HUMAN EMULATION TECHNOLOGY TO AID THE WARFIGHTER: ADVANCES IN COMPUTATIONAL AUGMENTATION OF HUMAN COGNITION

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ABSTRACT

As has always been the case, the core of a warfighter's ability to function effectively and efficiently rests on his cognitive abilities. In order to prioritize, respond appropriately, adapt to new and dynamic situations quickly, take calculated risks, and make effective decisions - all in real time - he has to be able to continuously update and maintain an accurate assessment of his environment. Sandia National Laboratories has created a technology that augments human cognition by employing psychologically plausible computational models of human cognitive processes.

1. INTRODUCTION

The core of a warfighter's ability to function effectively in battle rests on the efficiency of his cognitive abilities. He must be able to accurately assess the dynamic environment in which he finds himself. This environmental assessment (i.e., situation awareness) includes not only the positions and activities of enemy and friendly forces, but an assessment of the functioning and effectiveness of any technology he is using as well as his ongoing physiological and psychological responses.

Humans are typically very good at doing just these things. We are expert pattern recognizers, and our cognitive system is amazingly flexible while being constrained in a manner that keeps us from considering infinite possibilities before taking action. However, as technology becomes increasingly complex and as war becomes less traditional, these skills are being put to the test. Sandia National Laboratories has been working for several years on a technology to enhance these skills, making the human cognitive system even more effective and more able to deal, in real time, with complex technologies and their application to new and unexpected events.

The notion of augmenting human cognition is certainly not unique to Sandia, as attempts to create expert systems and decision aids have been going on for decades (e.g., Givan, Leach, & Dean, 2000; Koenig, 2001; Kraiss & Hamacher, 2001; Martin, & Billman, 1994; Utgoff, Berkman, & Clouse, 1997). However, we believe that the traditional approach to augmenting cognition has fulfilled its potential. We believe we are in need of a new technology – a new solution to the problem. Our answer to this need is a family of technologies we call Cognitive Systems. A Cognitive System is one that utilizes <u>psychologically plausible</u> computational representations of human cognitive processes to inform system design such that the resulting system engages the underlying mechanisms of human cognition, efficiently augmenting human cognitive functioning.

More specifically, the Cognitive Systems technology is manifest in what we call the Human Emulator. The goal of the technology is not to create a piece of software that the human has to learn and adapt to. Rather, the goal has been to create a piece of software that interacts with the human, and that learns how best to interact with the human, much as we learn how to interact with one another. When this sort of dynamic is created between a warfighter and our technology, the technology can aid the warfighter in his environmental assessment, thereby increasing his responsiveness, agility, lethality, and survivability on the battlefield - wherever and whatever the battlefield happens to be.

In order to accomplish this goal, we have created software that functions the same way a human cognitive system does. That is, we emulate not only the product of human cognition (i.e., the "answer"), but the process that results in that answer. Rather than creating a technology that is based on chains of if-then rules, which tend to be rigid, we are creating a technology that is able to flexibly recognize patterns in environmental stimuli in much the way a human does.

2. MODEL ARCHITECTURE

We have based the architecture of the Human Emulator on Klein's Recognition Primed Decision model of expert decision-making in the field – primarily firefighters on the fireground (Klein, 1997; Klein, Calderwood, & Clinton-Cirocco, 1985; Klein, Calderwood, & MacGregor, 1989). The RPD model is based on observations of experts making decisions for which they will be responsible in time-critical and risky situations. What Klein and his colleagues noted is that rather than considering many alternatives, weighing the pros and cons of each as is prescribed in traditional theories of decision-making and problem solving, the firefighters rarely spent much time determining an appropriate course of action. Rather, they rarely seemed to consider more than one course of action – they seemed to be able to recognize a type of situation and to rapidly apply the appropriate solution. That is, the firefighters appeared to be expert pattern recognizers.

In order to create a model that could recognize patterns of stimuli in the environment, have those patterns remind the model of a previously-encountered situation, and flexibly apply or recommend a corresponding solution, we created an architecture with three basic components: a semantic network comprising domain-critical concepts, a memory of past domain experiences, and a pattern-recognition algorithm. Population of these components requires a well-developed, theoretically-based knowledge engineering method which has also been developed by Sandia National Laboratories.

3. APPLICATIONS

3.1 Discrepancy Detection

One current project focuses on determining when a warfighter's ongoing assessment of a situation is inaccurate. Creating a model that is able to perform this type of *discrepancy detection* paves the way for models that are able to augment human cognition by enabling more rapid detection of errors and more rapid and accurate problem solving and decision-making. Eventually, the model will not only be able to determine errors in a warfighter's situation awareness, but will be able to learn and improvise in novel situations alongside the warfighter as he becomes increasingly capable and expert through experience. Early qualitative observations of the model's performance are promising.

3.2 The Insider Threat

This technology has also been applied to the early detection of insider threat. The project involved creating separate computational models of four experts with differing perspectives on insider crimes. These four expert models have been included in a global model that includes algorithms that allow the individual models to interact with one another in a manner similar to a group decision-making situation. Preliminary results indicate the group model makes the same decisions the experts do between 83% and 93% of the time and that the individual expert models behave the way the real experts do between 75% and 92.5% of the time.

CONCLUSIONS

Human Emulation technology is qualitatively different approach to creating intelligent computational systems than anything that has been created in the past. The key idea behind the success of the technology is that in order to create systems that are truly intelligent, they must process information in a human-like manner and come up with answers that are human-like rather than simply hard-coding a system with chains of if-then rules that cause it to come up with predetermined "right" answers with total disregard for the psychological plausibility of the processes involved. Early results indicate that this approach holds promise for a wide variety of applications.

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