AN EMBODIED CONVERSATIONAL AGENT WITH ASPERGER SYNDROME

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Abstract: We discuss the development of an embodied conversational agent with Asperger-like communication skills. The agent was developed for use in educational software in a virtual environment specifically aimed at autism spectrum disorder software. We describe the design and implementation of the agent, and pay particular attention to the interaction between emotion, personality and social context. A 3D demonstration shows the typical output to conform to Asperger-like answers, with corresponding emotional responses.

1 INTRODUCTION

The prevalence of reported cases of autism spectrum disorders worldwide has increased dramatically over the past two decades. The latest CDC report puts the number of people with autism at 1 in every 110 (Center for Disease Control, 2009). Autism spectrum disorders (ASDs) display as a moderate to severe lack in language, communication and social skills. As language and communication are the essential components of conversational agents, this clearly has a major impact on the way that such agents communicate in educational software developed for children with ASDs.

There is clear evidence that children with autism find benefit in computer supported education and therapy (Parsons et al., 2006; Tartaro and Cassell, 2007). Likewise, the advantages of embodied conversational agents (ECAs) in educational software are also well-known (see for example (López-Mencía et al., 2010)). However, it is important to note that such agents actually perform a social role (Doyle, 1999), and we argue that an ECA could be distracting rather than helpful to a person with autism. Weighing the advantages of an ECA in educational software versus the potential problems it could cause for persons with autism, we decided to implement both a standard ECA and an ECA with autistic traits. We believe that children on the autism spectrum would find better rapport with an ECA with autistic traits.

This work describes our design and development of an ECA with autistic traits, and its social affect.

The reader may note that the aim of the article is to describe the technical design, rather than the educational or psychological evaluation of the ECA. We describe some related work in Section 2, followed by our design is given in Section 3. We discuss results in Section 4, and future work in Section 5. We conclude in Section 6.

2 RELATED WORK

An ECA encompasses all aspects involved in a conversation – from speech to facial expressions and body language, to communication and interaction. People with ASDs, however, have huge difficulties following the unspoken parts of communication such as body language and facial expressions. As our aim is to build an ECA to assist people with ASDs, we intentionally ignored these graphical aspects of ECAs, and rather concentrated on the conversational language structure of the ECA. Note that the results of using an ECA with autistic traits versus using a neurotypical ECA is to be compared in the final stages of our project. We do take note of the work of Fabri *et al* in this regard (Fabri et al., 2007).

The idea of an ECA with emotion and personality is not new (Allbeck and Badler, 2002), and the seminal works on this topic are those of Badler (Allbeck and Badler, 2002; Cassell et al., 1994). Badler proposed parameterised action representations (PARs) to describe the interaction of an agent with its environment, and his EMOTE system combines PARs

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with movement analysis and psychological theory to represent emotion and personality in the agent. The standard five factor model for personalities (also known as the OCEAN model (John and Srivastava, 1999)) is used to describe personalities, while emotions are based on the Ortony-Clore-Collings (OCC) model (Ortony et al., 1988).

Gebhard extended this work by combining emotion and personality with mood (Gebhard, 2005), in the ALMA (A Layered Model of Affect) system. ALMA also uses OCEAN and OCC for personality and emotions, respectively, while mood is based on the pleasure-arousal-dominance (PAD) model (Mehrabian, 1996). Data files for each agent record how moods and emotions change over time and with external stimuli.

In order to conduct a conversation, an ECA can follow a set of rules, or use a artificial intelligence reasoning engine to calculate reasonable responses. Rule-based systems can produce surprisingly convincing conversations, as the well-known Eliza proved (Weizenbaum, 1966). Nowadays, there are a myriad of conversational agents (also known as chatterbots) available (for example, see (L'Abbate et al., 2005; Bass, 2005)), each with their own advantages and disadvantages. We based our work on the well-known A.L.I.C.E. (Bush and Wallace, 2005), as it serves as an international standard on chatterbots. It also provides an open standard (called AIML) for interaction.

In the next section, we highlight the interaction of the different components of our system, and show how it links to external systems.

3 DESIGN

In the design of any ECA, one has to design both the agent itself, as well as its supporting graphical and language processing environments. We first consider the design of our ECA in isolation, and then describe its supporting underlying graphical and language processing environments.

Our agent is intended to be an ECA with autistic communication behaviour. The reader should note that ASDs are on a continious spectrum, from individuals who are totally isolated and non-communicative, to individuals who are high-functioning, participative members of society, and just have some degree of communication and social difficulties. Since our ECA is intended to communicate, we modeled his behaviour on that of a person with high-functioning autism (also called Asperger's syndrome).

Personality is generally accepted to be independent of autism (Austin, 2005), and our first step was to build a background character profile and personality for our ECA. This was necessary to improve the believability of the ECA (Dryer, 1999). We also consulted a clinical expert in Asperger's syndrome (AS) to verify our final character profile and personality (Forrester, 2010).

Our ECA is an 11 year old boy with AS. He is almost exclusively interested in dinosaurs and Star Trek. He converses at length about these topics. His other conversation skills are low, particularly in non-factual topics. Physically, he does not like to be touch unexpectedly, and has a distinctly large personal space. He dislikes crowds, loud noises, and sharp smells. He shows little interest in competitive sport, although he does like swimming and horseriding. He spends many hours on the computer, browsing the internet on his special topics of interest. He attends a mainstream school, but has few friends. He struggles socially, but does well in some academic subjects. He has two siblings – an older brother and a younger sister. He has a typical relationship with both, although his brother is quite protective, whereas his sister has little patience with him. He loves animals, especially the family Labrador.

Given the character profile, we could develop the OCEAN values of his personality. Note that, although there is no evidence for an 'autistic personality', some OCEAN values seem typical of a person with a high autistic quotient (Wakabayashi et al., 2006). Therefore, in this character design, we tried to follow the common correlation identified by (Austin, 2005) and (Wakabayashi et al., 2006). They found that people with autism typically have low scores for extraversion and high scores for neuroticism. The former also identified low agreeableness, while the latter identified low conscientiousness as being typical of people with autism. We now look at how we can derive our ECA's OCEAN values from the above profile[1].

- While our character's ability to absorb and vigour for seeking out information about his special interests may be thought to be an indication of a high score for "openness", it actually is not. A more careful examination will show that he actually greatly lacks in active imagination, has little regard for aesthetics and he has difficulty identifying his own inner feelings, let alone phrase them for other people. This is an indication of a medium-negative "openness" value. We select a

[1]Note that, in reality, OCEAN values aren't "guessed" based on brief personality descriptions, but rather are obtained from reputable tests, such as the NEO Personality Inventory (NEO PI-R) or NEO Five-Factor Inventory (NEO-FFI) test (Costa and McCrae, 1992).

value of -0.6.

- Like many people who have AS, our agent is diligent in his work (which he comprehends). But for him, working on something which he understands is more than a pleasant escape from a misunderstanding world. He feels pride and satisfaction in a job well done. This is an indication of a medium-positive “conscientiousness” value. We select a value of 0.5.
- Although our agent likes having friends—sometimes actively seeking new friends out—and can be talkative at times, one might assume that he is fairly extraverted for someone with AS. The basic human need for social interaction is, however, virtually universal. Upon closer examination, one sees that he typically prefers to be alone for a few hours a day, although he is not totally reclusive. This is an indication of a low to medium negative “extraversion” value. We select a value of -0.4.
- Our agent has difficulty to be accommodating of others. Although he recognises the necessity of being accommodating, he struggles with a natural tendency not to be so. This is an indication of a low-negative “agreeableness” value. We select a value of -0.2.
- While our agent is often angry and feels isolated, this in itself is not necessarily an indication of neuroticism, but are side-effects of his AS: feeling unable to communicate his feelings in a “proper” way and having constant strain to understand and decipher a world built around people who are neurotypical are taxing on him. However, he is more susceptible to these negative feelings than the norm (regardless of the measure), but is resilient to long periods of anger and depression. This is an indication of a low-positive “neuroticism” value. We select a value of 0.3.

Following the formula given in (Gebhard, 2005), we are now able to calculate the agent’s base mood traits as

$$\begin{aligned}
Pleasure &= 0.21 \times E + 0.59 \times A + 0.19 \times N \\
&= 0.09 \\
Agreeableness &= 0.15 \times O + 0.30 \times A - 0.57 \times N \\
&= -0.32 \\
Dominance &= 0.25 \times O + 0.17 \times C + 0.60 \\
&\quad \times E - 0.23 \times A \\
&= -0.35
\end{aligned}$$

The score of +P−A−D indicates that the agent has a default mood of being *docile*, as described in (Gebhard, 2005).

Given the background profile, personality and mood indicators for the agent, we now consider our conversation data set. For our first prototype demonstration program, we fixed two conversation topics (dinosaurs and Star Trek). Our expert AS psychologist worked with a 15 year old boy with AS to construct several representative prototype conversations which demonstrate different emotional responses. These were then used to build the necessary AIML template matching response files. We are currently in the process of extending our conversation data set. Our current demonstration program therefore restricts the types of questions, and the content of the questions rather severely. This will clearly be remedied as the data set grows.

Now, given an agent and its accompanying conversation data sets, we need to let the agent interact with its environment. This interaction is quite simple – in a typical conversation, the user can type in a question. If the question is a factual specialized question from the knowledge base of the ECA (in our case, dinosaurs or Star Trek), the answer can be extracted from the knowledge base. Here, no emotion or personality is involved. Otherwise, if the user question is a generalized question not involving the knowledge base, it needs to be answered in a chatterbot fashion, but with personality, emotion and mood taken into account. Hence, our system in essence provides a connection between various external modules, as illustrated in Figure 1. Of interest here is the use of the Natural Language ToolKit (NLTK) (Bird et al., 2009), the ALMA system (Gebhard, 2005), and the use of an SQL database. Note that the virtual environment we use is the Myoushu engine (Chamberlain, 2009; Van Zijl and Chamberlain, 2010). Myoushu is a language-independent quick-development platform for 3D ASD educational and therapy tools.

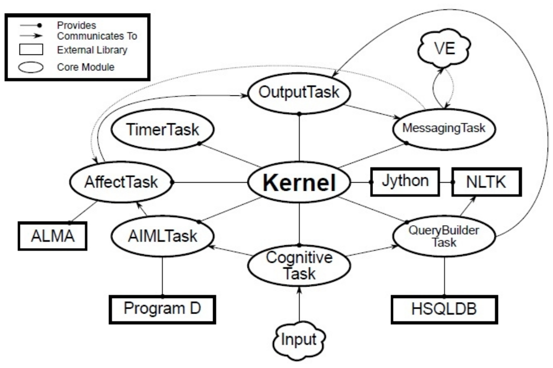

Figure 1: Design overview.

In a typical scenario, the system receives some question from the virtual environment (VE). This question is then sent to the cognitive task module, which parses the question and decides whether it is a factual specialized question or not. If it is a specialized question, the question is sent to the query builder task which transforms it into an SQL query. The answer to the query is returned from the knowledge base. This answer is used to construct a response, which is sent back to the virtual environment. On the other hand, if the original question was not a specialized question, it is sent to the AIML task, which uses pattern template matching to produce an answer code. This answer code is then sent to the AffectTask module, which produces different responses based on the code, personality, current emotion and current mood.

The more interesting part of the system is of course the AffectTask module, which enables the autistic traits to be incorporated into the answer generated by the AIML chatterbot. Based on our conversational dataset, we constructed the AIML patterns in the AIML XML files. For the personality, emotion and mood files, we constructed an XML-like data file, which specifies the conditions and their influence on the resultant answer.

4 EXPERIMENTAL RESULTS

To demonstrate the working of our ECA system, we developed a prototype 3D demonstration, which we describe below.

4.1 3D Demonstration

In our demonstration, the user takes on the role of a person who is about to conduct a short, informal interview with a boy who has AS. As the demonstration starts, the user finds him-/herself in a waiting room outside a therapist's office. The user sees the child's "therapist", who effectively provides the user with a brief tutorial of how the demonstration works. When she is finished speaking, she leaves the waiting area. The user must now open the door which leads into the office and speak with the agent. The user can discuss different topics with the agent. Two of these topics will influence the agent's demeanour in a positive way, two topics will influence it in a negative way and one topic is neutral, having no dramatic effect on the demeanour of the agent. When the user is finished with the conversation, he/she can exit the demonstration by leaving through the same door through which the therapist left.

To illustrate one of the sensory integration problems which people with AS normally have, a couple of scenarios were built into the demonstration. The first one is a radio inside the office which plays baroque music. While the radio is on, the agent's mood will deteriorate steadily. This demonstrates the fact that most, if not all, people with AS have to strain to distinguish between competing sensory sources (Attwood, 2006) (in our example, the music and the conversation with the user). If the user switches the radio off, then the agent's mood will improve. At some point, a dog will start barking in the background. This second scenario will have the same negative effect on the agent as the first one, but this time the user can do nothing to stop the source of the problem. If both the radio and dog are audible, then agent's mood will deteriorate rapidly.

Figure 2: Demonstration program screenshots.

4.2 Results from 3D Demonstration

As representative examples of the working of our system, we follow three different inputs to the system via the demonstration program. We discuss the data flow as the inputs are processed, and show the output to the questions. In all the examples below, we assume that the ECA is in a neutral emotional state when the question is posed. The reader should note the appropriate "Asperger-like" answers, depending on the mood and emotion of the ECA.

Example 1. Input: "What are your parents' names?" This is a general statement rather than one from the knowledge base on dinosaurs or Star Trek. Hence, the cognitive task identifies it as such, and this input is sent to the AIMLTask.

The pattern template in AIML matches against "WHAT * YOUR PARENTS NAMES" (with internal code ID A008) and sends the code to AffectTask to evaluate against emotion and mood. No specific conditions match in this neutral case, so the default response is sent to the OutputTask.

The OutputTask formats "Robert and Alison." as the response with no animations and sends no update signal to the affect engine (this is a neutral question/response). The output is sent to the VE.

For another example, we consider a factual question to illustrate another data flow through the system.

Example 2. Input: "Where did Triceratops live?" The cognitive task, recognizing this question as a special interest topic, sends the question to the QueryBuilderTask. Here, the input is matched against the Dinosaurs feature based grammar, and the query "SELECT 'location' FROM 'DinoSpecies' WHERE 'name' = 'Triceratops' " is constructed via NLTK. The query is executed, the result retrieved from the database, and set to the OutputTask. The OutputTask sends "Triceratops lived in North America." to the VE.

As the last example, we consider an emotional question of the kind that is typically difficult to handle for a person with AS.

Example 3. Input: "How do you feel when your sister is nasty to you?" Again, the cognitive task recognizes the question as a general statement, and sends it to the AIMLTask. AIML matches the question against "HOW DO YOU FEEL WHEN * IS * TO YOU" (with internal code ID C005) and sends it to the AffectTask. The AffectTask checks the ECA affect state and matches the condition where the dominant emotion is "disliking". The associated response is sent to the OutputTask. The OutputTask formats "I don't know!" as the response. While the response is being given, a slight rocking animation is played, indicating a high level of distress in the ECA. The "NastyThing" signal is sent to the affect engine, which negatively influences the agent's affect state. The output is sent to the VE.

5 FUTURE WORK

In the previous sections, we described the design and implementation of an ECA with autistic communication traits. This is interesting in itself, but we want to investigate the use of such an ECA in educational software for children with AS.

We are currently in the process of implementing the ECA in an educational game. This is a simple game reinforcing arithmetic and grammar skills. It is currently in use in a local school for children with learning disabilities, but without any ECA. In previous experiments, we noted that children with AS prefer not to have any help from human teaching assistants when playing the game. However, this sometimes caused frustration, when they could not find a

Figure 3: Educational game screenshot.

correct answer. The role of the ECA would be to alleviate such frustrations in an autism-friendly manner.

The evaluation of the reaction of children with AS versus children without AS will be assessed, with regards to our ECA, in future work.

6 CONCLUSIONS

In this paper we presented the motivation for and the design and implementation of an ECA with autistic traits. At the heart of the implemented system lies a collection of hand-constructed, Asperger-like conversations. These conversations were used to build pattern templates for Asperger-like chatterbot answers. A 3D demonstration prototype illustrates the influence of emotion on expected answers. We are currently building our ECA into an educational game for children with AS. We intend to evaluate the effectiveness of using the ECA with autistic traits in such software, as opposed to a standard ECA or human assistance.

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