Towards a Cognitive Architecture Incorporating Human Feedback for Interactive Collaborative Robots

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1 Introduction

The development of new collaborative robotic platforms opens the new possibility of human-robot collaborative scenarios provided that they are controlled by excellent control programs. Interactive collaborative robots need to be autonomous and possess social cognitive skills such as multimodal communication capability, recognise models of the environment and other agents, and aware of human attention and intention. On top of that, interactive collaborative robots must also able to interact fluently, learn from the interaction, and react appropriately to unprecedented situations. It is evident that the capabilities which are expected from interactive collaborative robots are too complicated to be achieved by static control programs. To successfully perform human-robot collaboration, we argue that interactive collaborative robots must be controlled by a cognitive architecture [1] that integrates multiple cognitive software modules. Inspired by the concept of Humanistic Intelligence [2], we also believe that the cognitive robot architecture must exploit the feedback from the human whom it is interacting with because humans possess superior cognitive capabilities that can be utilised by the cognitive robot architecture to enhance its cognitive skills.

2 CEMIRA - Cognitive Robot Architecture

To implement our idea, we present the concept of CEMIRA (Cognitive Embodied Multimodal and Interactive Robot Architecture) which is designed to interact with non-expert users by incorporating both verbal and non-verbal human feedback in the loop of its components. CEMIRA combines the strength of existing software modules with our proposed modules which is shown in Fig. 1 and described below:

- Situation Assessment Module: Translates information from the sensors into symbolic representations of the world conditions and human actions.
- Knowledge Manager Module: Acts as the symbolic facts storage and connects all cognitive modules.
- Mental Model Module: Maintains the symbolic interpretation of human feedback in the form of intentions, beliefs, and preference models.

- Collaborative Task Planner Module: Synthesises shared plans containing the actions of all agents involved in a given task.
- Natural Language Processing Module: Recognises basic speech statements or commands from human and verbalises symbolic facts into sentences.
- Interaction Manager Module: Defines the cognitive behaviours of the robot by acting as a decision maker and plan execution monitor.

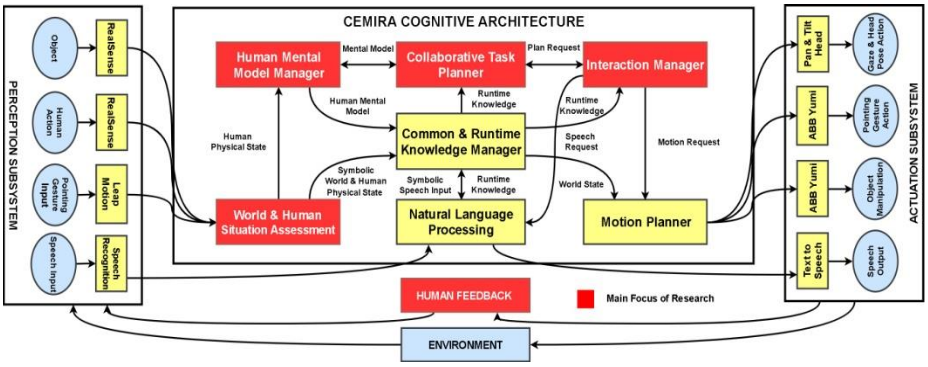

Fig. 1. CEMIRA Cognitive Architecture

CEMIRA follows several principles to successfully incorporates human feedback. First, it incorporates an attention mechanism to select which feedback modalities it should focus on in a given situation. Second, input modalities are processed in parallel using the concept of Embodied Multimodal Fusion (EMF) [3]. Third, it utilises fast and predictive data processing to maximise its percieved interactivity by human.

3 Future Works

CEMIRA is being developed as part of the first author's PhD research. Future works involve the completion of CEMIRA modules and the integration of CEMIRA with ABB Yumi collaborative robot as the actuator and the Intel RealSense sensor that detects non-verbal human feedback (eye gaze, head pose, hand gesture). Finally, we will evaluate CEMIRA in a human-robot collaboration scenario, in which human and robot talk about and move coloured blocks, by analysing how the system will perform with and without the human feedback incorporation.

References

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