Cog

by Matthew Louis Mauriello

Cog is a very interesting research project of MIT's Artificial Intelligence Lab and specifically a part of the Human Robotics Group (HRG) founded by Dr. Rodney Brooks. In the past, the lab has worked in many robotic domains including: space exploration rovers, micro (community) robots, and on numerous mobile wheel-base camera robots. Cog is part of more recent work on a family of biologically inspired robots. Cog represents the culmination of several of these projects and the sub-disciplines associated with Artificial Intelligence (AI), particularly computer vision.

Some of the projects that assist with Cog's development include the M4 project, Macaco, which represents early work into building a common head and camera system for social robotic projects within the HRG. Kismet is an anthropomorphic robotic face that helps explore the modalities of human expression and behaviors via facial cues and head positions. Kismet was a precursor project that helped to develop the behavior and personality software for Cog that, when combined with an anthropomorphized head, helps generate the experience of having a real "face-to-face" interaction[1]. Coco is an apelike quadruped robot that helps the HRG understands how full mobility, something Cog cannot do, impacts aspects of behavior and intelligence. Cog is, however, unique in that the goal of the project is to be able to interact with the system as you would interact directly with another human in the hopes of producing humanoid intelligence overtime [1].

System Description

Source: ai.mit.edu/projects/humanoid-robotics-group/cog/overview.html (Peter Menzel, 2000)

The project hypothesized that "humanoid intelligence requires humanoid interactions with the world." [1] In order to facilitate these types of interactions, Cog has a humanoid body and a collection of sensors that replicate human senses. These senses include: sight in the form of a camera system, ears that are made up of powerful microphones, and actuator feedback. This feedback provides Cog with both a proprioceptive and a rudimentary sense of touch. In addition to his senses, Cog has been a test bed for integrating advanced algorithms for things like gaze tracking, facial recognition, and learning. Rather than explicitly programming the behaviors exhibited by Cog, researchers have given him some very low level commands and then allow him to develop models for controlling actuators [2]. The picture is that of Brooks and Cog. Cog is looking at Brooks and replicating his motion with the slinky, which is one example of a possible social interaction.

[1] On the importance of face-to-face interaction: Andrist, S., Pejsa, T., Mutlu, B., and Gleicher, M. (2012). Designing Effective Gaze Mechanisms for Virtual Agents. In *Proceedings of the 30th ACM/SigCHI Conference on Human Factors in Computing (CHI 2012)*. Austin, TX.

The construction of Cog has involved an impressive amount of engineering. Cog has various processors and microcontrollers running in parallel through his entire body alongside the many sensors and motors. Much of the equipment has been custom-built and relies on the QNX real-time operating system. Additionally, the main audio and video processing is actually preprocessed on exterior machines and then fed back to Cog's systems due the massive amount of specialty computing required to have Cog operate in real-time. Finally, the motor system provides an incredible twenty-one degrees-of-freedom, which gives Cog a range of motion very similar to the human body. This is all designed to give Cog the ability to interact with the world similar to a human. [3]

Background

The Cog project began as early as 1993 with the goal of building a dexterous robotic prototype that would allow HRG to work on problems related to understanding human cognition. From the onset, the Cog project has focused on social interaction as a vehicle of learning. However, human interactions are closely tied to embodiment, sensory and motor system integration, and a developmental structure. Whereas classical AI has focused on representation of the human mind with various models that enable general processing, the HRG uses a cognitive and neurosciences approach [3].

In classical AI there is generally some internal representation of their environment that allows actions like planning. These models of the world tend to be as detailed as possible and as such are very time consuming to construct and are also computationally heavy. Research suggests that humans do not always work with highly detailed internal representations of the world when they perform complex tasks, but rather rely on partial information and experience. Additionally, humans also rely on external sources of information (i.e. by being able to look back at a scene rather than internalizing every bit of information they come across) and they later refer back to these sources. Cog will try to duplicate the human capacities to reason based on imperfect information and on the ability to refer to external sources of information over internalizing vast amounts of situational data [3].

It is interesting to think about how processing in the brain actually works. Thinking generally is thought to occur in the brain, which might be considered one entity. Although, the brain is actually made up of many parts that are responsible for different things including: maintaining our body, controlling our senses, processing various bits of information, and for our conscious thought. You could actually think of the brain as a parallel processing system. However, many AI systems are modeled on a singular control system and one central processing unit. Cog is different in that it is composed of many different computer systems and microcontrollers that function in parallel.

Cog has been developed using principles that the HRG believes are avoided by classical approaches to AI. These principles integrate, what Brooks refers to as, development as well as social and physical interactions [3]. It seems very hard to distinguish development from the "classical" area of machine learning. The HRG defines development as a framework for acquiring complex skills; Cog receives some basic instructions and then acquires further data through controlled interactions that allows him to "learn" some aspect of his system. The group's process of development is based on mastering small problems that lead to mastering larger problems, which sounds very similar to providing training data and initial classifiers that allow a program to tackle slightly larger problems through successive iterations. Based on this perspective, the claim that "development" makes Cog different from classical AI seems to carry little weight but perhaps it is because of the social interaction aspect of the system.

The social interactions being developed for Cog are modeled after human children. Children are heavily reliant on the parents for information and nurturing. It seems odd that AI systems are expected to have human level intelligence when it takes our own children so long to develop their full capacities. In fact, it seems only natural that the use of development and social interactions would provide a more natural means of developing a sophisticated intelligence. The researchers working on Cog have spent a lot of time integrating basic behaviors, some of which include: target tracking, facial recognition, and gaze following. They hope that by providing these sorts of resources the researchers will be able to scaffold learning through a mimicry mechanism, something human children naturally do, among other things. Certainly, this is not a new idea, Turing proposed a similar idea [4] in in the 1950s. However, Cog appears to be one of the first projects to seriously consider developing an AI by attempting to recreate a child's mind and then giving it the ability to learn through social interaction.

Conclusions

Cog is an extremely interesting project because of its unique take on how to build a robotic system with human capabilities. To achieve a human like intelligence it seems only natural to attempt to emulate the process by which a human child develops its abilities. The research makes an interesting note that humans progressively change over their life time, gaining the capacities of an adult human only after acquiring experience. The way that biological systems develop appears to be analog to the constant state of upgrading and integration that Cog seems to experience over the course of the project. In terms of dexterous robots, Cog may not be as impressive anymore as there are numerous similar projects[2] in recent history, but the approach to understanding cognition and intelligence is a very unique application for such a system.

References

1. (1997) "*Cog: overview.*" Humanoid Robotics Group. Massachusetts Institute of Technology, Artificial Intelligence Lab. Retrieved 2012-09-25: http://www.ai.mit.edu/projects/humanoid-robotics-group/cog/overview.html
2. (2008) AI Lab: Cog the Humanoid Robot. MIT TechTV. Retrieved 2012-09-25: http://techtv.mit.edu/videos/531-ai-lab-cog-the-humanoid-robot
3. Brooks, R.A., Breazeal, C., Marjanovic, M., Scassellati, B., Williamson, M., (1999) "The Cog project: building a humanoid robot." Computation for Metaphors, Analogy, and Agents. C. Nehaniv (ed), Lecture Notes in Artificial Intelligence 1562. New York, Springer, 52–87
4. (1950) Turing, A.M., "Computing machinery and intelligence". Computers & Thought. MIT Press (1995). Cambridge, MA, 11 - 35

[2] A dexterous robot project worth looking at is Robonaut (R2), built by NASA & General Motors, for the ISS.