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Recognizing emotional state of user based on learning method and conceptual memories

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ABSTRACT

With the increased use of computers, electronic devices and human interaction with computer in the broad spectrum of human life, the role of controlling emotions and increasing positive emotional states becomes more prominent. If a user's negative emotions increase, his/her efficiency will decrease greatly as well. Research has shown that colors are to be considered as one of the most influential basic functions in sight, identification, interpretation, perception and senses. It can be said that colors have impact on individuals' emotional states and can change them. In this paper, by learning the reactions of users with different personality types against each color, communication between the user's emotional states and personality and colors were modeled for the variable "emotional control". For the sake of learning, we used a memory-based system with the user's interface color changing in accordance with the positive and negative experiences of users with different personalities. The end result of comparison of the testing methods demonstrated the superiority of memory-based learning in all three parameters of emotional control, enhancement of positive emotional states and reduction of negative emotional states. Moreover, the accuracy of memory- based learning method was almost 70 % percent.

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1. INTRODUCTION

Due to the extensive use of computers and electronic devices in human daily lives, the role of emotion regulation and increasing positive emotional state becomes more and more prominent. If the negative emotions of user's increase, user efficiency will also decrease greatly [1]. This reduced effectiveness only increases the number of errors made by ordinary users, while it may cause irreparable problems for professional users who are responsible for sensitive tasks [1]. To enhance positive emotional states, one can control his/her emotional states and change them into positive emotional states; in fact, emotional control can actually help one prevent his/her negative states [1, 2]. One of the uses of emotional control is in educational and tutorial systems [3, 4], where emotional control prevents fatigue and lack of interest in users [3].

Thus, the importance of emotional control has become more prominent with the increased use of computers and interaction of humans with computers. On the other hand, with an increase in computer programs, graphical interfaces of applications play a more significant role in computer programs due to direct communications with the users [5]. Graphical interface is considered to be one of the fundamental parts of applications for human interaction with computer [5]. Adaptable interface that can automatically change and adapt it based on its task and interaction is one of the most important topics for research [6]. Hence, excitement can be controlled by using adaptive graphical interfaces.

Colors are one of the most influential basic functions in sight, identification, interpretation, perception and senses [7]. Colors have impact on emotional states [7-9] and can change them. Bright colors like yellow and blue have positive emotional states, while dark colors like black and gray are associated with negative emotions [10]. So, one may change emotional states by using user interface color [11]. As it is possible to change emotional states using color change, we can thus control the emotional states and lead them to positive emotional states. The main hypothesis of this article is: "emotional states can be controlled through a change in the user interface color".

In this paper we decided to learn the reactions of users with different personality types versus each color for control emotion by modeling of the communication between the user's emotional states and user personality. For this purpose, we used a memory-based system for learning and interface color changes according to the different positive and negative experiences of users with different personalities. In this paper, to evaluate we used the five-factor personality of neo five-factor inventory (NEO-FFI) in order to evaluate personality [12]. In addition, we implemented a training tool as C ++ programming language in order to test the system.

Correct response in human-computer interaction which is based on emotions relies on two main parts: 1) emotion recognition and 2) response generation. Errors made when generating an appropriate response are due to two reasons: errors arising from emotion recognition and errors made when making responses. The main purpose of this study is to make use of the correct experience-driven response in the user interface. Therefore, emotion recognition phase was removed in order to minimize the errors and the self-assessment manikin (SAM) non-verbal pictorial assessment test was used to determine the emotional state [13].

The memory system is made up of two parts; episodic memory and semantic memory. Episode memory saves the details of the experienced significant events, while semantic memory demonstrates the abstract of episodic memory contents. Usable memory system has the ability to learn and will be completed as it is used more and more. The memory model used in this study is learning based on actions and emotions. But a typical learning system such as Q-learning is learning only on the basis of the best practice in a given situation. In conventional methods of learning, useful details such as the time of the action, the intensity of emotion, and the subject and object are not taken into account. In other words, Q-learning loses the details, while the memory-based learning model which has been used in this article is based on the details of an experience. In this study, attempts were made to control the emotional states of users and lead them to positive emotional states. In fact, for users with different personality traits, we tried to use their prior experience and select user-friendly colors as background and prevent the user from creating negative emotional states. In simple terms, commensurate with users' personality and experiences, the individuals' emotional states may be controlled through user interface color and changed into balanced and positive emotional states. One-way ANOVA analysis was used in this study for the assessment process with results revealing the significant effectiveness of the memory-based learning model.

This paper is organized as follows. First, we describe the related works. Then, we present the background of the study including the memory, personality, mood and SAM. In the fourth section, we will present the memory-based learning and explain the details of this framework. We will then describe implementation of a C++ programming language learning tools developed to evaluate the framework, after which the results of the evaluation will be presented. In the last section, we will present the discussion and the conclusion.

2. RELATED WORKS

Suk and Irtel [9] performed some experiments so as to find the relation between emotional states and colors. The purpose of this article was to describe emotional responses to color perception in terms of emotional state dimensions. Finally, they gained a table that revealed the relationship between colors and emotional states. Their research also showed that the color characteristics will influence the emotional states. Unlike light and chroma, hue has no effect on emotional states. The effects of personality have been neglected in the study conducted by Suk and Irtel.

OU and his colleagues [14] examined the relation between color and age. Their results showed that users' age is associated with their color preferences. They found out that older adults prefer stronger colors with more Chroma, while the younger people prefer chromatic colors. We have used a sample from a particular age range in this study in order to obtain more appropriate results. Epps and Kaya [10] carried out some studies so as to examine emotional states as associated with colors vision. They found out that bright colors like yellow and blue are associated with positive emotions (like happy), whereas dark colors like black and gray are associated with negative emotions (like sad, anger) and yellow and red are associated with more anxiety than are blue and green.

Sokolova and colleagues [15] investigated the relationship between emotion regulation and color preference. Kurt and Osueke [7] showed that colors affect the emotional states and vice versa. The main aim of their study was to explore the effects of colors psychology on individuals. Colors may change states and are actually one of the basic functions in sight, identification, interpretation, perception and senses. They found that cold colors such as blue and green are relaxing, while warm colors which including red and yellow are energy-making.

Noori *et al.* [16] introduced an intelligent interface named an adaptive user-interface based on users' emotions (AUBUE) adapting its colors based on emotional states of users. In this intelligent interface, which can recognize emotions based on users' interactions through a keyboard and accordingly change the background color in such a way that it decreases the negative emotions in users. This interface consists of 4 sections: keyboard interpreter, event interpreter, mood update and color selector. Keyboard Interpreter analyzes the user's interaction with keyboard and converts them into a number of events. Event Interpreter converts keyboard events into fuzzy and then maps them onto emotions and optical camera communication (OCC) model has been used in order to use emotions. Mood update receives the list of the active emotions and their intensity as the input, obtaining the user's current mood based on the user's current mood and emotions and sending it to color selector. In the color selector, when the user's emotional state was determined, the appropriate color mode is selected. The appropriate color for a mode is a color which overrides the current mode. They showed that the use of colors can affect controlling the emotional states, but it was confronted with some problems and effectiveness of colors was not significant. Among the problems were: 1) Low number of the recognized emotional moods, 2) lack of accuracy in the emotion recognition procedure 3) Ignoring users' personality and 4) lack of learning from users' experience.

We seek in this study to solve the problems posed by Noori *et al.* [16] and to assess the possibility of controlling emotions by using colors. In order to solve the first and second problems, we removed the emotional state diagnostic phase and used the SAM phase instead. Users had different expectations from color change. In other words, users with different personalities expected different colors. Users with different feelings may have different color expectations. People with different personalities may react differently in dealing with a particular event [17] and each color has different impacts on different people with different personalities [18-20]. Some studies have also dealt with the effect of individuals' personality on their favorite colors. In fact, it can be said that the basic problem set forth in Noori *et al.* [16] was lack of the system learning process in both interactions and choice of colors. Hence, adding the learning ability can have a significant effect on controlling emotions. So, we have used in this study a memory-based learning model in order to solve the third and fourth problems by taking the user's personality into consideration. The aim of this research is to control emotional states using learning model by taking into account the users' personalities and through the use of user interface graphic color when interacting with the software.

3. BACKGROUND

3.1. Memory

Short-term memory and long-term memory are two large divisions of human memories. Short-term memory holds and keeps the experienced events only temporarily. These events are either happening at the moment or have happened just a few seconds ago. Long-term memory is the same as short-term memory with the exception that it keeps events in our mind for a longer period of time (permanently). This memory can be divided into two types: declarative memory and procedural memory.

Declarative memory keeps "explicit knowledge that we can express and are aware of". Procedural memory keeps "the knowledge of how to do things that are implicit. This study has been designed and conducted based on the memory framework and system presented in [8]. The declarative memory, with two types of episodic memory and semantic memory, has been used in this framework. The following is a brief explanation about these memories. But for more comprehensive information, you may refer to [8].

- Episodic memory: stores details of the remarkable experienced events
- Semantic memory: can store up general knowledge. This section of memory has not been used in this paper.
- Semantic graphs: are a kind of semantic networks displaying an abstract of the event memory contents. Semantic graph has been conceived as a component added to semantic memory and capable of learning.
- General graph: is a kind of semantic graph, which is an abstract of semantic graphs and includes general knowledge about all of the factors involved.

The intensity of the emotions that an individual feel during an experience can influence the retrieval of that experience from the event memory. Episodic memory can be considered as a machine learning method that 1) has memory; 2) both right and wrong answers of the system are considered as experience and 3) the addition of any recovery experience will affect other experiences. Semantic memory displays personal experience and does not include general information. Semantic memory also includes general knowledge abstracted from personal experiences (episodic memory). Abstraction of experience includes "cleaning up a lot of the received details and keeping the important relations between them". Since the main purpose of this study is to use experiences, only that part of memory which is capable of learning has been used in this study. In other words, the part of semantic memory of the memory model which has no learning capability has not been used in this study.

3.2. Personality

Personality has been defined as a set of distinct and stable thoughts, emotions and behaviors that shows our adaptation with the world. McCrae and Costa (1990) have defined the personality traits as the dimensions of individual differences in the tendency to show stable patterns of thought, feeling and action. They identified five powerful factors in understanding human personality traits. Based on this model, human personality was divided into five main dimensions including extraversion, agreeableness, conscientiousness, neuroticism and openness to experiences. These dimensions are commonly known as the Big Five personality traits and can be summarized as follow:

- Extraversion (E): extroverts are socially-oriented, but sociability is just one of their attributes. Loving the people around, preferring large groups and conventions, being active, courageous and being too talkative are among their attributes.
- Neuroticism (N): a general tendency to negative emotions such as fear, sadness, confusion, anger and feeling of guilt and hatred constitutes neurosis.
- Agreeableness (A): the agreeable people are basically altruists, feeling compassion towards others and eager to help them and believing that others are mutually helpful.
- Openness (O): resilient people are curious about the inner and outer world and their life is rich in terms of experience. They are willing and eager to accept new ideas and unconventional values and experience positive and negative emotions more highly and deeply than inflexible individuals.
- Conscientiousness (C): purposeful conscientious people are strong-willed, determined, precise and reliable.

3.3. Mood

In fact, a person's mood is their status with higher durability than emotions and has many effects on cognitive processes and learning. The PAD model has been used in this study in order to display and process a person's mood. This model has defined a person's mood as their medium mental condition in different situations. The mood in PAD space has three dimensions: P (pleasure), A (arousal) and D (dominance), considered to describe and measure a specific emotional response. Pleasure (P) evaluates the quality of pleasant-unpleasant emotional experience. Arousal (A) refers to physical activity and psycho-physiologic changes and dominance (D) defines a sense of control or lack of control in a specific situation. Each dimension is defined as a variable that can take values between -1 to 1. If the variables are classified according to whether they are positive or negative, 8 modes can be defined in as presented in Table 1. The important question raised here is whether or not these eight emotional states mutually contradict one another, the answer of which has been shown by a study to be positive. These eight emotional states are in mutual conflict with one another.

Table 1. Categorization of modes based on their dimensional signs

Mode	
+P+A+D = Exuberant	-P-A-D = Bored
+P+A-D = Dependent	-P-A+D = Disdainful
+P-A+D = Relaxed	-P+A-D = Anxious
+P-A-D = Docile	-P+A+D = Hostile

3.4. Self-assessment manikin

Several methods have been used for detecting emotional states and have been embedded in different systems for testing. In general, three methods can be used to detect the emotional states:

- Physiological: such as skin conductance, heart rate, blood pressure, electroencephalography (EEG), and so on.
- Psychological: verbal description of an emotion or emotional state, standardize check list, questionnaire, and so on.
- Behavioral: facial expression, voice modulation, gesture, posture, motor behavior, mouse and keyboard, and so on.

In other words, it can be said that there are two ways to tag emotional states, one is done automatically by diagnostic tools and the other is done by humans. SAM [13] is a method of tagging by humans. SAM is used more often in most automated methods so as to help one determine the accuracy of their work.

Self-assessment manikin (SAM) is a test used for evaluation of emotion with reliability coefficient ranging between 55/0 and 78/0 and the concurrent validity ranging between 56/0 and 78/0. SAM is a visual representation of the PAD dimensions developed by Lang as an alternative to self-report scales [13]. Lang developed SAM as a functional visual scale for evaluation of pleasure, arousal and dominance. Its displays in each dimension is along with a visual feature on a 5-point scale among which the respondents are to choose what they feel. SAM uses manikins for each emotional dimension in a scale. The answer to each row rates one of the three PAD variables, which can help identify an individual's emotional state. As previously mentioned, the emotion detection phase was removed so as to minimize the errors and self-assessment manikin was used instead.

4. METHOD

The learning-based memory framework developed by [8] is presented in Figure 1. This framework includes 1) meta-model, 2) analyzer, 3) evaluator, and 4) a memory modulator. Meta-model includes episodic memory, semantic memory, semantic graph and general semantic graph. Analyzer is a perceptual categorization mechanism. Assessment provides and represents understanding of perceptions (output analyst) according to memories content (meta-model). "Memory modulator" updates memories. The following information describes the applied changes. As mentioned above the details of the highlighted events will be saved in the episodic memory. In the episodic memory module, four aspects of each experience will be recorded (action_i, group_j, emotion k, and intensity). These four aspects mean that an individual with group_j personality in front of the background color i, has experienced the emotional state k with an intensity. In fact, using this method, this system will be able to retrieve the user's previous experiences. As mentioned previously, all memory modules presented in [8] have been used in this study. The four aspects of each experience (that will be recorded) are described in the following.

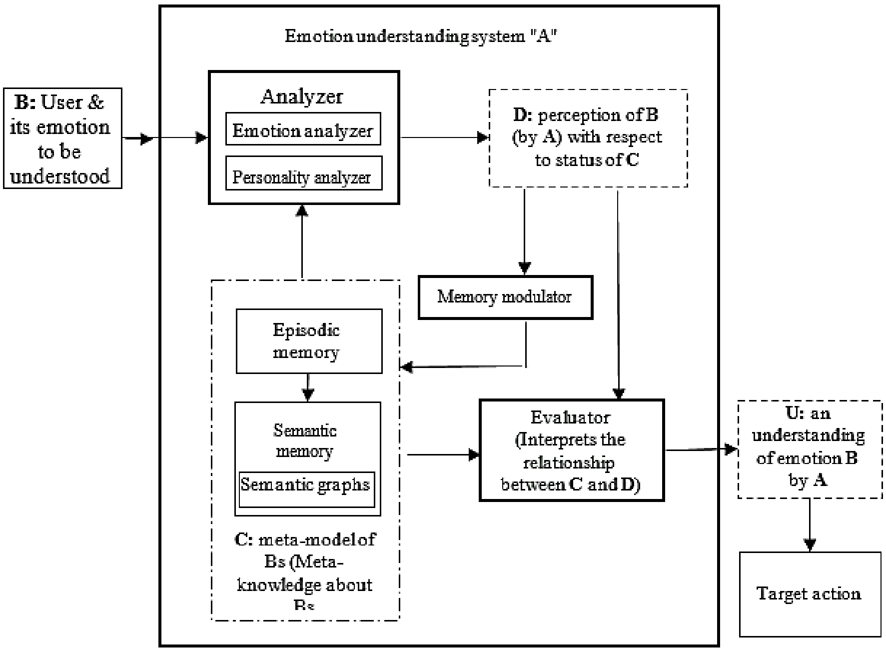

Figure 1. The framework of emotion understanding [8]

- Action

In this study, the operations are a set of background colors. Due to the wide range of colors, we have used color communication with emotional states in Suk *et al.* [9]. They obtained a set of colors for every emotional state but there are different color themes in each emotional state, and from our point of view the diversity of colors in every emotional state is due to the user's personality. For elicitation of the user's feedback, the set of colors related with each emotional state is demonstrated in each emotional state. Because of the low number of colors in some certain emotional states, we made some changes in colors based on the results of the articles [7, 10] so as to improve and increase the number of colors to be chosen. At the time of testing the tools, after receiving the emotional state of the user, a set of colors associated with that emotional state is displayed and a question is asked about the color that represents that emotional state. But at the time of the test after determining the emotional state, if emotional state is positive, color selection is done according to the experience and for that positive emotional state. But when the user is in a negative emotional state, color selection will be done according to experience for the emotional state contrasting that negative emotional state, meaning that an opposite color is displayed so that it may create a positive emotional state. Table 2 shows the colors used in this study.

Table 2. Table of colors

P	A	D	Color
+	+	+	
+	+	-	
+	-	+	
+	-	-	
-	+	+	
-	+	-	
-	-	+	
-	-	-	

– Type

The classification done by [8] was objective-based, while it is personality-based here. An experience by an individual with a particular personality type may occur for all persons with the same type of personality.

– Emotional state

Eight PAD emotional states have been used in this study, which have been explained in section III.c Mood.

– Intensity

As mentioned earlier, the intensity of the user's emotional states can influence the retrieval of an experience from the episodic memory. This is why each user is asked about the intensity of generated emotional states and will select a number in the range (0-100) as excitement intensity.

The recovery operations are also done based on the article written [8], in which only minor changes were made. Here, when the system interacts with a user, if it has an experience about the user, it will exactly use that experience. But if the user is a new one and has not already used the system, or has had no experience about the generated state, the retrieval of experience will occur based on the memory model [21].

Emotional states (emotion_ k) in nodes, actions (action_ i) the edges and weights are certainly factor (CF) in semantic graph. Semantic graph allows us to compare some experienced candidates by using the certainly factor [22, 23]. To calculate the certainly factor, we use saving time, new experience, and excitement intensity. For calculating the overall certainly factor, the certainly factor of all experiences that make an emotional state in an individual with a particular personality type needs to be calculated. When more than one action is present, the action with the highest degree of certainly factor is selected.

General semantic graph is also a kind of semantic graph and is actually an abstraction of semantic graphs and includes general knowledge about all human beings with different personality types. The general law of abstraction for semantic graph is that if an experience is repeated in more than half of the semantic graphs, that experience will be added to the general semantic graph [24, 25]. Thus, semantic graph experience may be used for all types of people.

5. EVALUATION

System evaluation is done based on the user evaluation method. Therefore, we used user's viewpoint for assessment in different parts. In fact, for evaluation of the memory system and assessment of the accuracy rate of the memory system's response to the gained experiences, the user is asked about how satisfied he/she is with the colors. At the end, after the user worked with the system, his/her feedback will be collected through a questionnaire. A questionnaire is used for several reasons:

– The system is made for users and they should comment about the system and thus help the designers in the construction and designing of the system.
– The user's structured responses to the designers' purposeful questions can be much more effective than the measurements methods which are not free from errors.

- Instead of asking for a complex feedback from experts, ordinary users can use the questionnaire.
- It is easier for users to compare the performance of multiple systems.
- After working with the system, the users will respond to the questionnaire including demographic questions and also questions used in order to get feedback from users concerning emotional state control and positive and negative emotions.

5.1. Expriment

For evaluation, the tools were tested and evaluated in three different modes:
- Base mode without changing the color
- Color change and via AUBUE method
- Color change by memory-based learning

Users worked with C++ programming language learning tool. The total number of users in the test was 48 people; each mode was tested by 16 members, 8 women and 8 men. In addition, for testing the memory-based learning method, some users needed to interact with the system so that it could collect the primitive data. This was done by 30 users, 15 women and 15 men. The mean age of the users in the study was 23.5 years; with SD of 2 years. Each user typed at least 6 programs in C++ language. Furthermore, each user worked with the educational tool in one of the modes of testing and evaluation. The users responded the questionnaire items after they finished working with the system.

5.2. Data analysis

In the questionnaire, the whole data were obtained via a 7-point scale, with 1 showing the weakest and 7 representing the highest degrees. One-way ANOVA was used to analyze the data. Analysis was done for the main hypothesis of the research, i.e. emotional control, and also a positive emotional state and negative emotional state. In fact, the emotional control should help increase the positive emotional states and decrease the negative emotional ones. Three comparisons were made in different modes for three variables of this study:
- Comparison of the base mode with color change by AUBUE method
- Comparison of the base mode with color change by memory-based learning model and
- Comparison of the color change mode by AUBUE method with that by memory-based learning model.

The accuracy of memory model developed in [8] was determined but due to the changes made in the model, the accuracy parameters were measured again. In fact, we can state that accuracy is the ratio of the number of the correctly retrieved actions to the total number of the retrieval ones. Errors were determined based on users' feedbacks. In other words, the user's dissatisfaction with the presented color is considered as error, and ultimately the accuracy for the memory model was obtained 70.213.

5.3. Controlling the emotional states

The results of evaluating the emotional state control parameter are given in Table 3. The number of participants in each method was 16, and the mean values obtained for emotional state control in the three methods were 2.94, 3.56 and 5.31 respectively. This means that the amount of emotional state control is greater for the memory-based learning model than for the other modes.

Color change method using AUBUE was better than the base method but the results had not enough superiority. A comparison of the first and second methods showed that the effect of the conditions was not significant for the variable emotional control. The change color method using AUBUTE was shown to be better than the base method, but the results showed no considerable superiority. The results of a comparison of the first method with the memory-based method was shown to be significant and the effect of situations was significant with effectiveness of 2.18. As a result, memory-based method is better than the base state with significant efficacy.

In addition, the result of comparison between AUBUE and memory-based method showed the superiority of memory-based method with 1.83 effectiveness. The results of the comparison showed the superiority of the memory-based learning method in emotional state control parameter over other methods with a noticeably high effectiveness.

Table 3. Descriptive table about the results of evaluation of the emotional state control parameter

User	Color 1	Color 2	Color 3	Color 4	Color 5
Emotional State	Bad	Good	Normal	Hard	Easy

6. CONCLUSION

In this study, an adaptive user interface was implemented so that the user interface color will change in accordance with the user's emotion. Also, by learning about the reactions of users with different personality types against each color, communication between the user's emotional state and personality and suitable color has been modeled to control the emotions. For modeling the user's experiences, the memory-based learning system was used.

The memory system used here includes two parts, namely episodic memory and semantic memory. Episode memory saves the details of experienced significant events, while semantic memory demonstrates an abstract of the episodic memory contents. The used memory system is capable to learn and will be completed as used more often. NEO_FFI was used for personality assessment and the user's point of view was also used for evaluation of the model in the form of a questionnaire.

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