

Kaz Kawamura, Ph.D.

**Life Fellow, IEEE
Director, Center for Intelligent Systems
Vanderbilt University**

“Synthetic Approach to Cognitive Systems: A Perspective from Cognitive Robotics”

Introduction

Today robotics technology is broadening its applications from factory to more general-purpose applications in domestic and public use, e.g., partner to the elderly, rehabilitations, search and rescue, etc. If robotics technology is to be successful in such unstructured, dynamic environments, it will need to meet new levels of robustness, physical dexterity and cognitive capability. This presentation discusses an emerging field called *cognitive robotics* from developmental point of view, i.e. “learning from building”. Research topics and features of cognitive robotics are introduced. A case study of internal rehearsal for performance enhancement for cognitive robots will be introduced.

Cognitive Robotics: An Overview

Cognitive Robotics is an emerging field of robotics. Currently there is no generally accepted definition of cognitive robotics since *cognition* like *intelligence* is difficult to define. However, the field of cognitive robotics generally considered to comprise the design and use of robots with human-like intelligence in perception, motor control and high-level cognition. To realize cognitive robots many overlapping disciplines are needed, e.g. robotics, artificial intelligence, cognitive science, neuroscience, biology, psychology, and cybernetics. Thus, attempting to tightly define the subject is not constructive as often its nature is amorphous, growing and a strict definition could exclude future relevant work.

The origin of modern cognitive robotics comes from the field of cybernetics, the study of control and communication in living organisms, machines and organizations. The term cybernetics was popularized by Norbert Wiener in his 1948 book. Cybernetics had a crucial influence on many important concepts such as goal-directed behavior generation, self organization and situated nature of intelligence, which are now commonly used in the intelligent robotics community.

As the opening paragraph of this section stated, the goal of cognitive robotics is to build a robot with human-level intelligence. There are two problems with this statement. First is “intelligence”. The term intelligence is used in a variety of situations and is difficult to quantify. Another problem is “human-like”. What do we mean by human? Do we mean an ordinary adult? How about children? Even a three-year child can show many levels of intelligence. This simple argument may be enough to show the problems with the term “human-level intelligence” to evaluate the performance of cognitive systems such as assistive robots (Figure 1).

Cognitive Robot and Internal Rehearsal

It is known that humans are able to have sensory experiences in the absences of external stimuli. It thus seemed reasonable to assume the existence of an ‘inner sense’ where sensory experiences and consequences of different behaviors may be anticipated in cognitive robots. The idea of the existence of such an inner sense does not necessary go against the theory of embedded intelligence advocated by a number of researchers who de-emphasize the role of internal world models and instead emphasize the situated and embodied nature of intelligence. An alternative to internal world models is the ‘simulation hypothesis’ by Hesslow [1] which accounts for the ‘inner world’ in terms of internal simulation of perception and behavior. Our approach may be termed as a “grounded internal simulation” utilizing one type of internal representation of perception and behavior (Figure 2).

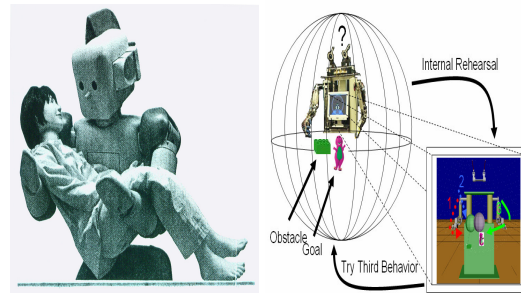


Fig.1

Fig.2

Figure 1: Concept of an assistive robot RI-MAN

Figure 2: Concept of an internal rehearsal system “grounded simulation”.

Conclusion

Cognitive robotics is still an evolving field with many possible and exciting future directions. This talk presented a synthetic approach to realize cognition such as “Cognition, we want to say, requires both fluent real-world coupling and the capacity to improve such engagements by the use of de-coupled, off-line reasoning” [2] for robots and the difficulties in evaluating the performance of cognitive robots using assistive robots.

Reference:

1. Hesslow G (2002), Conscious thought as simulation of behavior and perception. *Trends in Cognitive Science* 6(6) June, 242-247
2. Clark A. and Grush R (1999) Towards a cognitive robotics. *Adaptive Behavior*, 7(1): 5-16