 5. The rule viewer for the simulation

4.0 Result and Discussion

The data in Table 3 revealed that 50 trials tested for heart rate and temperature variable inputs. Using the generated four rules, emotion values were calculated, and emotion state was determined.

Table 3. The simulation result of the human emotions by fuzzy logic

Trial	Heart Rate	Temperature	Emotion Value	Emotion State
1	68	32	35	Undefined
2	96	31	54	Sad
3	83	31	34	Happy
4	97	33	84.5	Undefined
5	83	33	84.5	Undefined
6	78	31	34.7	Happy
7	97	31	55.6	Sad
8	85	32	34.4	Happy
9	73	30	9.84	Relax
10	92	32	41.9	Happy
11	81	31	34.5	Happy
12	104	32	59.5	Sad
13	82	30	13.9	Relax
14	97	32	55.6	Sad
15	104	32	59.5	Sad
16	93	31	45.6	Happy
17	104	30	15	Undefined
18	90	32	36.7	Happy
19	113	34	84.4	Angry
20	73	31	34.9	Happy
21	84	32	34.4	Happy
22	93	30	15	Undefined
23	104	32	59.5	Sad
24	110	33	84.2	Angry
25	86	30	14.9	Relax
26	72	31	35	Undefined
27	83	30	14.3	Relax
28	65	34	84.5	Undefined
29	71	34	84.5	Undefined
30	75	32	34.8	Happy
31	80	30	12.7	Relax
32	98	31	56.7	Sad
33	110	34	84.3	Angry
34	98	31	56.7	Sad
35	114	34	84.5	Angry
36	107	31	60.2	Sad
37	97	33	84.5	Undefined
38	106	31	60	Sad

Continuation of Table 1.

39	88	32	34.9	Happy
40	97	32	55.6	Sad
41	108	31	60.3	Sad
42	101	32	58.4	Sad
43	81	32	34.5	Happy
44	92	30	15	Undefined
45	69	32	35	Undefined
46	95	31	52.2	Sad
47	105	33	84.4	Angry
49	86	30	14.9	Undefined
50	100	33	84.5	Undefined

The sample trial is 50, and Pearson correlation between Heart Rate and Temperature is= 0.203 and P- Value = 0.162.

Figure 6 shows the four rules generated by the Fuzzy Logic, the heart rate, temperature variable and emotion output.

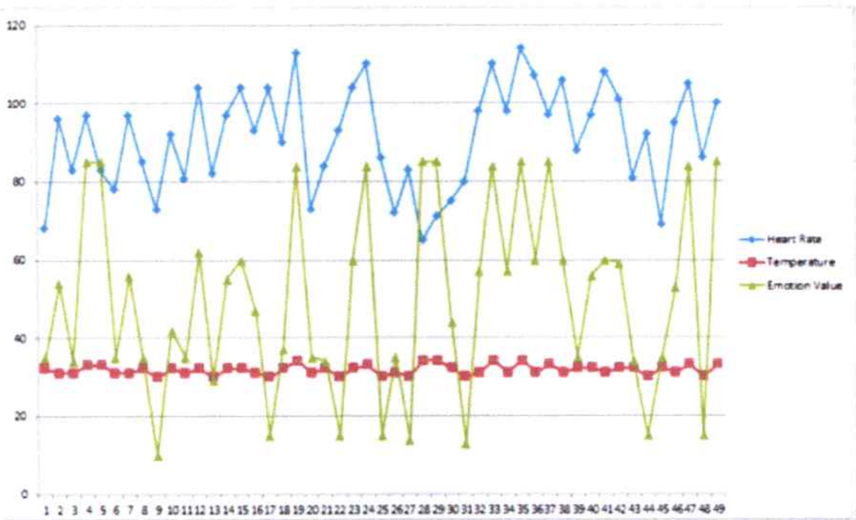

Figure 6.Line chart of the input and output variables

5.0 Conclusion

In this study, a model for emotion recognition system, based on data provided by physiological sensor. The literature review enabled an appropriate method of selection for the sensors utilized in order to achieve emotion recognition. Physiological sensors were found to be the best approach to recognize emotional changes of a human being, as they provided information about changes that take place physiologically and are out of a person's control. Therefore, in applications such as human-robot interaction, where the concern has a natural and effective communication, physiological sensors can bypass computational models of emotion, yet achieve a believable emotional behavior.

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