A WEB-BASED SYSTEM FOR DELIVERING INFORMATION ABOUT USER'S MENTAL HEALTH

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Abstract – *This paper describes a web-based application for affective modeling and delivering information about user's mental health and emotional characteristics. The component for affective user modeling is based on the standard test in psychiatry and clinical psychology Emotions Profile Index. Since the assessment of the emotional state involves imprecision and uncertainty fuzzy decision-making techniques are used to formulate presentations in the form of informative paragraphs taken from the predefined knowledge base. Utility function is defined over the profile attributes and the social context. For delivering information about affective profiles agent based interface is created that covers subject-agent and psychiatrist-agent forms of interaction. This approach contributes to the research efforts related to personalized assistance and health care in the e-Health sector.*

1. INTRODUCTION

In the past years we witnessed the application of information technologies to improve access and efficiency in the processes related to health care. Digital technologies are becoming more important in health management aiming to reduce the cost to deliver health care services at a distance. In addition, the Internet is increasingly used by citizens to obtain medical information.

It has been long argued that the Internet can potentially provide resources for efficient health care and disease prevention [1]. The growth of online tools for web based medical data access changes the traditional clinician-patient relationship [2].

Citizens/patients can take more control of their health by accessing personalized information from their homes. The issue of personalization is rather complex with many aspects that need to be analyzed and resolved. Such issues include, but are not limited to, the following: what content to present to the user, how to show the content to the user, how to ensure the user's privacy. The existence of accessible clinical information reduces the time and effort the clinicians devote to patients. Teams of health professionals can coordinate their activities more effectively sharing information about the same patients.

Furthermore, there are discussions about the quality of the Internet health care information and the potential harm from inaccurate information sources. In that sense, public health officials have to recognize the need for standardization and certification of the health care information found on the web.

This paper describes an interactive application that provides information about user's mental health and emotional characteristics. The application is implemented in a web-based environment. The approach is interesting due to the increase of e-Health systems in recent years and the importance of having online access to health related information. The main advantage of the application developed is the delivering of personalized information in an environment adapted to the user.

Advances in information and communication technologies open the possibility for widespread use of novel human-computer interfaces. Among them there are interfaces based on automated speech recognition, like the system described in [3]. This project focuses on telephone-based monitoring service for chronic hypertensive patients.

Nowadays, animated agents provided with a personality and a social competence, and with verbal and nonverbal abilities represent a new approach to creating natural and efficient interfaces. Several projects describe embodied conversational agents, like REA [4], DFKI Persona [5] and pedagogical agents [6, 7].

For delivering information about affective user profiles agent based interface is developed. The programmable interface of the Microsoft Agent package [8] that includes several predefined characters is used for the audio-visual implementation of the virtual agents. The package has a speech recognizer and text-to-speech engine.

Agents developed in this work interpret the profile created by the user modeling component. Important aspect of the agent behavior is the social role awareness. When interacting with the patient the agent has to behave according to the norms and standards appropriate for that situation. The behavior is different when presenting a diagnosis to a psychiatrist or psychologist. In a particular social setting the social distance between the participants and the power that the agent role has over other roles determine the appropriate behavioral and communicative conventions.

Several agent architectures are based on the decision theory [9, 10]. Since the description of user affective state involves imprecision in this work a fuzzy decision-making paradigm is proposed to deal with this uncertainty.

Next section describes the user modeling component and the rule-based methodology for refinement of the profiles. Then the conceptual model of the agent is presented. This approach is illustrated by an example that shows the principles of fuzzy decision-making paradigm. The paper ends with a brief discussion and conclusions.

2. COMPONENT FOR AFFECTIVE MODELING

The affective profile is built according to the standard test in psychiatry and clinical psychology Emotions Profile Index. This instrument uses the idea that personality traits are mixtures of two or more primary emotions [11]. For example, personality trait cautious includes expectancy and fear as two main emotional components, and affectionate includes acceptance and joy.

EPI assesses the user affective state based on a partial ordering scheme of personality traits: adventurous, affectionate, brooding, cautious, gloomy, impulsive, obedient, quarrelsome, resentful, self-conscious, shy, and sociable. The emotional dispositions, such as fear, anger, joy, sadness, acceptance, disgust, expectancy and surprise, represent the user affective state. One type of a user profile is shown in Figure 1.

The user modeling component infers the emotional state of the user and presents the appropriate interpretation in the form of expert explanations, or offers a diagrammatic view of the results. Expert explanations of the emotional profile are obtained using the affective modeling system and consulting experts. In this work they are formed by merging fragments of texts activated by fired fuzzy rules.

EPI is used for initialization of the user affective profile. The user model might be modified using fuzzy rules [12].

Emotional state is described with linguistic labels for the fuzzy variables <R,I,N,S,D,O,E,A> denoting emotional categories reproduction, incorporation, orientation, protection, deprivation, rejection, exploration and destruction, respectively.

Fuzzy rules with the following general pattern are used for updating of the profile:

$$\text{if } x_1 \text{ is } A_1 \text{ and ... and } x_n \text{ is } A_n \text{ or ... then } y \text{ is } B,$$

where A_i and B are linguistic variables from the universes of discourse U and V respectively, x_i is an instance in the universe U corresponding to membership value $\mu_{Ai}(x_i)$, y is an instance in V with membership value $\mu_B(y)$.

Condition part of the rule might, for example, include events from the application where EPI is used for the assessment of the user emotional state. Action part might specify new values for the attributes in the user model or might activate other rules. The process of fuzzy inference is formalized with the following fuzzy automaton:

$$FA=(I,S,O,f,\lambda),$$

here I is a set of input linguistic variables, S is a set of automaton internal states and O is a set of output linguistic variables.

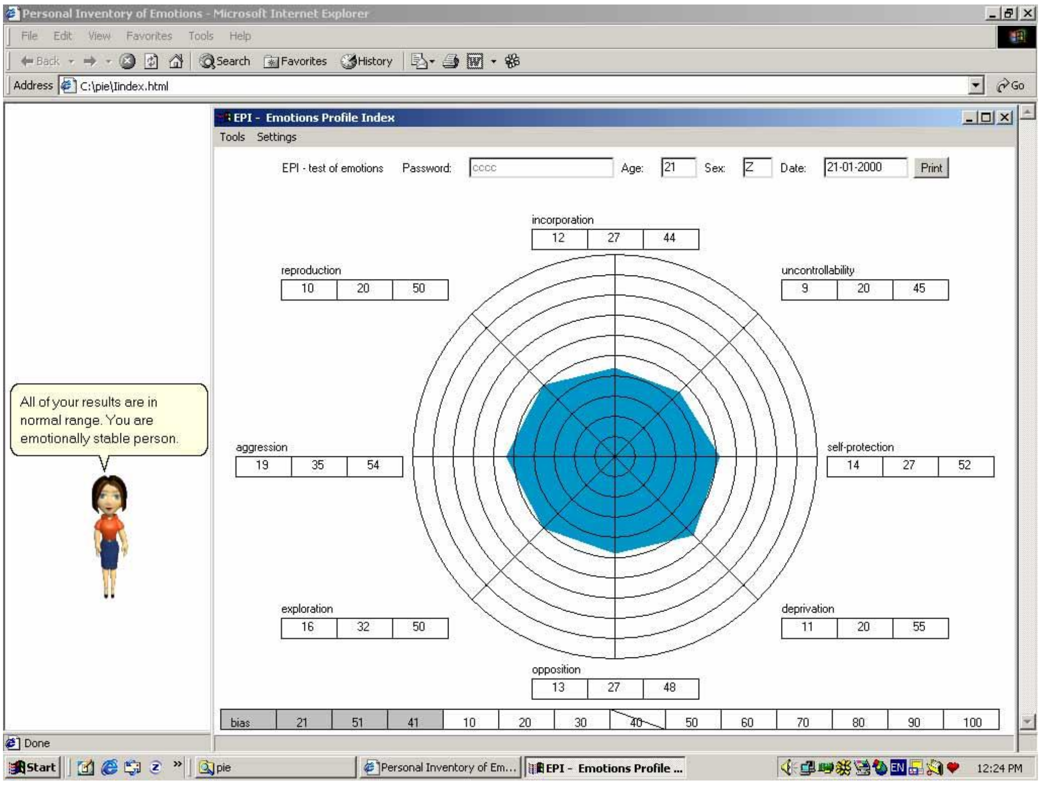

Figure 1. An example of a created affective profile

Transition function f is defined as f: SxIxS $\rightarrow$ {0,1} and output function λ as λ: SxIxO $\rightarrow$ {0,1}, where $f(s_i,i_p,s_j)=1$ if there is link from state s_i to s_j, and $f(s_i,i_p,s_j)=0$ in other cases, and $\lambda(s_i,i_p,o_p)=1$ if o_p is the output at state s_i when input is i_p and $\lambda(s_i,i_p,o_p)=0$ otherwise. The fuzzy automaton has to be deterministic.

That is, for a given input and current state there is only one next state and output. So, some constraints are imposed: function f has value 1 for exactly one next state s_j being in state s_i when the input is i_p and λ has value 1 for only one output o_k being in state s_i when the input is i_p.

To obtain next states the automaton computes max-min operations from the current state and inputs. Let current input x has membership values

$$I=[\mu_{i1}(x),\ldots,\mu_{ip}(x)],$$

for every input linguistic variable i_k and S is the current state of the automaton distributed over several states, where the degree of activation of the states is defined with value in the interval [0,1]. The next state S' is computed as fuzzy composition

$$S'=S\circ\max[\min(\mu_{i1}(x),f(s_i,i_1,s_j)),..,\min(\mu_{ip}(x),f(s_i,i_p,s_j)).$$

User affective profile might be modified to include evidence from psychiatrists. The experts might add a rule that is inconsistent with the rest of the rules. Analyzing the process of fuzzy inference using fuzzy automaton may help in detecting undesirable and ambiguous situations.

3. FUZZY DECISION-MAKING FRAMEWORK

In this section the formal model of the agent fuzzy decision-making process [13] is represented together with the transformations of the decision-making situation under the influence of the social roles. The role of the agent is associated with certain goals and behaviors to model social competence.

Let the set of feasible alternatives or actions that the agent is able to perform in state $X_i \in X$ is $S=\{S_1,...., S_n\}$.

The state X_i is the decision context. Agent actions in this model are actually conversational acts. In general case S represents the subset of the space R^p, or with other words an alternative might be defined with p attributes.

The agent goals and motives are formalized as decision criteria. The motives determine priority of the goals. The set of agent goals and motives is

$$C=\{C_1,...., C_k\}.$$

The criteria are defined as functions

$$C_j : R^p \rightarrow R,$$

where j=1,...,k.

The image of S in R^k is the set of feasible solutions for the multi-criteria problem of selecting an alternative

$$B_S=\{B_i \in R^k \mid b_{ij}=C_j(S_i),\ j=1,..,k,\ S_i \in S,\ i=1,..,n\}.$$

Actually $B_i=\{b_{i1},..., b_{ik}\}$ are evaluations of the alternative S_i, i=1,...,n versus all the criteria.

Ordering the set of motives and goals is realized with the function that assigns weights to the criteria in different decision-making situations

$$W : X \rightarrow [0,1]^k$$

where $W(X_i)=(w_1,..., w_k),\ \ X_i \in X,\ \ i=1,..., n$ denotes the importance of the motive or the goal j=1,...,k for the agent in a particular situation.

Using the defined terms the agent utility function for the alternative $S_i=\{s_{i1},..., s_{ik}\}$ is given with the following formula

$$U(S_i)= f(g(w_1, s_{i1}),..., g(w_k, s_{ik})),\quad i=1,..., n$$

where $g : R\ X\ R \rightarrow R$ is a function that transforms the evaluations of the alternatives with the criteria weights, and $f : R^k \rightarrow R$ is an aggregation operator that gives the unit score of appropriateness of the alternative versus all the criteria. For example, f might be the minimum operator and g maximum t-conorm

$$g(w_j, s_{ij})=\max\{1-w_j, s_{ij}\},\quad i=1,..., n,\quad j=1,..., k.$$

In the cases where the type of aggregation is neither pure "anding" denoting complete lack of compensation nor pure "oring" denoting complete submission to any good satisfaction, OWA operators [14] might be used. OWA aggregation operators act like quantifiers, providing ways to represent aggregation where "many", "most", "few", etc. criteria are satisfied by the alternative.

The agent selects actions that maximize its performance measure and in that sense performs utility-directed action selection

$$U(S^*)=\max_i(U(S_i)),\quad i=1,..., n.$$

Agent actions feasible in situation X_i are subset of the set Δ^* that we call the set of behavior conventions $S \subseteq \Delta^*$, where Δ is the set of all elementary actions in any situation of X, Δ^* is a set of all sequences that can be formed from the elementary actions of set Δ.

The decision-making situation is represented with the following quadruple

$$V=(X_i, S, C, U)$$

where X_i is the state or decision context, S is the set of actions feasible in particular situation or appropriate conversational acts, C are agent goals and motives that serve as decision criteria and U is the utility function.

Under the influence of the social roles the decision-making situation is transformed in

$$(X_i, S, C, U^{'}).$$

The impact of the social roles is implemented through the change of the criteria weights. The transformed utility function is

$$U^{'}(S_i) = f(g(w_1^{'}, s_{i1}),..., g(w_k^{'}, s_{ik})), \quad i = 1,..., n.$$

4. IMPLEMENTATION

This section illustrates the previously described methodology for delivering appropriate explanations of the obtained affective profiles.

Two characters are defined to cover the subject-agent and psychiatrist-agent forms of interaction. First agent will assign higher importance to expressions of empathy and giving advice to subjects and the second will value more the actions offering detailed explanations of the results about the mental health of the user. Agents with different characteristics are defined by varying the utility function.

To exhibit social competence, an agent ought to possess the ability to select adequate behaviors. The process of selection depends on the evaluation of the situation and on the desirability of the possible outcomes.

Let the affective profile under consideration belongs to a person with certain pathological manifestations and let the following alternatives from the knowledge base are activated:

- S1: This is a cautious and anxious person. The results show that this person is constantly worried of getting into troubles that she could not be able to overcome. Also this person is worried about what other people think or speak about her.
- S2: There is a possibility for phobic and obsessive-compulsive behavior.
- S3: It looks that you have some problems. Is that right? You have to visit a psychiatrist.
- S4: For further analyses you have to consult a psychiatrist. Your results show anxiety and some other pathological problems.

The agent that presents information to subjects will display the alternative S3. The alternative S4 is less suitable because of the low performance on some of the criteria. The explanation that alternative S4 offers might have negative impact on the subject.

The agent that covers psychiatrist-agent form of interaction will present detailed information about the pathological problems of the subject. This agent will display alternatives S1 and S2.

5. CONCLUSION

This work describes a human-computer interface with agents that deliver information about the user's mental health. Agents are able to adapt their behavior by changing parameters related to the social roles. The formal model of the agent includes fuzzy decision-making techniques to deal with the uncertainty involved in the assessment of the user's emotional state.

The component for affective user modeling is based on the standard test in psychiatry and clinical psychology Emotions Profile Index. In addition, a rule-based tool is used to refine the user model by integrating evidence from additional sources, such as expert opinions.

The implementation of this tool as a web-based application is interesting due to the increase of e-Health systems in recent years and the importance of having online access to health related information. This work contributes to the new health care delivery models that tend to be citizen/patient centered taking into account the individual preferences and needs.

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