COGNITION IN NATURAL ENVIRONMENTS: USING SIMULATED SCENARIOS IN COMPLEX DECISION-MAKING

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ABSTRACT

We present a new approach using virtual environment scenarios to study decision making in complex tasks. Using simulation techniques we build a bridge between abstract and naturalistic environments to help understand differences in behavior between them. The proposed 'virtual environments' provide a methodological tool to examine what aspects of the naturalistic environment drive expert performance.

1. SUMMARY

Decision making under uncertainty is a poorly understood process, yet one critical to the needs of both the military and society, in general. We describe a coordinated multi-disciplinary effort to investigate decision making under uncertainty in complex and dynamic environments. Our research effort has two overarching goals – the first epistemological and the second methodological.

Our epistemological goal concerns understanding decision making in naturalistic complex domains with significant risky consequences to decision makers. We investigate the interaction between risk attitudes and perceptions of complex environmental and social information. Applications of the knowledge generated from these studies range from training of recruits, preparation of soldiers before entering new contexts, and examination of the general public's attitude and decision-making process concerning complex social policies. Our methodological goal is to use virtual environment technology to recreate, in a controlled environment, the rich array of cues and information relied upon by decision-makers in naturalistic domains. This environment will allow us to blend and enhance the techniques of controlled experimentation in economics with those of naturalistic decision-making in psychology

2. EPISTEMOLOGICAL ISSUES

Presently we use naturalistic decision making as the theoretical framework for our research in expert information processing (e.g., Orasanu & Connolly, 1993), with particular emphasis on event-based approaches to learning and training. Event-based scenarios (e.g., Fowlkes et al., 1998) and virtual reality simulations allows one to present numerous and varied complex scenarios. We use this approach to understand the nature of perceptual processing engaged by experts, where cues from exploring and observing the environment influence expectations of what will be perceived. These perceptual expectations aid in the comprehension of the environmental cues resulting in an understanding of the situation that is used to predict future events (Adams et al., 1995; Salas et al., 2001).

The superior ability of experts to quickly abstract the more meaningful cues has intrigued researchers in cognitive psychology for years (e.g., Ericsson & Charness, 1994). Not only do experts know what is important, and thus seem to be able to filter out irrelevant aspects of their environment, their expertise also allows them to make critical assessments based upon a limited amount of information (Fiore et al., 2000). With expertise and cue processing as our scientific backdrop, our theory development will allow us to better understand how it is that experts become aware of critical cues in complex scenarios and use them in their decision making. We can then apply this knowledge to the training of non-experts.

3. EXPERIMENTAL CONTEXT

Our specific experimental context will involve testing expert and non-expert decision making in a "Virtual Forest Walk-through." (Micikevicius et al., 2004) This environment, developed to support the rendering of large diverse forests, is appropriate for a variety of applications. This included military applications such as search-and-rescue missions (underbrush as well as trees are modeled accurately), and economic policy applications such as measuring voter attitudes towards controlled forest burns (a component of the system models the evolution of forests under differing burn rates).

One of the challenges that we address is how to accomplish the biological modeling, tree evolution and level-of-detail management for large forests on commodity workstations. We have developed algorithms appropriate for direct implementation on programmable graphics processing units (GPUs) and on clusters of workstations. We have also developed complexity reducing techniques based on studies of human perception in the context of trees (see Micikevicius et al., 2004; Sims et al., 2001; Sims et al., 2002).

The use of controlled experimentation has proven a valuable method in economic policy making to assess voter attitudes or to predict individual economic actions. The central feature of such experimentation is the imposition of consequences that are salient to the participants, such as monetary ones. This avoids well-knows response biases (Cummings et al., 1995, Harrison & Rutstrom, 2005). Recent debates in economics question the relevance of abstract stimuli such as those in laboratory experiments, the most convenient and commonly used form of experimentation. A more novel approach involves designing actual field situations to test natural decision making, but at a great expense (Harrison & List, 2004). This work proposes a middle-ground by introducing naturalistic tasks, cues, goods, and experience levels into a controlled, laboratory-like environment using virtual simulations, but maintains the significance of the consequences through the use of monetary incentives.

CONCLUSIONS

We are conducting behavioral experiments integrating the science and technologies of virtual and mixed reality environments (VE) with the methodologies of experimental economics and naturalistic decision-making. The advantage of using VEs is that they provide a rich means of representing real-world scenarios in a controlled simulation, involving factual and counter-factual visualization of the scenario, the use of natural visual, haptic and auditory cues, and even the use of appropriate techniques to augment perception of the scenario. These settings are considerably more realistic and complex than those generally implemented in the standard experiment, but allow the replicability and control necessary for the application of experimental methods. The goal is to study the decision making process of experts in situations involving significant risk, and to use this knowledge to train non-experts in complex decision making.

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