# ADVANCED APPROACH FOR EXCHANGE OF INFORMATION BETWEEN HUMAN BEINGS AND COGNITIVE ROBOTS

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**Abstract**

More and more people want to know what drives and inspires other people and why some people are successful, and others are not. Robots don't yet have all of the higher-level cognitive functions that people do, like planning actions and understanding language. This is because technology isn't quite there yet. This is the case because robotics is still in its early stages. This is one way in which the playing field is not level. In this article, we offer a framework for understanding ideas, actions, and language all at the same time. This is the first thing we need to do to reach our goal. Several cognitive modules can be put together to reach this goal, with multimodal categorization and an advanced method being the most important. Through this combination of the two, reinforcement learning can be used along with the ability to act in line with what you know. With the help of, the robot can say what it wants to say through its actions and understand what people say. With the help of the Bayesian hidden Markov model and language learning, this is possible. We used a real robot to put the suggested design to the test and show how it could be used.

**Keywords.** Cognitive Robots, Human-Robot Interaction , Human Factors

## Introduction

Because of advances in technology, there are now a number of different ways in which people can communicate with one another. Images, films, electronic gadgets, and even robots can all be used as communication tools [1]. Communication can take place through a multitude of channels. Speech and writing are two common modes of communication among people because using them is something that can be done on a regular basis. They would frequently communicate with their audience, whether at work or school, by utilising both written and spoken language in order to explain concepts and share ideas with that audience. On the other hand, despite the fact that it is simple to implement, there is a possibility that it won't attract people's attention or convey the message that you want it to. Mayer and Fiorella [2] investigated a wide variety of instructional methods, including signalling, temporal contiguity, and segmenting, with the goal of effectively communicating knowledge through the use of text and graphics. [Citation needed] It is possible to use various instructional strategies in order to communicate knowledge through the use of text and graphics. They discovered that highlighting vital information, writing things out by hand, and highlighting critical aspects was the most effective method for learning new abilities and perfecting existing ones. When compared to static representations such as diagrams and figures, dynamic representations that include things that are moving have the potential to aid signalling by drawing people's attention to the information being conveyed. People might be fooled into thinking that you wrote it on your own if you do it well enough. In this piece, we'll take a look at the process of creating animated diagrams and figures with the help of multiple robots working together. It may be simpler for presenters to highlight crucial information and provide assistance to audiences in digesting and gaining an understanding of the information they are giving. Although a significant amount of research has been conducted on robots that are capable of talking and interacting with people, it is not clear how numerous robots can be utilised to present visual information to a group of people. In a circumstance such as this one, real-time control systems can be of assistance in improving communication between the audience and the presenter by having a variety of robots point out essential information. The numerous examples that were given make it very evident that the mode of communication that was advocated for is an efficient one. Mobile robots were positioned above a camera and placed over a whiteboard that had been inverted in the other direction. The user made a mess of the test bed, which was just a prepared board with scribbles all over it. Using the new method, robots can be programmed to represent any number of alphabetic letters. Our experiment consisted of no more than six robots so that we could keep things as straightforward as possible. Using a camera from above, robots have successfully interpreted the written text of a letter that was written by a human user. After that, the robots determined their objectives depending on the activity that was currently being performed or the distance that separated them from each feature point in order to complete their duty. As a direct consequence of this, each robot was able to localise itself in order to recognise a specific pattern. As part of our research, we came up with a fresh concept for how people and robots might be able to collaborate in order to provide information and make communication easier. In addition, a few straightforward experiments were carried out to demonstrate that the system we described operates as intended. Image processing and the Hungarian task localization algorithm were combined in order for six mobile robots to successfully complete their jobs during the testing. This was made possible thanks to the combination of these two technologies. In addition to that, they utilised a whiteboard table to assist the children think more clearly by using it to construct letters and shapes.

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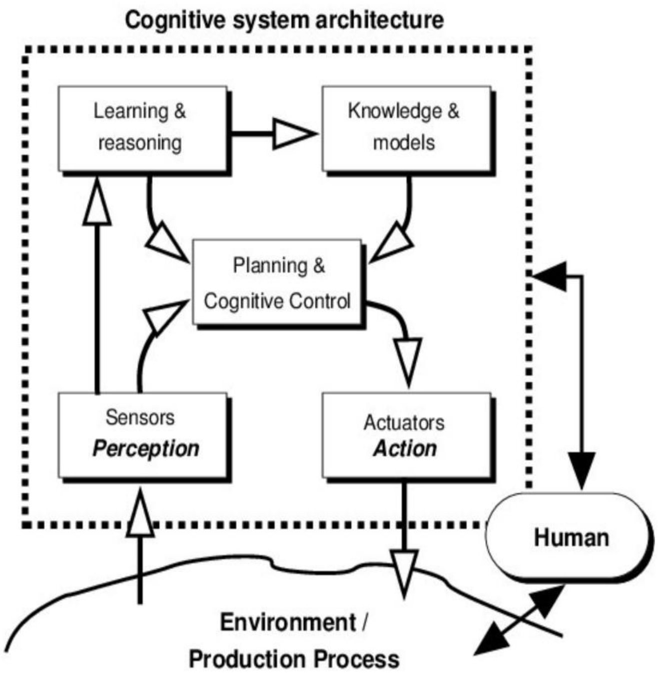


Figure 1: The cognitive system architecture Buss, M., et al.[11]

Finally, the design lives up to the lofty standards we set for it. The proposed system would only require one time to be set up, after which it would be fully operational and ready for use. It utilised a regular whiteboard table as a means of communication and for assisting others in comprehending what was going on. Following the completion of this research, it is highly likely that researchers will conduct a user study in order to test our system in a variety of settings. These settings may include a traditional communication medium, a media-based medium, and the system that was suggested, all of which involve robots.

**Related work**

W. Jo et al[1] There is a theory that various mobile robots will display, in their own unique style, what various lecturers or presenters have written on a whiteboard table. Many different objects, such as shapes and letters, might be referred to as "this kind of thing." It will be easier for the audience to understand what is being said because many robots will be moving around, making it easier for them to follow along. Image processing and job allocation allow us to extract feature points from a handwritten form or letter. After that, we can place a number of robots at these spots to draw attention to the letter or form. Numerous symbols and letters, including the alphabet itself were used in this article's experiments to verify its effectiveness..

A. Shin, et al[2] A significant portion of the research that focuses on human-robot interaction makes use of conversational robots. These robots are able to carry on conversations with humans in a manner that is both verbal and physical. But even with the protocol, controlling the robot to move and speak is still a task that requires a significant amount of cognitive effort. During the preliminary inquiry with a humanoid, it was discovered that wizards had difficulty concentrating, making decisions, carrying out actions, and contemplating the consequences of their actions. Apprentice of Oz is a human-in-the-loop solution that was developed with the goal of reducing the mental strain placed on the Wizard of Oz by each individual subtask. The assignment process is a collaborative effort between the wizard and the system. In this paper, we go into detail on each individual subtask that makes up the system.

M. Chita-Tegmark, et al[3] Because they are mechanical, robots lack a gender identity. A lot of what we learn through our interactions with other human beings, such as gender roles and expectations, might be unintentionally and erroneously applied to our interactions with social robots. Because of the parallels between the two kinds of interactions, this is possible to occur. Emotional intelligence (EI) is a critical component in human social interactions, and this paper examines how gender influences people's perceptions of robots and humans. Specifically, we are interested in how people's perceptions of robots and humans alter based on gender..

H. P. Chapa Sirithunge et al[4] This research describes a human investigation to determine the behavioural features in humans that can be used by an assistance robot in a domestic environment to analyse the situation prior to an encounter by using a wizard-of-oz (WoZ) experiment. The goal of this investigation is to determine whether or not these features can be used by the robot. The participants' responses, both verbal and nonverbal, to an encounter that was initiated by a robot were recorded and analysed in order to identify shifts in human behaviour that indicate an interest in engagement.

V. Charisi, et al[5] As part of human social interactions, expressiveness, or the use of nonverbal modalities to convey or enhance the transmission of internal feelings and intentions, is a crucial component. The utilisation of a wide variety of modalities is one way to describe expressivity. Artificial agents are being studied for their expressivity, and as a result, robots are now explicitly being considered for their usage in continuous social interactions. In addition to animation, robot design, and mechanical challenges, cognitive science and developmental psychology are also included in the scope of research into this topic. Scientists from many domains will be able to meet at this workshop in order to advance the state of the art in the creation of expressive robots. Participants will debate methodological potential and constraints, with the goal of establishing a clear vision for the next steps in expressive social robots.

F. Yan, et al[6] The transmission of information from a human to a robot using only natural language is not only feasible but also very effective. The inconsistency of human and robot spatial cognitive styles, high frequency communication, and low cognition-level symbol matching control have all had a significant negative impact on the operational efficiency of tasks requiring spatial cognition, such as locating and exploring. This has had a significant negative impact on the operational efficiency of these tasks. This research makes use of ACT-R cognitive theory to provide an innovative approach to the representation and processing of information by robots. The goal of this endeavour is to increase the adaptability of interactions between humans and robots that are aided by natural language. The partnership of humans and robots in the field of space exploration is a tangible illustration of this principle being put into practise.

S. Ye et al[7] Embodied cognition has been shown in research conducted in the field of cognitive science to be linked to increased levels of social empathy and cooperation. In order to get a better understanding of how human embodiment might help create and increase trust in human-robot interactions, we had participants learn Greek letters that were associated with dancing routines with the assistance of a humanoid robot. The participants had the option, while they were engaged in the activity, of either moving their bodies in a dance-like manner or interacting with a touch screen. According to the findings of the study, the participants' levels of trust in the robot increased significantly more when it was embodied in human motion as opposed to when it was controlled via a touch screen device.

I. Brinck, et al[8] The human kinematics embedded in a robot's movement can influence the human's behaviour. In numerous situations, human subjects demonstrated social motor intention by mimicking movements that expressed social intention with movements that had a similar kinematic profile while attempting to maintain eye contact and engage in turn-taking behaviour while performing the activity. An ecologically sound approach to the design of Human-Robot Interaction (HRI) based on motor processing promises to be both cost-effective and easy to use, as well as environmentally friendly.

F. Cantucci et al[9] Because it possesses these abilities, the robot is able to alter the level of intelligent collaboration it engages in by adopting the task at the various levels of assistance outlined by Castelfranchi and Falcone's theoretical framework on delegating and adopting. In addition to these two benefits, the capacity of the architecture to explain in detail the approach that the robot will use to complete the work that has been delegated makes the behaviour of the robot more understandable. Our proposed implementation of the cognitive architecture uses JaCaMo, a framework that allows for the development of multi-agent systems as well as the integration of a wide variety of characteristics that are associated with multi-agent programming.

**Proposed Methodology**

A shared memory system enabling incremental symbiotic evolution, including a shared model of each other, is outlined in the following lines. Physical contact paradigms for skill transfer and animated body schemas are all instances of shared memory systems. Each of these building components is not a stand-alone entity, but rather is characterised by intra and inter bidirectional interactions: within the mind of each working partner or even across their brains, with reference to visible (overt) acts and mental (covert) actions. As a result, these encounters take place both inside and outside each individual's headspace. To achieve symbiotic cooperation between robots and humans, it is necessary to take into account the goals and objectives of both parties. The negotiation of intentions based on a mutual understanding of actions may be part of this process of incorporating intentions. Consider, for example, "haptic dancing," in which this modality serves as the primary means of communication between the dancers. As a result of these overtly synchronised behaviours, we believe that this process of purpose integration is bolstered by both auditory and tactile channels. An essential aspect of collaborative success but not enough on its own. The partners' covert and mental acts, which establish their motor plans off-line, must be backed by some type of resonance. Other than using a range of time scales and bounds, researchers perform their work in "real" as well as 'virtual time,' with an alternating pattern of visible activities and mental actions, similar to the way symphonies alternate between music or quiet.

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The brain activity associated with tasks that do not include movement or the activation of muscles has recently been the subject of research by those with an interest in motor cognition. These are "motionless" and "muscleless" motions, respectively. Recent research shows that cortical networks in the brain's motor areas are active even when there is no overt movement. Predicting the effects of potential acts while engaged in goal-directed reasoning and monitoring the activities of others while engaging in social interactions are examples of these situations. In order to help humans in a variety of natural living settings, cobots must have the same skills. These kinds of processes are frequently studied in the framework of simulation theory or emulation theory in academic circles. An abstract representation of movement kinematics is created and maintained through emulation, according to the theory of emulation. To support motor imagery, you can change this representation to facilitate self-initiated or external stimulus-induced motor imagery. Sensory data is typically output as though the movement has already taken place in an emulated environment. When it comes to motor cognition, the simulation theory states that the objective, the motor plan, and sensory consequences of an imagined action all exist in the same neural circuits as they do in the real thing, with execution being prevented while motor imagery takes place. Observing someone else "grab an apple" or comprehending the term "grip an apple" entails a simulation that activates the same motor areas as when one "grabs an apple" in one's own hands, according to this interpretation. Despite the fact that simulation and emulation are closely linked and are sometimes used interchangeably, this article will not dig into the exact definitions and interpretations of these terms. As an alternative, we're focusing on the creation of computational building blocks (inspired by ideas like emulation and action modelling) that can be applied to the study of human robots. It's well accepted that forward models play an important role in facilitating action generation and simulation, but the computational formulations based on these models come from many different perspectives. Examples include optimal feedback control active inference based integral forward models and body schema-based simulation networks. As an example, a forward model may predict how you should turn a handle to open a door, or it may predict that you will need to use a tool in order to reach an object that is otherwise inaccessible. No matter what computational model is used, "cognitive economy" — the ability to reuse the same system (in this case, action generation) to support other activities (action ideation, understanding) — must be present for this feature to be important to both the brain and an autonomous robot.

As well as being utilised in a motoric sense, simulation can also be employed in a broader multi-modal context, involving simulation of both perception and action, which necessitates associative mechanisms. Inferences are made over a longer period of time, and the long-term memory of the agent is involved (whether it be a robot or a human). Constructive episodic simulation is a term used to describe these processes, which are thought to involve a core network in the brain that supports a wide range of functions such as recollecting the past, simulating future states or alternatives to events that are currently taking place, and inferring the viewpoint of the other person. For example, one could examine the role played by various prefrontal cortical areas in supporting reasoning and then propose a Bayesian probabilistic framework that would operate on behavioural strategies stored in long-term memory with the goal of monitoring goals, switching strategies and learning new ones, for example. (as necessary). robots could learn to recall past experiences by analysing environmental signals or objects in the environment, simulate future scenarios with simulated rewards, and infer the user's intent using a neural episodic memory architecture, according to a new study (in which case, the observed actions act as a partial cue triggering episodic simulation). Processes like episodic simulation and perspective taking are important to consider when considering the long-term participation of humans and robots in any shared workplace (domestic or industrial). To better understand human-robot interaction, we'll take a look at some of the most essential subsystems.

**Results Analysis**

Except in the fields of commercial aviation and military systems, where human factors professionals have been involved for a considerable amount of time, there is a need for a greater involvement from human factors specialists in the research and design of human-robot interaction. Specifically, this involvement is required. Both driverless cars and unmanned aerial vehicles have substantial challenges in terms of ensuring public safety and gaining social acceptance.

The results of the Task Dynamic Analysis presented earlier make it abundantly evident that human factors specialists, even on the most fundamental level, need to develop a more nuanced understanding of dynamics and control in order to fulfil their professional responsibilities. The subject of how people, artificial intelligence, and computer-controlled technologies may be most effectively integrated into a system needs to be reexamined. However, design engineers have a responsibility to be mindful of the limitations of AI in terms of its ability to comprehend context.

When attempting to instruct or programme a robot, one encounters several linguistic challenges. The study of human-robot interaction opens up a vast number of doors for the incorporation of human qualities into the design of instructional materials that use symbolic representations.

Operators' Mental Models (i.e., what they think, what they know, whether or not they misunderstand, etc.) become increasingly important as the complexity of systems increases and the stakes get higher. Similar to how people think and reason, modern control systems rely on continually updated internal models to make sense of what's going on in the surrounding environment. Cognitive scientists have spent a significant amount of time researching mental models; nevertheless, human factors researchers are now making use of mental notions such as context awareness and trust, both of which entail active mental models. Eliciting and comparing operator mental models (in both real-time and off-line) with the computer's appraisal of the situation is something that I feel will have benefits for human-robot systems in terms of both safety and efficiency.

Education and training have been considered part of human factors since the beginning, and computers have been incorporated into training systems for many years. The implementation of robots, or computers with the ability to move and express emotions similar to those of humans, into educational settings is an apparent next step.

The most difficult study problems are probably going to arise in the fields of human values, human anxieties, and lifestyle choices. Should a job always be done by a computer or other type of automated system, regardless of whether or not it can be done more effectively by a robot? The question that needs to be answered is how robots can be designed to operate

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alongside people in the job or to help those who are ill or elderly. Should machines ever be permitted to "exercise their own judgement" when it comes to making decisions on whether or not to kill a human being or cause damage to property in the service of national security, or should humans always be involved in such deliberations? These vital issues have been brought to the attention of researchers, but not nearly enough research has been done on them. Are there any human factors methodologies and insights that could be utilised in order to find solutions to these problems?

**Conclusion and future work**

Assembling activities in manufacturing systems can be studied using the cognitive interaction technique. When it comes to analysing mental burden, this research presents scenarios in a laboratory setting that take into account difficulty, participant skills, and observed performance. The context of human-robot collaboration has been deemed appropriate for this. In collaborative robots, one of the most typical activities is assembly, while problem solving is one of the most representative human tasks. In this work, the relevant tasks are integrated in laboratory scenarios, keeping these notions in mind. They demonstrate that it is possible to maintain a reasonable workload while working on both major and secondary jobs. This feature may take the operator's condition into account when determining how vital flexibility is. In real-world industry 4.0 settings, the operator may face task modifications, task complexity, task sharing with a robot, and interruptions (for instance, noise). There are a number of situations in which a better understanding of the forms of cognitive load (intrinsic, extraneous, and relevant) and their link to mental burden could be beneficial for the enhancement of human information processing, performance, and the overall system. Understanding this human cognitive load will allow for the building of intelligent assistant systems that will aid and support human operators in future cognitive manufacturing systems.." It's also possible to improve the design of an assistance support system from the standpoint of a human–robot team by considering fluency as an extra component. There are two robots available in the laboratory, therefore the human's role in this job can be expanded in future works. Participant selection would be made based on how well each robot performed in terms of quality and performance. Human decision-making would be the subject of this investigation. As argued in, it is vital to include the human–robot team's interaction abilities in addition to traditional viewpoints such the operator's physical, sensory, and cognitive features. This dimension is where fluency lies.

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