

HBM-view: Designing a Model Viewing Tool for Behavioral Scientists

Tylar Murray

University of South Florida
Department of Electrical Engineering
tylarmurray@mail.usf.edu

Daniel Rivera

Arizona State University

Eric Hekler

Arizona State University

School of Nutrition and Health Promotion

D. Spruijt-Metz

University of Southern California
Center for Economic and Social Research
Los Angeles, California

Andrew Raij

University of Central Florida
Institute for Simulation and Training

Abstract—In this paper we present relevant definitions and design considerations relevant to human-behavior modeling software. The guidelines presented here are based off of a user-survey and expert-panel review performed in development of the BehaviorSim model-building tool designed especially for use in behavioral science. Lessons learned through iterations of this tool and unique considerations for those targeting behavioral scientists are highlighted. Our initial survey of 12 behavioral scientists reveals the diversity of opinions and approaches to behavior modeling within the community and gives context to this emerging area of research. In addition to these guidelines, a theory-agnostic method for defining Human Behavior Models (HBMs) is proposed and techniques for supporting different modeling paradigms within a single user interface are discussed.

I. INTRODUCTION

A. Problem Statement

The increasing prevalence of wearable technologies and user-behavior collection, behavioral researchers are becoming increasingly overwhelmed with data.

State-of-the-art user interface often predicts user behavior in order to preload data or to customize the application. Researchers have seen the potential for optimizing a behavioral intervention to suit not only the user, but also the context. Just-in-Time Adaptive Interventions (JiTAI) promise to provide the optimal nudge at the optimal time to aid users looking to change their behavior. Imagine, for example, an anti-stress app which knows not to interrupt your work meetings, but also knows when to play your favorite song to help you relax on the drive home. Or consider a smoking cessation app that knows precisely when and where you are most likely to crave, and distracts you with a game of sudoku before you even realize you were about to want a cigarette. The impending wave of context-aware, affective computing applications seems to be the holy grail of behavior change, but researchers are increasingly finding that our models of human behavior are not ready. The search space of designing an intervention for even a single user can be prohibitively large,

Though the machine learning approaches which are enabling detailed behavior-prediction can be applied to behav-

ioral research problems, the inner workings of these models often do not tell researchers much about how the human system works.

On the other hand, psychological models of human behavior act as a guide for behavioral scientists looking to predict behavior, but are rarely computational in nature - making their application in adaptive systems impossible.

A hybridization of these two approaches may allow researchers to leverage the strength of each as they are applied in adaptive behavioral interventions.

B. Human Behavior Modeling

A Human Behavior Model (HBM) is any computational model which attempts to define the human systems conversion of measurable contextual information into measurable behavior outcome. HBMs are a set which intersects the set of computational cognitive models, both sets include approximations of cognitive processes, but in contrast with cognitive models, HBMs put a greater emphasis on the measurable in and outflows of the human system. Cognitive models traditionally have focused on creating a comprehensible representation of cognitive processes, but HBMs have no such restriction and require only that a model define behavioral output as some function of contextual input. Thus HBMs include formulations which may not be considered a cognitive model. For instance, a model which offers little more than statistical relationship between contextual input and behavioral output may be considered an HBM.

For our purposes, we classify HBMs uncovered by our literature review into three classes based on intended application 1) Automation Agents - models developed to act as automated decision agents, 2) Emergent Behavior Studies - models developed to identify emergent behavior of a population, and 3) Cognitive HBMs - models developed for prediction and understanding of an individual's behavior. Note that these categories are not mutually exclusive - a single HBM could theoretically fulfill all three roles, but the requirements for each category are quite different, and thus existing models in each category are usually quite different.

* TODO: how do HBMs address the issues raised in above problem statement? * why are they important for the future behavioral research? [?] * how do they fall short?

C. Existing Tools

Our review of existing tools and publications in the area of behavioral modeling has uncovered three types of tools: 1) Dynamical System Modeling Toolkits, 2) Cognitive Architectures, and 3) Agent Modeling Toolkits. Though each approach seeks to address the problem of human behavioral modeling, the intended use of the model is very different. Thus each approach makes an approximation of the human system from a different perspective, and the resulting models show little resemblance. These three types of tools are in partial alignment with the aforementioned three classes of HBMs.

1) *Dynamical System Modeling*: Works in this group focus on generalized model-building. Applications include network and business analysis as well as semi-physical system modeling. One might be able to use these systems for modeling a human agent, but a more rigid model architecture for organizing the flow of information is needed. One of the contributions of the behaviorSim toolkit is the implementation of a general structure of information flow through a human agent.

Specialized modeling toolkits are often developed to create a variety of more detailed models focused around a single modeling goal. This is precisely the goal of the behavior-Sim toolkit. In this search specialized toolkits focusing on neurological simulation, molecular dynamics, product inventory flow, economics, astrophysics, neurological networks, and power system modeling were all encountered in this search. Works on more relevant topics such as social interaction and behavioral modeling are highlighted in the spreadsheet and warrant further investigation.

2) *Cognitive Architectures*: The next group is a large set of modeling toolkits which aim to create artificial intelligence through the modeling of cognitive processes. Though a well implemented artificial intelligence will serve as an excellent model of human behavior, such an implementation is far from feasible at this time. The behaviorSim toolkit takes a more empirical approach to modeling cognitive functions than existing cognitive architectures.

3) *Agent Modeling*: Agent modeling has proven useful in many industrial and commercial applications across multiple disciplines. Agent models are generally developed for one of two purposes: 1) to act as an intelligent actor in an automated task, or 2) to observe the emergent characteristics of many interacting agents. The behaviorSim toolkit does not aim to accomplish either of these goals. It is for this reason that the common BDI agent architecture is not suitable for modeling of human behavior based on empirical evidence.

II. CASE STUDIES

Here we present findings from multiple iterations of development of a tool designed to help behavioral scientists formulate computational models of human behavior. Evaluation at each step of this iterative process involved a small number of testers as guided by <http://www.nngroup.com>.

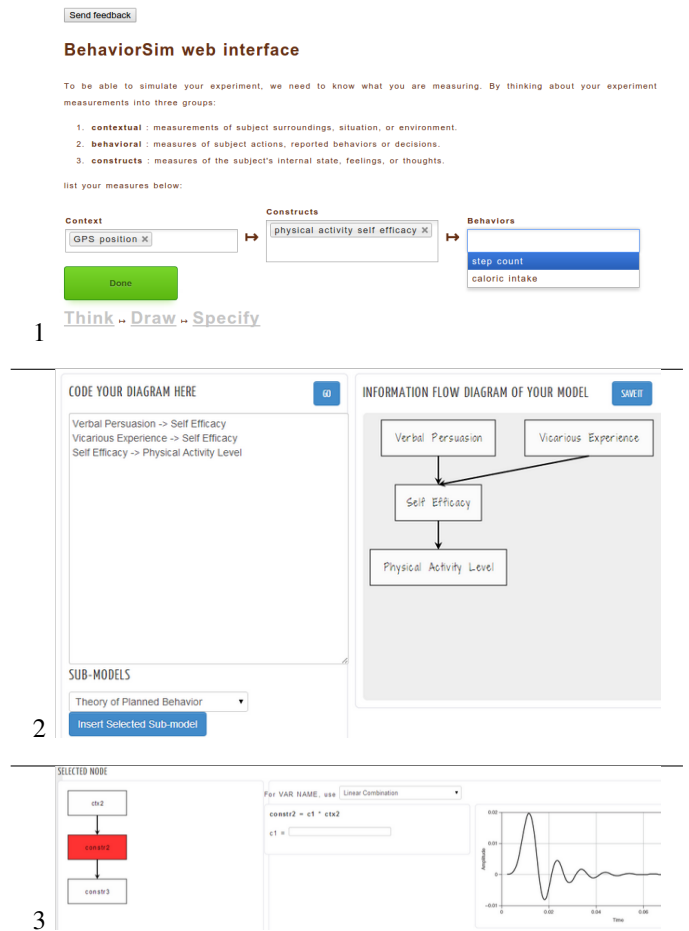


Fig. 1. behaviorSim Model Builder v0.1.x separated model-building into three separate stages: 1) think, 2) draw, 3) specify.

com/articles/why-you-only-need-to-test-with-5-users/). \subsection{Paper-prototypeModel-BuildingTask} A paper prototype was evaluated informally through discussion. This prototype allowed us to find that a careful choice of terminology was important, since some overlapping terms were the cause of significant confusion and user efforts were focused on defining the inner workings of the system. At the Annual Conference. Out of these, approximately 12 surveys were returned. In general, users still had trouble with modeling exercise. Most did not stray far from the original solution and others provided very different solutions which do not fit the ‘engineering view’ of the problem. In the survey questions participants reported that they wanted nearly all participants expressed a desire for increased collaboration. What are the outflows of each? specify-How exactly can each construct delays, etc until the construct behaves as you think it should. Do lot of what ifs of your model. Use system identification techniques on data. p-values’. \begin{figure}[!t]\centering\includegraphics[width=0.9\columnwidth]{img/behaviorSim_process}\caption{The five stages implemented in v1 of the behavior simulation}\label{model-builder-tutorial}\end{figure} This application was designed to draw, specify, etc...), the step-wise design is difficult for users who are seeing the process one-step-at-a-time. TODO: review my notes for more

The first iteration of the behaviorSim Model-Builder (see figure 1) took a step-wise approach to the task, which made backtracking difficult.