In Proceedings of the Sixth International Conference on Cognitive Modeling, 372-373.
Mahwah, NJ: Lawrence Earlbaum.

The simBorg Approach to Modeling a Dynamic Decision-making Task

Christopher W. Myers, Hansjörg Neth, Michael J. Schoelles, & Wayne D. Gray
Cognitive Science Department
Rensselaer Polytechnic Institute
[myersc, nethh, schoem, grayw] @rpi.edu

Motivation

Understanding decision-making processes within dynamic task environments via embodied computational cognitive models proves to be a challenge for the modeling community (see Gonzalez, Lerch, & Lebiere, 2003 for an example). Decisions made by an agent may be the result of explicit, strategic moves, or result from implicit, cost-benefit tradeoffs occurring at the level of 1/3 of a second. Understanding and properly modeling decisions occurring at these different levels is a challenge for the modeler. This paper proposes a novel incremental modeling approach (see Byrne, 2001 and Gonzalez et al., 2003 for examples of other incremental approaches) that promises to inform decision theory as well as limitations within the chosen modeling architecture.

The *simulated cyborg* (or, *simBorg*) approach blends computational embodied-cognitive models of interactive behavior with artificial intelligence based components in a simulated task environment (Gray, Schoelles, & Veksler, 2004). simBorgs combine human and machine components. This combination of high fidelity cognitive modeling (human) and AI (machine) facilitates the development of families of models that allow the modeler to hold components (memory, vision, etc) at different levels of expertise without concern for cognitive plausibility. For example, rather than modeling human problem solving, the modeler can rely on various *black-box* techniques (i.e., cognitively implausible AI), thereby focusing on predicting how subtle differences in costs and benefits in interactive methods affect performance and errors.

The current modeling endeavor adopts the simBorg approach in order to build a family of interactive decision-making agents. The following section will present the task of interest followed by a fraction of the family of simBorgs under development. Finally, we conclude with future directions we plan to lead the family of simBorgs.

Task Description

The dynamic decision-making task is Decision-Making Argus Prime (D-MAP). D-MAP is a scenario–driven simulated radar environment. The display contains a radar display on the left half and a decision-making task (DMT) on the right half. The users' goal was to choose the alternative with the highest threat value (TV) from the DMT. See Figure 1 for an example of D-MAP.

Each DMT contained a minimum of 2 and a maximum of 6 alternatives. The alternatives were presented in a tabular format where each table entry corresponded to a radar target. There was only one correct answer for each DMT. Each DMT was limited in time (60 s), and had a 1 s interval between the offset of one DMT and the onset of another.

A correct decision resulted in the elimination of the chosen target from the radar. Threat values were accessed by moving the cursor to a radar target and clicking it. It is important to note it was not necessary, nor were participants instructed, to access the TVs for <u>all</u> targets in a given DMT. A scenario continued for 720 s or until all remaining targets had a threat value of 1.

The amount of time for the TV to appear after clicking on a radar target varied as a between-subjects independent variable. One group (n = 12) had no time between clicking the target and the appearance of the TV (0-Lock). The second group (n = 12) had a 2 second delay between clicking a target and TV appearance (2-Lock).

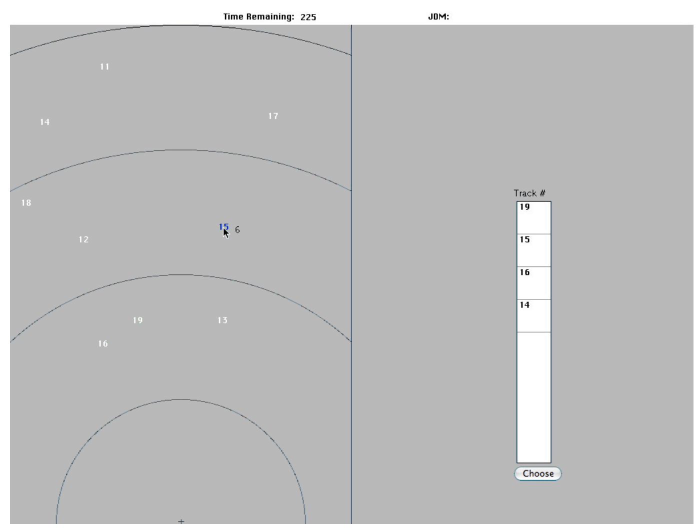

Figure 1. The D-MAP task environment with 4 alternatives occurring in the DMT.

The *Borgs: A Family of simBorgs

This modeling endeavor is based on the simBorg approach of holding particular cognitive processes of decision-making at an expert level and varying others. The models will range from a cognitively *implausible* optimal agent (allBorg) to a cognitively more plausible simulated human user. We title this process the **Borg family of simBorgs*, where the * represents a wildcard for the type of simBorg under development. For example, if visual search is of interest and memory is held optimal, the *seeBorg* is born. Such models allow optimization of one aspect of human performance while allowing other aspects to be realistically simulated (Gray, Schoelles, & Myers, 2002) informing both theory and application. An early goal of the *Borg family of models is to predict when and explain why participants *satisfice* (Simon, 1956) in the D-MAP task environment. It is extremely likely that participants satisfice as a result of the costs embedded in the task environment, therefore it is important to pinpoint which costs (visual search, memory, TV delay, etc) are the greatest contributor.

It is likely that the simBorg approach will uncover adaptively optimal behavior that might be construed as satisficing. For example, suppose *all* threat values are *correctly* recalled for each alternative in a DMT and a decision is made without checking one radar target. This is actually optimal behavior, however it could easily be misinterpreted as satisficing.

All simBorgs are modeled using the ACT-R architecture, however it is important to point out that this method may be employed using any cognitive architecture. Only two of the *Borg models will be discussed at a general level in this abstract due to space limitation.

Normative (allBorg)

The allBorg will be cognitively implausible in nearly all aspects of the decision-making process (memory, visual search, etc) to provide the highest level of performance possible in D-MAP. Only movement times for eyes and hands will be the agent's constraints. Figure 2 provides a process flow of the allBorg agent. The allBorg agent will provide a ceiling of performance that we propose all human participants strive to achieve given the environmental constraints.

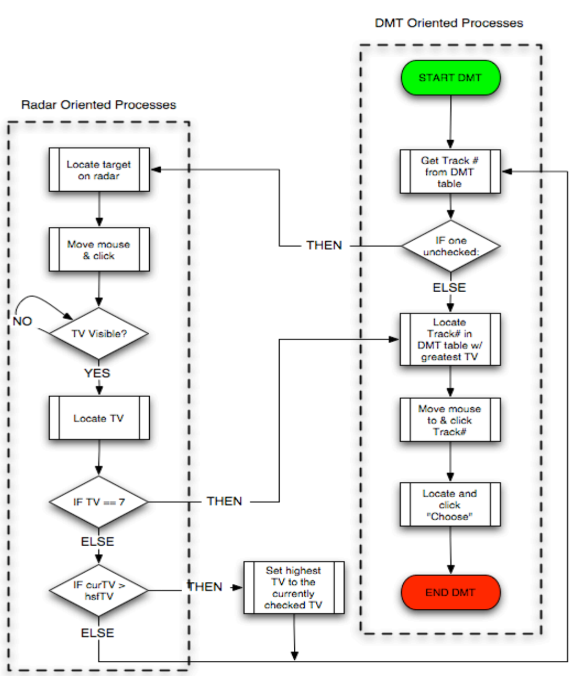

Figure 2. Process flow of allBorg. curTV stands for Current TV being checked and hsfTV stands for Highest So Far TV.

Refining Visual Search (seeBorg)

The seeBorg agent's memory will use ACT-R's declarative memory repository without decay. Thus, seeBorg's memory will always be precise, holding the cost associated with memory to a minimum. In contrast, seeBorg's visual search processes and strategies will be the modeling focus and will provide insight to the benefits of different search strategies and the effect of costs involved.

The primary goal of the seeBorg will be to explore the effectiveness of different search processes. For example, storing radar target positions in memory to be used in later DMTs (Byrne, 2001; Ehret, 2002). However, because the seeBorg's memory is absolute, we will gradually impose the same limitations on seeBorg's memory which humans face, namely decay which leads to errors of omission and commission.

Future Directions & Conclusions

Although all of the models have not been completely constructed (nor discussed in this abstract), we believe that the *Borg family of simBorgs will inform both decision-making theory as well as model development. We believe that what appears to be satisficing on the surface and that may actually be adaptively optimal behavior will naturally fall out of the incremental simBorg approach to modeling. Finally, after fitting the cognitively most plausible agent to the human data, we plan on porting the agent to a version of D-MAP that includes Argus Prime's target classification task (Schoelles & Gray, 2001), allowing us to determine if the same visual search and memory strategies transfer to the new task environment.

Acknowledgments

The work reported here was supported by a grant from the Air Force Office of Scientific Research AFOSR #F49620-03-1-0143, to Wayne D. Gray.

References

Byrne, M. D. (2001). ACT-R/PM and menu selection: applying a cognitive architecture to HCI. *Int. J. Human-Computer Studies* 55, 41-84.

Ehret, B. D. (2002). Learning where to look: Location learning in graphical user interfaces. *CHI Letters, 4*(1), 211-218.

Gonzalez, C., Lerch, J. F., Lebiere, C. (2003). Instance-based learning in dynamic decision making. *Cognitive Science 27,* 591-635).

Gray, W. D., Schoelles, M. J., & Myers, C. W. (2002). *Computational cognitive models ISO ecologically optimal strategies*. In the 46th Annual Conference of the Human Factors & Ergonomics Society. Santa Monica, CA: Human Factors & Ergonomics Society.

Gray, W. D., Schoelles, M. J., & Veksler, V. D. (2004). *Simborgs: Towards the building of simulated human users for interactive systems design*. 48th Annual Conference of the Human Factors and Ergonomics Society, Santa Monica, CA.

Schoelles, M. J., & Gray, W. D. (2001). Argus: A suite of tools for research in complex cognition. *Behavior Research Methods, Instruments, & Computers, 33*(2), 130-140.

Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological Review 63*(2), 129-138.