Senseario: An interactive application for improving emotional awareness in high-functioning autistics

Temitope Sonuyi
MIT Media Laboratory
20 Ames Street
Cambridge, MA 02139, USA
temi@mit.edu

Paulina Modlitba
MIT Media Laboratory
20 Ames Street #320G
Cambridge, MA 02139, USA
paulina@media.mit.edu

ABSTRACT
Common sense is knowledge that we tend to take for granted. However, there are individuals for whom this general knowledge is incomprehensible. Autistic individuals for example, generally lack emotional and social common sense; they have difficulties recognizing suitable responses in emotional situations, as well as the emotions of other individuals. In this paper, we describe an interactive software application for improving emotional awareness in these scenarios. Based on natural language commonsense knowledge, as stored in Open Mind Commonsense (OMCS), our application guides the users through everyday situations, and encourages them to reflect upon their emotions and behavior in order to improve their affect awareness and social skills.

Keywords
Commonsense reasoning, interactive applications, user interfaces, HCI, affective computing, affective UI, Open Mind Commonsense, Eventnet, software agents, AI, behavior, autism, special learning.

INTRODUCTION
French writer, essayist and philosopher Voltaire once said that "*Common sense is not so common*". This statement addresses one of the most central questions in the philosophical discussion of common sense: Assuming that we by common sense mean knowledge that is held by people in general, is there such a thing as "common sense"? Is there a universal knowledge base that can be taken for granted? Considering cultural, generational and individual diversity the answer is most likely "no". There are exceptions to every fact; knowledge that one individual or community considers natural might be extraordinary to another. Taking knowledge for granted can cause embarrassment and misunderstandings. At the same time, lacking a sense for what is assumed to be common sense can also lead to awkward situations. Individuals with autistic spectrum disorders (ASD) normally lack this kind of knowledge; they recognize concrete facts and events, but usually fail when it comes to identifying and understanding general or abstract concepts. These individuals also often lack normal emotional intelligence and social awareness in the sense that they do not recognize other individuals' emotional states, or the relation between actions and their consequences [1]. In this project, we introduce an interactive application that exploits common sense computing capabilities for enabling autistic individuals, and others who feel the need to reflect over their behaviors and emotions, to improve their affective awareness. By reflecting on emotions in social stories that they construct, the users can get a better understanding for how certain events influence our emotional state and mood, as well as how our emotions and personality influences the decisions that we make in our everyday life.

BACKGROUND
The motivation for this project stems from a recognition of people who lack normal emotional perception. Most commonly this lack of perception manifests itself in people with some form of Autism, which lead us to begin looking at the problem from that angle.

Autism
Autism is defined as a pervasive developmental disorder and is considered a severe and complex psychiatric condition that occurs in about 0.2% of the human population. Still today, theorists do not have a clear picture of the cause and nature of the disorder. The key symptoms are however fairly well-documented. The diagnosis of autism relies on inter alia, qualitative impairment in social interaction; qualitative impairment in communication; restricted, repetitive and stereotyped patterns of behavior and speech. For this reason people with autism are usually very good at carrying out concrete and repetitive activities, but fail when it comes to social activities that require an understanding of social rules and interactions, as well as emotions. It should be pointed out that there is a high inter-individual variability regarding intelligence among autistic individuals. Autism with normal or high IQ is referred to as high functioning autism or Asperger's Syndrome. These

people tend to have a well-developed vocabulary but nevertheless have profound difficulties to understand abstract social concepts and also have difficulties generalizing from one situation or concept to another [1, 13].

Computer Assisted Education for Autism

The potentials in using computers for education and training of people with ASD have been recognized for many years now [12]. As Rosalind Picard points out: "*One way to help autistic people is to have a trained person sit down with them and repeatedly walk through situations to help them learn how to understand and respond… This is interaction that could be provided by computers capable of understanding emotion. Computers with an ability to teach this understanding – via games, exploratory worlds, virtual social scenarios, and other interactions that provide repetitive reinforcement, could be developed with present technology*." [13]

Software applications and agents for autistics have been developed within many research fields, for many different purposes [4, 6, 15]. Our application is however the first training software to apply commonsense knowledge to direct the interaction. By implementing a common sense knowledge base, we enable the application to reason about everyday facts and relations that people with ASD (as well as computers) normally are not able to recognize and comprehend.

SYSTEM AND INTERFACE

The main function of our application is to create stories regarding everyday life events, by adding one event at a time. At each stage, the user gets feedback about the affective value of the event.

System

The beta implementation of the application works as follows. First, the user chooses a persona out of a set of 15 pre-determined characters for the interaction session. A short description of the persona's distinguishing features is presented, in addition to a picture that illustrates these features. The user then enters an event that functions as a starting point for the social story. Based on the characteristics and emotional state of the chosen persona and the affective value of the chosen event, our application chooses a set of likely and appropriate subsequent events. The output approach is very similar to that of a predictive typing aid; the user is presented with a number of more or less likely alternatives, of which one is marked as the most likely event. The approach is fail-soft since it suggests possible "solutions" to the user, rather than forcing them. The user has the freedom to choose the option of his or her preference. After that, the affective value of this newly selected event is displayed. Lastly, a new event is chosen on the basis of the last emotional state of the user.

Events

The list of subsequent events is determined by two major factors: (a) commonsense knowledge regarding human actions and goals, and (b) the features and emotional state of the persona. The chosen event is first fed into a commonsensical goal planning tool, called EventNet [5], which is based upon the Open Mind Common Sense database (OMCS) [14]. By extracting cause-effect and action-goal links from OMCS, EventNet builds an associative network of tens of thousands of nodes about human actions. Upon receiving an event, EventNet feeds back a list of adjacent (related) events, ranked by probability. We then use Emotuslite, a tool for applying PAD values to text, to retrieve a three-dimensional PAD affect value. The PAD model, as introduced by Mehrabian [9], consists of three nearly independent dimensions: Pleasure (P), Arousal (A), and Dominance (D). Specific terms describing affect can be visualized as points in the three-dimensional space.

Based on the PAD score of the events, we then identify the event whose affect value is closest to that of the persona. This event is then highlighted when presented to the user.

Personality, mood and emotion model

One of our most challenging tasks in building our application was to find a sufficient model for the relations between personality, mood, emotional state, and behaviors of the personas. We decided to implement a simplified version of the Ortony Clore Collins (OCC) model [11]. The OCC model has come to establish itself as the standard model for emotion synthesis. A large number of studies have used the OCC model to generate cognitive emotions and behaviors for their embodied agents [2]. The OCC model addresses the problem of representing emotions by grouping emotions according to cognitive eliciting conditions, rather than by using sets of basic emotions. The OCC model provides a set of rules for generating emotional potentials and states. It assumes that emotions arise from emotional reactions to situations consisting of events, agents, and objects, and hence synthesizes emotions as direct outcomes of situations. Since being in an emotional state is itself a situation, the model also permits emotions to trigger additional emotions, or to repeatedly trigger the same emotion.

Based on the functions of our application, we have chosen to focus on the event aspects of the OCC model. In other words, our model includes events, emotional state, mood and personality of the persona. The model is based on the idea that the persona, or individual, is a constantly changing being that not only triggers external events, but also is influenced by these events. Each individual has a personality, mood and emotional state, of which the emotional state is the most dynamic concept. The personality of an individual is simplified to having n values, where each dimension is represented by a value within a certain interval $\{0, 1\}$. To make mapping between events

and personality easier and more direct, we chose to describe personality by using the PAD model mentioned above.

Mood and emotional state have a similar structure as personality, but changes over time based on events that occur, and therefore has to be updated at each step of the scenario. Based on the assumption that an individual's emotional state is influenced by her current mood, the new emotion influence is processed in two steps. The first step consists in updating the mood; the second step consists of updating the emotional state. The mood is update by a function that calculates the mood change based on the personality, the previous emotional state, and the emotional influence, i.e. the desired change of intensity for each emotion. The emotional state can then be updated by a function that also takes the new mood into account.

We want to point out that the data used for updating the emotional state and mood is (so far) not based on empirical evidence. The data is currently only based on our personal experiences of how personality, emotions, and mood interact and influence our behavior and should therefore not be treated as core aspect of this research project.

INTERFACE

Figure 2 shows a screenshot of the end-user's interface. The interface consists of four main frames: 'Personality', 'Event Choices', 'Result' and 'Scenario'. In the result window information regarding the affect value of the current event is presented, both as a caricatured facial expression, and by meter bars. In the scenario window, the preceding events are displayed in chronological order, each with a facial expression that indicated the affect value of that particular event, to give the user an overview of the scenario and affect development of the story.

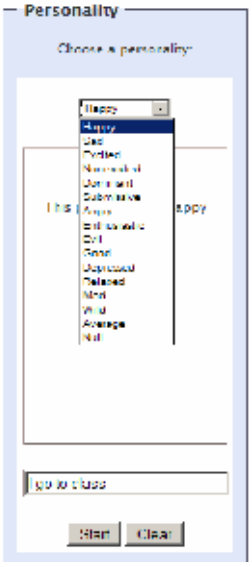
We choose to enhance the graphical user interface with facial expressions primarily because people with ASD primarily seem to be visual thinkers [7, 10]. It is however very important to keep these expressions simple, since studies have shown that autistics normally have difficulties with distinguishing more complex, belief-based emotions such as surprise [1]. One possible benefit of implementing these stereotypical facial expressions is that the user learns to recognize the relationship between certain emotions and their respective facial expressions.

Figure 2. The Senseario Interface

SCENARIO

Here is a description of intended interaction between a user and the application.

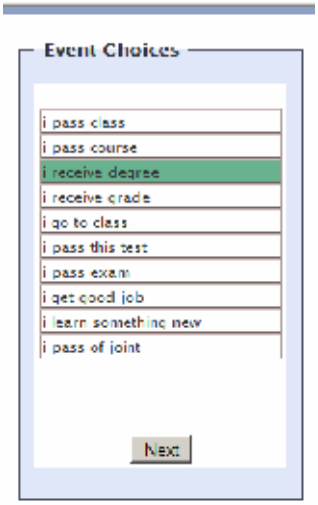
- Upon navigating to the web site, the user first chooses a 'Personality' from a list of predefined personalities that each have an explanatory title, PAD value and description associated with them. In this case the user chooses the "Happy" labeled personality. This personality selection will later be used to dynamically choose event recommendations, as well as generate mood and emotion values.



- After choosing a personality, the user enters an initial event sentence in order to start the scenario.

In this case the user types in “I wake up”. The user then clicks the ‘Start’ button to instigate the session.

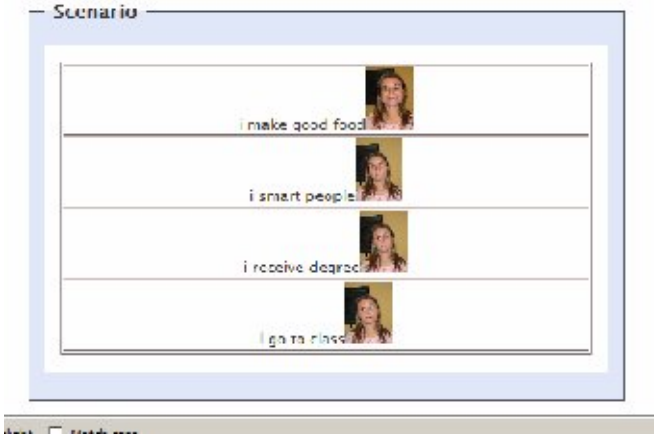
- Upon clicking ‘Start’, the user’s attention is directed to the ‘EventChoices’ field, where a list of choices is displayed. In this case all of the choices are events that would logically follow after “I wake up”. From this list, the event that the system has identified as the most likely subsequent event is marked. The process of ranking the events is two-fold. EventNet feeds back a long list of events, ordered based on commonsensical probability. Thereafter, our application uses the personality, mood and emotion state of the persona to rank the top then events of that list. The user is free to ignore the “recommendations” of the application by choosing any event from the displayed top-ten list. When the desired event has been selected, the user clicks the ‘Next’ button.



- Upon clicking next, three things happen:

  - First, the selected event is analyzed to find its PAD value and corresponding basic Ekman emotion [3]. Both of these values are then displayed in the ‘Result’ field of the user interface. The PAD values are displayed by meter bars, while the Ekman emotion is shown in the form of a human face that is expressing the indicated emotion. In addition, the event sentence that is associated with the two values is displayed in a label.

  - Second, the selected event sentence and the human picture of the Ekman emotion are placed in the ‘Scenario’ field along with all of the past event-emotion pairs in chronological order.



  - Lastly, the ‘EventChoices’ field updates itself to display the next set of possible events. The user may then either click ‘Next’ directly to choose the pre-selected event, or select a different event and then click ‘Next’, and so on.

CHALLENGES

The implementation of commonsense knowledge results in several challenges and limitations. As mentioned above, the source of the knowledge used by our mechanism is the OMCS database [14]. OMCS is a web based application that enables users around the world to collaboratively build a database of facts about everyday life. At the moment, OMCS contains over 700,000 English sentences.

Open natural language knowledge databases, such as OMCS, bring about two major limitations: ambiguity and noise [8]. Thus, the main challenge is to create an application that is able to make sense of the knowledge data, by disambiguating and filtering the output. In

addition, the application ahs to be able to cover up for "black holes" in the database; despite the large amount of data, there are many facts and relations that the database do not cover. However, even though OMCS is still a somewhat brittle corpus, it can still be useful. By making the application fail-soft, i.e., enabling the user to ignore the output of the application, the user does not have to be restricted by the limitations of the application. In the case where the application fails to produce a sufficient result, seen from the user's point of view, the user is free to choose a more satisfying alternative.

FUTURE WORK

Future work is planned to improve a number of features in the application presented in this paper. These adjustments concern both our specific application, and EventNet, the commonsense knowledge tool that it utilizes. First and foremost, we need to evaluate and enhance the personality and affect model that is used. At this point the algorithms being used are based on biased assumptions, rather than on empirical data. In addition, further research and testing may suggest that the general OCC model that we have chosen to implement is not the most suitable one.

Further, there is a need for filtering the output generated by EventNet. A possible approach is to enable the user to choose a certain context, e.g. "A day in school" or "Me and my family", and restrict the output to events that are related to that particular situation. Currently, the output is far too eclectic, regarding both spatial and temporal context.

Concerning the graphical user interface, we intend to examine the different ways in which the user can choose a persona for the interaction. At present, the user is limited to a set of stereotypical personas that have been created by the authors of this paper. This approach brings about problems when the characteristics of the personas are not obvious to the user. A more straightforward approach might be to let the user enter the preferred personality values directly. It is also plausible that the user wants to enter personality input in a more indirect format, e.g. by writing a piece of text that illustrates the chosen personality.

CONCLUSION

In this paper, we have presented a software application that encourages users to reflect upon their emotions in every-day situations in order to improve their affect awareness and commonsense reasoning. By reflecting on how personality, emotions and mood mutually influence and are influenced by events, the users can improve their affect awareness and commonsense reasoning. Though this particular research project focuses on helping individuals with autistic spectrum disorder (ASD), a group of individuals that normally lack commonsense to some extent, the affective commonsense engine that the application is built upon can be used for any kind of emotion and behavior synthesizing, such as for embodied animated agents, computer game avatars, and robots. These are merely a few of the ways that this project can create a new platform for applications via the combination of commonsense reasoning, affect and personality traits.

ACKNOWLEDGMENTS

We thank our teachers Henry Lieberman and Hugo Liu, and our classmates for advising us throughout this project. We also want to thank Jose Espinosa for giving us access to, installing and understanding EventNet, Hugo Liu again for Emotuslite, and Christian Becker at the University of Bielefeld for providing us with a model for converting PAD values to Ekman's six basic emotions.

REFERENCES

1. Baron-Cohen, S. *Mindblindness: An essay on autism and theory of mind*. The MIT Press, Cambridge MA, 1997.

2. Bartneck, C. Integrating the OCC Model of Emotions in Embodied Characters. *Workshop on Virtual Conversational Characters: Applications, Methods, and Research Challenges* (Melbourne, Australia, 2002).

3. Becker, C., Kopp, S., and Wachsmuth, I. Simulating the Emotion Dynamics of a Multimodal Conversational Agent. *Affective Dialogue Systems: Tutorial and Research Workshop, ADS 2004* (Kloster Irsee, Germany, 2004).

4. Eliasson, E., Fredrikson, A., Rybrand, M., and Wahl, M. Musbus: a personalized mouse training program for children with autism. *Conference on Human Factors in Computing Systems CHI '99 extended abstracts on Human factors in computing systems* (1999), 326-327.

5. Espinosa, J. EventNet: Inferring Temporal Relations Between Commonsense Events. *Fourth Mexican International Conference on Artificial intelligence, MICAI* (Monterrey, Nuevo León, Mexico, 2005).

6. Harris, B. and Summa Chadwick, M. A computerized system for Neurologic Music Therapy. *Journal of Computing Sciences in Colleges* 21, 2 (December 2005), 250-257.

7. Hart, M. Designing for individuals with memory and cognitive disabilities: Autism/excel study. *Proceedings of the 7th international ACM SIGACCESS conference on Computers and accessibility Assets '05* (2005), 136-141.

8. Lieberman, H, and Liu, H. Adaptive linking between text and photos using common sense reasoning. *Conference on Adaptive Hypermedia and Adaptive Web Systems*. LNCS 2347, Springer.

9. Mehrabian, A. General & Precise Tests of Emotions, Feelings or Affect (the PAD Emotion Model). Available at http://www.kaaj.com/psych/scales/emotion.html#definition.

10. Minshew, N. and Goldstein, G. Autism as a disorder of complex information processing. *Mental Retardation and Developmental Disabilities Research Reviews 4, 2* (1998), 129-136.

11. Ortony, A., Clore, G., and Collins, A. *The Cognitive Structure of Emotions*. Cambridge University Press, Cambridge, 1988.

12. Panyan, M.V. Computer Technology for Autistic Students. *Journal of Autism and Developmental Disorders 14,* 4 (1984), 375-382.

13. Picard, R. *Affective computing.* The MIT Press, Cambridge MA, 1997.

14. Singh, P. The Publication Acquisition of Commonsense Knowledge. AAAI Spring Symposium (Stanford Univeristy, Palo Alto, CA, 2002).

15. Werry, I., Dautenhahn, K., Ogden, B., and Harwin, W. Can Social Interaction Skills Be Taught by a Social Agent? The Role of a Robotic Mediator in Autism Therapy. Lecture Notes In Computer Science; Vol. 2117. *Proceedings of the 4th International Conference on Cognitive Technology: Instruments of Mind* (2001), 57-74.