Joint decision making by two bots

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May 31, 2021

Abstract

The aim of the current project was to model a realistic, non-verbal joint decision making process between two bots. How to model as good as possible non-verbal joint decisions is still challenging, although such models based on psychological literature have a lot of future applications like virtual agents. We used the network-oriented modeling approach to build the joint decision making model and the Unity engine to visualize the bots, their internal and external states, and the scenario. The scenario we used is a therapeutic session.

1 Introduction

One of the current challenges in the robotics field is joint-decision making between multiple robots. Specifically, it is challenging how two robots that have initially different viewpoints can become adapted to each other through non-verbal communication. Therefore, the aim of our project was to develop an emerging complex joint decision process that can serve as software for virtual or real robots. The joint decision process emerges from the interaction between the two autonomous bots, in which non-verbal interaction plays the most important role. It will be based on modern theories from psychology and neuroscience, in order to create as realistic human-like bots as possible. To verify our joint decision making model, we will conduct multiple simulation experiments and these simulations will be visualised by bots displayed as avatars.

2 Related work

Several mental mechanisms from psychology and neuroscience were used to create the internal structure of the bots to increase the human-likeliness. The principle of mirroring, namely that people's preparation state for a certain action is activated when the corresponding action of another person is observed, can be explained by mirror neurons and mirroring links (the connection from the sensor-representation state of the action of the other person to the preparation state of a person's own action) [Iac09]. People rely on such mirroring in their non-verbal communication and therefore, mirroring might play an important role in the design of a decision process of bots.

In addition to mirroring, a bot needs to decide to conduct or not conduct a certain action. In humans, according to [Dam94] and [Dam99] a prediction loop is used to internally simulate the predicted effect of an action on one's emotional response preparation state.

3 Method

The simulations of these bots are based on bot models where the internal processes are also modeled in some detail. To achieve this, the network-oriented modeling approach presented in [Tre19] and [Tre20] has been used to create a dynamic interplay of mental states.

Our joint decision model is adapted from [Tre11], and the modeling structure is displayed in Figure 1. Our huge novelty is that we have made the joint decision model adaptive, meaning the aspect of learning is incorporated within the model. To achieve this adaptability (a higher-order network model), we have relied on Hebbian learning principles and these Hebbian learning states and connections regard the second model layer. On top of that, we have added H states, which are in turn learning rates for the Hebbian learning. These H states are the third layer of the model. Only the basic network architecture, with the Hebbian learning displayed in red arrows between the relevant time-varying states, is displayed in the Figure 1 for the readability.

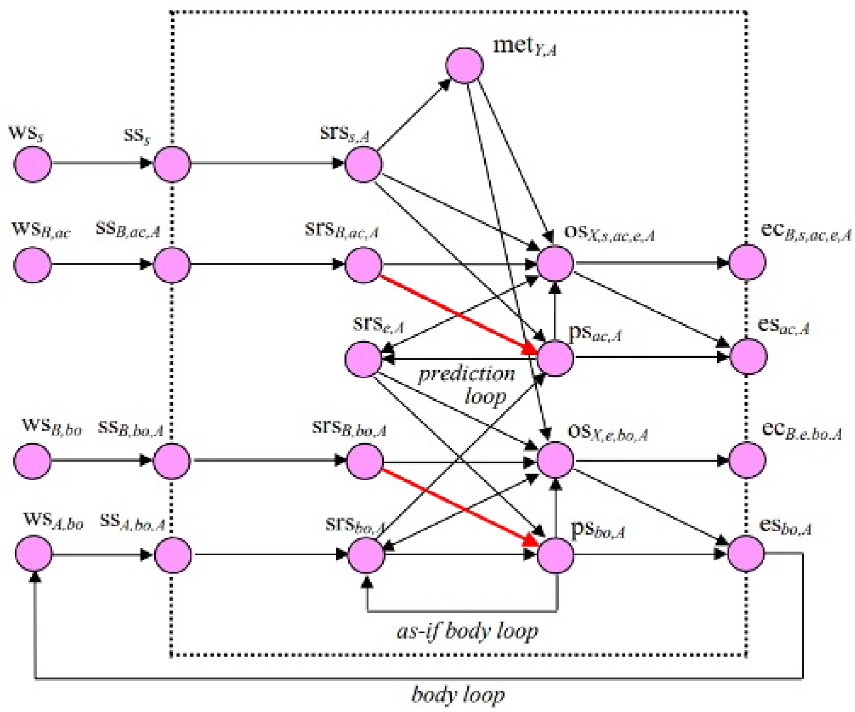

Figure 1: Network architecture of a single bot.

3.1 Scenario

A wide variety of individual and situational differences are present in the real world. There are many possible outcomes in joint decision making [DT12] and all these differences can be captured by different model/parameter settings. In our current scenario, we have chosen one bot who is relatively eager to conduct the specific action closeness of contact and another bot who initially does not want to have this closeness in the contact.

3.2 Visualisations

The scenarios are visualized in Unity using the free assets [Gam20] and [Gam21] for the male and for the female agents, respectively. In each scenario the female agent represents the therapist whilst the male agent represents the patient. The assets from the room in the background were provided by the Unity asset [Dev20]. The room's design was slightly changed from the provided example to give it more of a therapy room look. Animations were either included with the character assets, or were taken from Adobe Mixamo [Ado08]. Code that controls the flow of the sessions and controls the characters was written by us.

4 Results

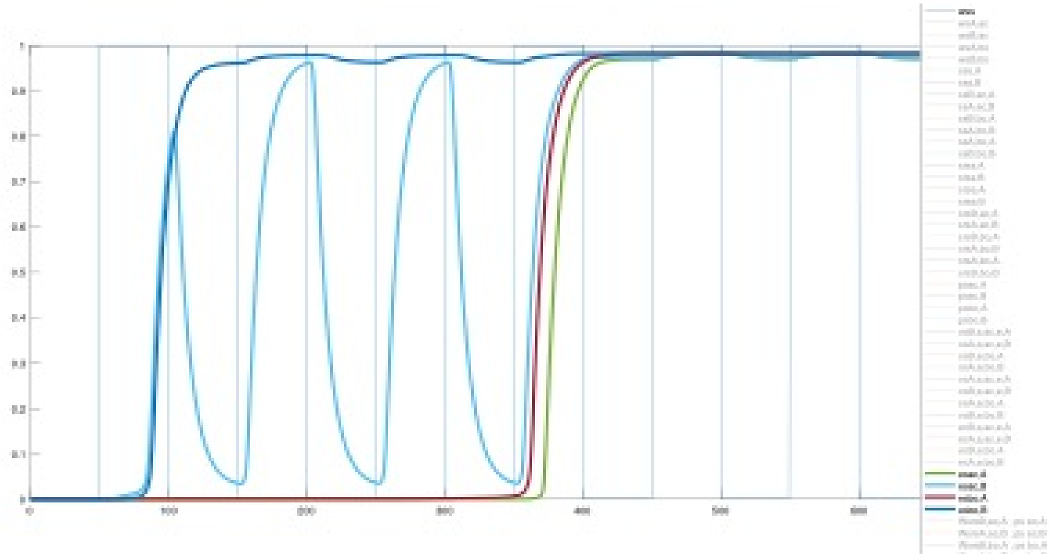

Figure 2: The simulation values. The values visualised in the simulation are highlighted: es_{bo} and es_{ac}. It can be seen that the therapist immediately has an open expression and stance, while the patient takes a few sessions to open up.

As displayed in Figure 2, we see that there are multiple stimulus intervals. Each stimulus interval regards a single therapeutic session. The therapist is bot B and the patient is bot A. From the first therapeutic session onwards, the therapist starts to execute a high level of closeness in contact and also has a high body state (good feeling) about this closeness of contact. In contrast, the patient does not display any closeness of contact or happy feeling at all during the first three therapeutic sessions. However, in the fourth therapeutic session, there is a breakthrough, in which the patient starts feeling better about the closeness in contact with the therapist and almost immediately afterwards starts to execute this closeness in contact. In the next therapeutic sessions, both therapist and client are close in their contacts and feel good about this closeness in the therapeutic relationship (joint decision).

For the visualisations, see Figures 3 and 4, the feeling is visualised through the facial expressions and the closeness in contact as leaning backwards and forwards.

5 Discussion and conclusions

Our aim was to simulate an adaptive joint decision making process between two bots and visualize both the execution of the action and the body state (feeling) of each both. Therefore, we have used a therapeutic setting and the joint decision regarded the closeness of contact. From our simulations, it turned out that it was possible to reach a joint decision - namely close contact - after several sessions. Our models were made adaptive with Hebbian learning principles (4 Hebbian learning connections in total for the two bots) that in turn each contained a learning rate. The basic model structure consisted of states with time-varying activation levels that were connected to some other states through temporal-causal relationships. Furthermore, there were sensing, internal and execution states. We conclude that we succeeded to model an adaptive joint-decision process with an application in a human-like situation, namely a therapeutic setting. These findings might serve as a foundation for the development of a virtual therapist in the future.

Figure 3: Screenshot taken of the scenario with the therapist (left) and patient (right). The therapist has an active posture and happy expression, in contrary to the patient.

Figure 4: In this screenshot, the therapist (left) and patient (right) walk to their seats in order to start a new session.

References

[Ado08] Adobe. Adobe mixamo. https://www.mixamo.com/, 2008.

[Dam94] Antonio Damasio. Descartes' error: Emotion, reason, and the human brain paperback, 1994.

[Dam99] Antonio R Damasio. *The feeling of what happens: Body and emotion in the making of consciousness*. Houghton Mifflin Harcourt, 1999.

[Dev20] DevDen. Devden archviz vol 1 - scotland. https://assetstore.unity.com/packages/3d/environments/urban/devden-archviz-vol-1-scotland-158539, 2020.

[DT12] Rob Duell and Jan Treur. A computational analysis of joint decision making processes. In *International Conference on Social Informatics*, pages 292–308. Springer, 2012.

[Gam20] A2 Games. Satomi: Anime-style character for games and vrchat. https://assetstore.unity.com/packages/3d/characters/humanoids/satomi-anime-style-character-for-games-and-vrchat-175748, 2020.

[Gam21] A2 Games. Rin new: Anime-style character for games and vrchat. https://assetstore.unity.com/packages/3d/characters/humanoids/rin-new-anime-style-character-for-games-and-vrchat-174995, 2021.

[Iac09] Marco Iacoboni. *Mirroring people: The new science of how we connect with others*. Farrar, Straus and Giroux, 2009.

[Tre11] Jan Treur. Modelling joint decision making processes involving emotion-related valuing and empathic understanding. In *International Conference on Principles and Practice of Multi-Agent Systems*, pages 410–423. Springer, 2011.

[Tre19] Jan Treur. A modeling environment for reified temporal-causal networks: modeling plasticity and metaplasticity in cognitive agent models. In *International Conference on Principles and Practice of Multi-Agent Systems*, pages 487–495. Springer, 2019.

[Tre20] Jan Treur. *Network-oriented modeling for adaptive networks: designing higher-order adaptive biological, mental and social network models*. Springer, 2020.