Anthropomorphic artificial social agent with simulated emotions and its implementation.

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Abstract
In this paper we describe an emotional human-machine interface as an anthropomorphic social agent which is able to comprehend emotions and react to emotional stimuli. We propose a neurobiologically inspired agent implementation that is based on mechanics of chemical and physiological processes within human brain. Implementation of model features simulation of neuromodulators such as dopamine, serotonin, and noradrenaline. Demonstration of emotions is achieved via combining aforementioned neuromodulators in different proportions. The Lovheim cube of emotions is used for this purpose. We also cover the topic of "uncanny valley" phenomenon. In conclusion of this paper we reached understanding of connection between mimics and motivation of individual. We have constructed realistic computation model which allows us to visualize agent's mimics in sync with his speech.

Keywords: intelligent agents, visualization, emotional artificial intelligence, neuromodulators, visual speech synthesis, expressive and controllable speech synthesis

1 Introduction

Today it becomes more and more apparent that IT-industry and humanity as whole needs more versatile and easy to use and understand human-machine interfaces. Those interfaces would feature context awareness and an ability to maintain a conversation, as well as a defined emotional reaction to interlocutor's actions and phrases. We could use them for designing systems, which are capable of learning during conversation and reflection in real-life environment. Use cases of emotional human-machine interfaces include but not limited to the simulation of an intelligent dialog respondent and the creation of human-friendly technogenic environment and the ergatic systems which enhance safety and capabilities of human. [3]

Among the examples of this new human-machine interface concepts that are already being used, there are intelligent personal assistants which recognize voice commands and chat bots that use user messages data bases to generate a response. However, it is not possible to attribute them to emotional artificial intelligence due to absence of complex inner structure that determines agents response and internal emotional state.

An agent implementing neuropsychological emotional model currently does not exist, even though emotions are essential part of human life – going from decision making to enabling self-preservation instinct. There are, however, many ways to convey emotion without altering agents inner state. In this paper, our cross-disciplinary goal was to create an anthropomorphic agent that has internal emotional state and reacts to emotional stimuli, that express sympathy or aggression towards its interlocutor.

2 Description of Computation Model

We propose a neurobiologically inspired agent implementation that is based on mechanics of neuro-physiological processes within the human brain. Long-term research in this field provided an option for us to define formal model that determines agents internal state. [11, 12, 10]

Design and development of the emotional model is carried out via simulation of neuromodulators: dopamine, serotonin, and noradrenaline [9, 8].

Different emotional states are achieved via combining aforementioned neuromodulators in different proportions. We use Tomkins affects theory [19, 18, 17, 16] for this, which is further extended by Lovheims cube of emotions [6]. Silvan Tomkins describes innate emotions that are exhibited by toddlers since birth as affects: anger, embarrassment, sorrow, fear, interest, happiness, surprise, disgust.

Emotional computation model would also benefit from integrating complex social emotions like: empathy, envy, love, aggression, awe, respect, etc. We also propose that agents model must also feature a set of various cognitive functions: knowledge and learning, intentions and plans and long-term goals [2, 14, 15].

We propose the following solution to aforementioned problem: construction of computation model of an essential set of functions, including basic emotions and other cognitive functions (memory, decision making, perception, understanding, judgment making and even language).

We should also mention an important problem specific to design of anthropomorphic human-machine interfaces – " uncanny valley " phenomenon. Modern implementations of social agents do not meet the requirements that people have to their virtual interlocutors. As a result, human and machine cannot reach understanding, since human can't trust agent or even find it to be creepy. Various ways of solving this problem were described, for example, in works of Japanese psychologists. [21]

3 Implementation

During implementation of agents model following steps were taken:

1. Three-dimensional model, which bounds together human emotions and neuromodulator-based computational processes [9] was used;
2. Various ways of designing conversational system capable of communicate with user in natural language;
3. Possible solutions in which one can tie together agents mimics and motivation were proposed;
4. We constructed realistic computation model which allows us to visualize agent's mimics in sync with his speech. **Text To Speech** technology was used to transform agents messages in the voiced speech. **Microsoft Kinect** controller allowed us to perform

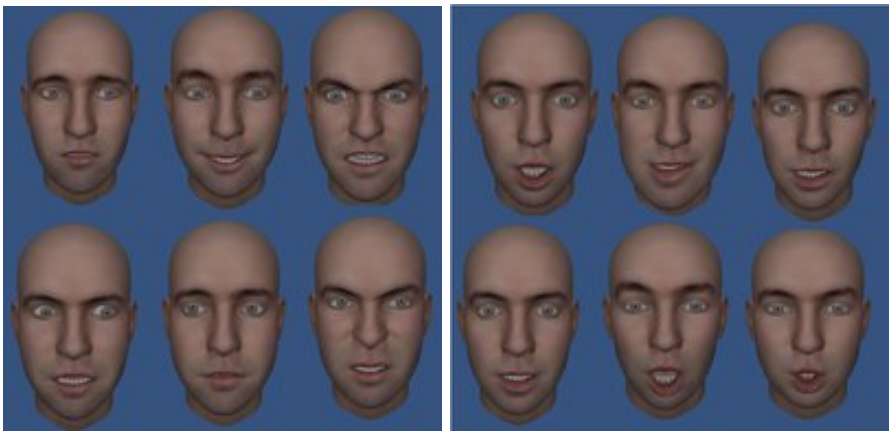

Figure 1: First prototype displaying various emotional masks

photogrammetry of human mimics during pronunciation of different sounds, syllables and during demonstration of various emotions. Afterwards we were able to create basic emotional states of our agent. Mimics recognition software **Faceshift** was used to carry out this part of work.

5. In the end, first prototype of virtual anthropomorphic agent finally was ready. The prototype was capable of voicing complicated text in two different languages while displaying appropriate human-like mimics. Correct mixture of mimic models of emotion and of speech pronunciation was achieved with **Blendshape** technology. Those masks were put on the 3D-model of a human head to create an anthropomorphic social agent. **Unity Engine** was an underlying framework for visualizing resulting agent, and **Microsoft Speech Library** was utilized for speech recognition and speech synthesis.

4 Overview of Existing Technologies

Research in the field of intelligent social agents is long. Each year, new software is developed and old software receives much needed updates. Among most prominent of ones that are related to emotional social agents there are:

- Speech recognition
- Speech analysis
- Simulation of human speech
- Simulation of human mimics and movements
- Common sense based reasoning
- Conversation support
- Conversation context awareness

For example, chatterbot Eugene Goostman [13] had passed Turing test [5] in open competitions that was held in 2014.

Speech translation systems such as **Skype Translator** are currently actively being developed, too. Many intelligent agents software had become commercially viable and are being used as intelligent personal assistants, like iOS **Siri** and Amazon **Alexa**. They primarily utilize speech recognition and speech synthesis and Q&A systems.

Companies that are concerned with creation of anthropomorphic androids are also exist. Aiko, ASIMO, Einstein Robot, Repliee R-1, and Ibn-Sinna are particularly remarkable.

Following are some solutions for Q&A systems to consider:

- IBM Watson – supercomputer that is capable of understanding questions in natural language and search for answers in data base;
- MicrosoftTTS, GoogleTTS, Ivona, Acapella are used for text-to-speech translation;
- FaceFX, CrazyTalk, MagPie synchronize lip motion with speech.

One example of the implementation of anthropomorphic social agents is a project Zoe of the University of Cambridge [20], performed in collaboration with the laboratory of Toshiba, the first prototype which was established in March 2013 and continues to develop now. It is a realistic virtual social agent with a three-dimensional model of a woman's face with a speech synthesizer and 6 emotional states.

The fundamental problem of human cognition, thinking, consciousness, self-consciousness (ego) is not solved yet, either. In other words, it remains a mystery how the elementary actions of neurons, cortical columns, Brodmann areas, lobes of the brain are formed phenomena such as motivation, imagination, creative thinking, sleeping, etc. Because of this, studies concerning human brain are on their rise, including "Connectome" [4], "Blue Brain", "Human Brain Project" as remarkable examples.

5 Future Work

General artificial intelligence development cannot be executed exclusively through predefined algorithms. Many aspects of human brain still remain mysterious to both scientists and engineers. Creation of machines that develop their very own algorithms in attempt to solve problems they encounter can be a viable solution. In essence, the result of this would be a machine that learns to learn. Danko Nicolich [1] suggested that this can be achieved through creation AI kindergarten. In AI-Kindergarten machines are not left alone to figure out on their own the necessary algorithms, but they are heavily guided through human feedback.

After advancing this far in our research, we determined our next steps.

5.1 Emotional Response Based on Innate Emotional Affects

There are inborn emotional reactions that any human exhibit since its very birth, such as crying, smiling and disgust. In the terms of Marvin Minsky, "Critics and ways of thinking" [7], when an element of analytical framework (critic) is triggered, there is some emotional reaction, such as fear, which is closely associated with physiological arousal and causes innate behavior. On the basis of this triplet (analysis-response-behavior), with age in humans occurs gamma strategy to deal with emotional reactions. Description of a formal model of these mechanisms in terms of computing systems will become an adequate solution to the display of emotions and emotional behavior of virtual agents.

5.2 Artificial Intelligence Kindergarten

Our main concerns in research of AI kindergarten are:

- Development of agents that are capable of learning
- Development of logical reasoning
- Development of machine self-reflection

5.3 Knowledge Base Queries Based on Natural Language Translation

Those are steps in which we are planning to handle those topic:

- Generation of multiple representations of knowledge base
- Natural language based machine learning
- Mechanisms of conversation maintaining and context awareness

5.4 Mathematical Model of Emotion Based Computing

It is possible to create a mathematical model of emotional decision making, which will be integrated into agent as part of his inner architecture. The model will be firmly based on ideas proposed by Marvin Minski in his "Model of Six", Tomkins psychological model and neurobiological studies of Lovheim. Integration of neuromodulators effects on human perception and reasoning and brain rhythms are also topics of discussion.

5.5 Common Sense Based Reasoning

Implementing human-like logical reasoning mechanism requires using approach based on common sense, as described in the literature by Marvin Minsky.

5.6 Generation of Psychological Attitude and Emotional Response

It is absolutely necessary that agent would recognize the person it is speaking to and act accordingly. As such, we can define an essential minimum of cognitive functions that every emotional intelligent agent should feature:

- Interlocutor recognition should work both in conditions of excessive and incomplete data, with varying levels of lighting and angle of image rotation;
- Calculating behavior matrices with motivation, preparation and previous experience as key parameters;
- Conversation maintenance and context awareness;
- Recognition of interlocutors mimics and intonation;
- Generation of psychological attitude to interlocutors;
- Generation of emotional response powered by sentiment analysis.

5.7 Computed Experiments and Validation

Final test that intelligent agent must pass is computational experiments such as well-known Turing test and research of "uncanny valley" phenomenon during conversations between agent and human.

6 Conclusion

There are many intelligent agents and artificial intelligence technologies today, but none of them can be identified as truly emotional based. We aim to fill this gap with our project.

So far we have described computation model which ties together human emotions and neuromodulator based computing and implemented the prototype of an intelligent emotional social agent, which is able to exhibit various emotions as well as talking. We also determined further researches we will need to conduct in order to finish the said agent and bring its artificial emotions to perfection.

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