HORIZON 2020

Temporal Adaptation and anticipation Mechanisms in Human-Robot interaction

Berichterstattung

Projektinformationen

TeAMH-Robot

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Zusammenfassung vom Kontext und den Gesamtzielen des Projekts

The advent of robots will change the role that artificial agents play in our lives, as the interaction with them will not be limited to specialized and well-structured work environments. When interacting with artificial agents, humans often encounter the Out of The Loop phenomenon (OOTL), which is a difficulty to predict and prevent failures, probably due to a lack of transparency in artificial agents' actions. The overarching aim of TeAMH-Robot was to develop a model of Human-Robot Interaction (HRI) that will prevent the OOTL phenomenon when interacting with robots. To this end, TeAMH-Robot used a novel approach to develop an efficient HRI that combines cognitive neuroscience methods with real-time interactive tasks with a humanoid robot. Firstly, TeAMH-Robot tried to understand how temporal adaptation and anticipation mechanisms allow humans to "stay in the loop" when mistakes occur. Then, TeAMH-Robot used this knowledge to implement a human-inspired computational model on a humanoid robot that ensures real-time coordination. Finally, TeAMH-Robot tested the efficiency of human-inspired behaviour in reducing the impact of the OOTL phenomenon. TeAMH-Robot has significantly extended the state of the art both in the field of cognitive neuroscience and robotics. In the former case, TeAMH-Robot highlighted that humans successfully stay in the loop in coordination tasks characterized by errors by adopting a priori top-down control and relying mostly on reactive temporal error correction mechanisms instead of anticipation. In the latter case, TeAMH-Robot showed that implementing human-inspired mutual adaptation on humanoid robots reduces the probability of the OOTL phenomena and increases shared agency promoting effective HRI. Finally,TeAMH-Robot increased the independence of the ER and enriched her expertise in transferable skills, such as grant writing, teaching, dissemination, and outreach.

Arbeit, die ab Beginn des Projekts bis zum Ende des durch den Bericht erfassten Berichtszeitraums geleistet wurde, und die wichtigsten bis dahin erzielten Ergebnisse

The scientific objectives of the outgoing phase were to identify temporal adaptation and anticipation mechanisms in human-human interactions characterized by errors. This objective aimed to answer the question: What are the mechanisms that allow humans to stay "inside the loop" when interacting with other human agents? A key outcome was supposed to identify how and to which extent temporal adaptation and anticipation mechanisms are crucial to ensure the co-agents' performance monitoring and its successful prediction of and recovery from errors. To this end, the ER has designed and implemented an experiment using musical paradigms aiming to evaluate how a leader-follower pair of individuals adapt their performance to reduce the negative impact of errors on coordination during a musical task. Results showed when errors were included in the task, participants' performance was characterized by lower variability in asynchrony and higher interpersonal coupling compared to correct sequences, suggesting that humans succeed in stay-in-the-loop by adopting a top-down control over sensorimotor mechanisms of coordination to reduce the impact of anticipations. The scientific objectives of the returning phase were to develop a module for humanoid robots that ensures real-time coordination and (iv) test its efficiency in reducing the OOTL. These objectives aimed to answer the question: Does endowing robots with mutual adaptation improve users' performance of monitoring their own and robot's actions, as well as the outcome of their combined actions when performing joint actions together? To this end, the ER has implemented the human-inspired computational model for temporal adaptation and anticipation (ADAM) on the humanoid robot iCub. Specifically, the ER designed and implemented a study aiming to evaluate whether implementing in robots temporal adaptation and anticipation processes that facilitate coordination in humans can reduce the OOTL phenomenon in HRI. To this end, human participants were asked to play a musical joint tapping task together with the iCub robot. Specifically, two versions of the task were developed. A version in which the iCub played always the same sequence played by human participants (Correct task condition) and a version of the task in which in 30% of the repetitions, the iCub played a mismatching sequence (Erring task condition). For both task conditions, we implemented the ADAM and integrated it with the robot to control iCub's tapping behaviour. In both task conditions, 5 different settings of the ADAM model were implemented, two of them relying only on the adaptive module and three relying on the joint module. Results showed that that endowing robots with temporal adaptation and anticipation mechanisms allows humans to stay in-the-loop, in two different ways. Firstly, it allows users to constantly update their internal model of the robot to reduce the prediction error about iCub's performance, thus resulting in higher synchronization and more strength in coupling for those conditions in which the robot is run based on human-like estimates. Secondarily, by increasing self-other integration and the perception of shared agency.

Fortschritte, die über den aktuellen Stand der Technik hinausgehen und voraussichtliche potenzielle Auswirkungen (einschließlich der bis dato erzielten sozioökonomischen Auswirkungen und weiter gefassten gesellschaftlichen Auswirkungen des Projekts)

To date, research on coordination in HRI has been traditionally limited to emergent coordination that arises spontaneously, and the main objective of these studies was to evaluate whether and to which extent humans synchronize with a robotic agent. In this way, the robot has been used as an embodied metronome. However, most HRIs in the real world will occur in applied contexts and will be characterized by planned and goal-driven behaviours. At the same time, research on planned coordination between human agents has been mainly focused on temporal adaptation and anticipation mechanisms in successful social interactions, i.e. when no errors occur. This prevented the understanding of how temporal adaptation and anticipation mechanisms allowed for the prevention and recovery of errors.TeAMH-Robot has significantly extended the state of the art in the field of cognitive and social neuroscience. By analyzing temporal adaptation and anticipation mechanisms during erring social interactions in humans, TeAMH-Robot highlighted that humans successfully stay in the loop in coordination tasks characterized by errors by adopting a priori top-down control and relying mostly on reactive temporal error correction mechanisms instead of anticipation. TeAMH-Robot also contributed to extending the state of the art in the field of robotics. By implementing a human-inspired computation model on a humanoid robot to reproduce sensorimotor coordination with a human co-agent, TeAMH-Robot showed that mutual adaptation reduces the probability of the OOTL phenomena and increases shared agency promoting effective HRI.
Despite its scientific contribution to the state of the art, TeAMH-Robot increased the independence of the ER and enriched her expertise in transferable skills, such as grant management, teaching, dissemination, and outreach.

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