MODELING BEHAVIOR AND ACTION: SIMULATING HUMAN ACTIVITY

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KEY WORDS

Law enforcement, psychology, decision, graphics packages, training

ABSTRACT

In developing simulations for asymmetric threats there is a need to model human action as well as human behavior. In a force-on-force symmetric simulation little attention needs to be played to the particular human elements involved in the force. In an asymmetric threat there is a substantial need to model the action as well as the behavior of the individuals in the scenario.

How can one explicitly represent human action? The question invites a host of answers depending on the use of the representations in the model. Further, any discussion of the representation of human action invites the participants to generate an enormous list of potential relevant considerations depending on whether one wants to model, predict or explain human action. We will examine a basic framework for promoting intentional agency in the human model.

OBJECTIVE

In training for asymmetric threats there is a need to model the action state of the individuals that constitute a threat. In a symmetric episode being tagged as the opposition readily identifies the opposition. The visual cues presented in a training episode are clear. Most often visual cues in the form of uniforms are used, but more subtle cues such as position may also be used. A typical circumstance may be to identify an individual, lock the individual, challenge the individual, process the challenge, and take appropriate action. The appropriate action is most often framed by doctrine and policy. In this case there is little need to either identify the action of the individual or attempt to interpret the cognitive state of the individual. In an asymmetric threat the identification of the opposition is not readily apparent. Neither uniforms nor positions will identify the opponent. Thus, there is a need for the trainee to be able to interpret behavior as being an action that signifies that the individual is an opponent. While it may be tempting to use highly stylized behavior as a signal to the trainee that the individual is an opponent, this eliminates the possibility that the opponent may process the information given by the trainee in a flexible and fluid way. The response of the suspected opponent is flexible when the suspected opponent has more than two modes of action and is fluid when the suspected opponent is capable of adjusting behavior patterns to circumstances. The key to building a training simulation that can depict asymmetric opponents is to distinguish between action and behavior.

The identification of the factors of human behavior that can lead to an appropriate model of human action can be used to project the subsequent behavior of the agent being modeled. A constraint on this effort is that it should produce a computable set of representations through a representation language such that the models can be executed by a computer program to either identify the behavior in terms of a mental model as a certain kind of action or through having the mental model produce descriptions of the behavior appropriate to the actions generated by the model.

BACKGROUND AND THEORY

How can one explicitly represent human action? The question invites a host of answers depending on the use of the representations in a model. Further any discussion on the representation of human action invites the participants to generate an enormous list of potential relevant considerations depending on how one wants to model, predict, or explain human action.

We will begin in a fairly simple way. Borrowing from Wittgenstein we will start with the question of what remains to be represented after I subtract the representation for “my hand moved’ from the assertion that “I moved my hand? Or more traditionally

> What remains if I subtract the fact my arm went up from the fact that I raised my arm? (L. Wittgenstein Philosophical investigations. Trans., G. E. M. Anscombe. MacMillan Publishing Co., New York, NY., Sect.621)

The simple behavior is not the same as the action in this case. The representation of my hand motion must be coupled to another representation to generate the notion that “I moved my hand” since it is quite possible to have my hand move and yet it not be the case that I moved my hand. For example, my hand may have been bumped by some one else or could have had a simple twitch. The first part, the movement of my hand, is difficult enough, but the key in modeling human action is to represent the part that has to be added to the behavioral representation. Let the behavioral representation be B and the action representation A. The representational scheme, S, must be produced such that

$$B + S = A.$$

What ever S turns out to be, it will have some measure of intentionality in the sense that the behavior is being done in terms of some goal or future state of affairs. For example, my goal in moving my arm may be to swat a fly or to get my coffee cup. The coupling of B + S projects some other state of affairs - the fly being swatted or the coffee cup being in my hand - that is not the actual state of affairs. In this sense whatever S turns out to be it will need to represent the doing of B in order to make actual some state of affairs (SOA) that is at that time only possible. Thus, the scheme to represent human action will also need to engage representations of goals (G) and possibilities (P) given that the behavioral representations will have already required a representation of time. Thus the following provides a more detailed account of the content of S

$$B + \{G, P, \ldots\} = A$$

The set of things to be added to the representations of goals and possibilities will be affected by another factor. This factor concerns whether or not the intentional object (the projected SOA) is something that can be represented using only references to the actor or requires reference to a social context. For example, when I move my hand and the action representation references the future SOA of having my coffee cup there is no need to appeal to social representations. However, when I move my hand and my intention is to signal time-out then there is a reference to some social construct. If that is so, then there will be a need for a set of social or conventional representations (SC) as well as a set off individual state representations (IS). The following expands on the basic approach:

$$B + \{G, P, SC, IS, \ldots\} = A$$

Clearly more and more details can be added to the list of things that will answer the difference between behavior representation and action representation. However, these four provide a core set from which to work. Now the issue will become the following: How can these representations be combined? What is the function that takes the particular representations in G, P, SC, and IS and converts them into a representation such that A can be modeled, predicted or explained?

One possibility is that here will be a variety of functions that perform this task so that for the functions $F_1, F_2, \ldots F_n$

$$\begin{gathered} B + \ [\{F_1(G, P, SC, IS)\} \\ or \\ \{ F_2\ G, P, SC, IS)\} \\ or \\ \ldots \\ or \\ \{ F_n(G, P, SC, IS)\}] = A \end{gathered}$$

The decision procedure by which F is selected depends on multiple weighted characteristics at the time (dynamic evaluation). If the dominant factor is IS, then the function will operate on those internal factors if the model is intended to be predictive of human action. Or, if the SC factors dominate then the function will operate on those internal factors if the model is intended to be predictive of human action.

APPLICATION DOMAIN

The domain of interest coincides with neither forensic psychology nor profiling though it does have areas of overlapping content. The main difference is that forensic psychology focuses on legal matters after a purported action has been taken and profiling focuses on diagnosis of traits before the action has occurred. Both can be, but neither is, directed at detection and both seem to operate from more full-bodied action descriptions.

In the domain of simulation for asymmetric training the descriptions of behavior leave questions about the attribution of an action. For example, in surveillance mode, the data would consist of visual images or behavioral reports and the task would be to determine if any of the action descriptors of interest should be applied. In the simulation mode, one would be given a model through which the various action and behavior descriptions would need to be generated. In either case there would also be a need for a neutral set of representations and models that would not be associated with the action descriptions of interest.

BUILDING A BEHAVIORAL SIMULATION

The behavioral simulation will be composed of some terrain and a collection of animated characters (animants). The animants operate in the space defined by the terrain and follow physical paths. For example an animant placed on a terrain will follow a path such that the projected visualization is of a man walking up a staircase. The physical characteristics of clothing style and gait are specified in the properties of the animant. Some may change over time. In particular the path relative to the environment changes and the motion, position, or gait may also change. The software simulation environment PeopleShop, from BDI, supports such functionality. It also extends the development of the behavioral model by allowing for sensor regions, signals, and choice points. The behavioral simulation operates such that given a script a particular animant follows a path and may react to signals that provide for a change in behavior that may include a choice in path. In the behavioral simulation a careful script must be constructed such that there is a transition from one physical state representation to another. The process is very similar to the use of key-frames.

```
begin perform(behavior)
repeat
{
 get point_on_path
 if (key_frame)
 {
  get signal
  get decision_condition
  new_behavior := evaluate(signal, decision_condition)
  perform(new_behavior)
 }
 else
 {
  continue behavior
 }
}
```

It may appear that providing signals and choice points would be sufficient to allow for the missing part of the action environment. However, this is not the case the animant is largely stateless and the behavior choice component is more tightly tied to the path description than the internal state of the animant. In the context of action the animant is stateless and therefore all components of the action and action identification components in the training simulation will reside in the script being executed and in the trainee. In such cases the successful trainee will generate a mental model that closely resembles that of the mental model that the simulation-training designer intended. Each new training episode will call for a new round of simulation building by the designer-trainer

ABOUT BDI AGENTS

An agent architecture, such as that provided by the IBM ABLE tool kit, provides the resources for building software agents that can exhibit intelligent characteristics. ABLE is a framework and component library for building intelligent agents using machine learning and reasoning. In general a software agent may be thought of as a computational system that has goals, sensors, and effectors, and decides autonomously which actions to take and when. A weak notion of agency includes

- Autonomy (agents operate without the direct intervention of humans or others, and have some control over their actions and internal state)
- Social ability (agents interact with other agents and humans via some kind of agent communication language)
- Reactivity (agents perceive their environment and respond to changes that occur in it)
- Temporal continuity (agents are continuously running)
- Goal-oriented (agents handle tasks by making decision about how to split the task into smaller sub-tasks that achieve the goal)

More complex agent architectures view an agent system as a rational agent having the mental attitudes of Belief, Desire, and Intention – BDI. These mental attitudes determine the agent’s behavior and are critical when deliberation affects action and the reasoning is subject to resource bounds.

An agent's beliefs are a component of its system state that represents information and which is updated appropriately after each sensing action. This component may be implemented as a variable, a database, a set of logical expressions, or some other data structure. Beliefs represent the informative component of an agent.

An agent's desires are a component of its system state that represents information about the goals to be accomplished and the priorities or pay-offs associated with the current goals. Desires represent the motivational state of the system.

An agent’s intentions are a component of its system state that represents the currently chosen course of action that is the output of the most recent call to the selection function. Intentions represent the deliberative component of the agent.

An agent continues to process its internal state and outside information in a non-terminating loop such that

```
repeat
{
  get new_external_information
  update_beliefs(new_external_information, beliefs)
  options := option_generator(new_external_information)
  selected_options := select(options, beliefs, desires)
  intentions := update_intentions(selected_options, intentions)
  behavior  := translate(intentions)
  execute behavior
  drop successful(desires)
  drop impossible(desires)
  drop inconsistent(intentions)
}
```

COMBINING BEHAVIORAL SIMULATION AND BDI AGENTS

To build training simulations that are compelling and have a high degree of fidelity to the cognitive tasks involved in asymmetric threat situations, a combination of behavioral simulation and BDI agents is desirable. The behavioral simulation provides the underlying behavior system and the BDI agent provides the conjunction of characteristics needed to transform behavior into action. The implementation of the BDI agent provides the functions that select the appropriate behavior from a behavioral repertoire (library) when given goals, possibilities, social conventions and individual sates. Within the BDI realm the translation of goals is direct and options embody the relevant notion of possibility. Further the combination of the new external information with the current beliefs concerning the representation of that information provides for a relevant notion social convention. Finally the intentions of the BDI agent map to the BDI notion of an individual state.

The decision whether to replace the evaluation function in the behavioral simulation by a BDI agent or replace the execute behavior statement in the BDI agent by a behavioral simulation is a practical choice. One possibility would be

```
begin perform(behavior)
repeat
{
  get point_on_path
  if (key_frame)
    {
    get new_external_information
    update_beliefs(new_external_information, beliefs)
    options := option_generator(new_external_information, available_paths)
    selected_options := select(options, beliefs, desires)
    target_intention := update_intentions(selected_options, intentions)
    drop successful(desires)
    drop impossible(desires)
    drop inconsistent(intentions)
    new_behavior_on_path  := translate(target_intention)
    perform(new_behavior_on_path)
    }
  else
  {
    continue behavior
  }
}
```

The combination of an animant and a BDI agent is capable of representing the performance of an action in a training system. The success of the trainee will depend on building an acceptable model of the animant’s actions that leads the trainee to perform the correct action in return. Further, the construction of BDI agents can be tailored to the general characteristics of an agent type so that efficient reuse is possible. Finally, behavior representations become action representations when animants are coupled with BDI agents.

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