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A Methodology for Composing Behaviour Models for Military Simulations

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Despite the consistent requirement for Human Behavior Models (HBMs) in defence simulation, surveys of Computer Generated Force (CGF) Artificial Intelligence (AI) reveal consistent limitations that restrict use of CGF's in training and experimentation (Parkinson, 2009). A lack of standardization and issues with scaling make it difficult to transition cognitive models from the laboratory to operational environments (Douglass & Mittal, 2011). Operational environments contain a diversity of computing devices, simulation specifications and languages, as well as a diversity of human expertise, with a strong requirement to share common representations (Kramer, Miller, Unrau, & Armstrong, 2010). Methodologies that deliver robust, re-useable, scalable HBMs for operational use will have a large, positive impact.

This poster outlines a methodology for the composition of different behavior model components into a single simulation application. If deploying composite models was straightforward, simple decision models could be combined to emulate more complex aspects of human decision-making. Sophisticated cognitive models could be combined with procedural AI to extend the capabilities of existing CGF tools. The same high-level decision model could easily be used in two different synthetic environments. This work is based on previous simulations built with multiple levels of system abstractions (Emond, 2011; Miller, Unrau, & Kramer, 2010), and the application of ontology (Tzeng, Hsu, Cheng, & Huang, 2009) and semantic web technologies (Horrocks et al., 2004; W3C OWL Working Group, 2009) as a means to provide interoperability between heterogeneous military simulation systems (Turnitsa, Padilla, & Tolk, 2010).

For HBMs of different levels of abstraction to exist in a single application, two new processes must be added to a classical sense, decide, and act loop (RTO/NATO, 2009; Wray, Laird, Nuxoll, & Jones, 2002). In figure 1, a higher-level decision model (Decide #2, red) is combined with a lower level model (Decide #1, orange). The base information flow is shown in green - the lower level HBM senses the environment, makes decisions, and acts on the synthetic environment in a conceptual representation natural to that model. To combine this HBM with a higher-level model, the information flow in blue is introduced. The more concrete concepts 'sensed' by the lower level must be abstracted for use in the higher level. Conversely, the abstract decisions must be made more specific to be actionable at the lower level.

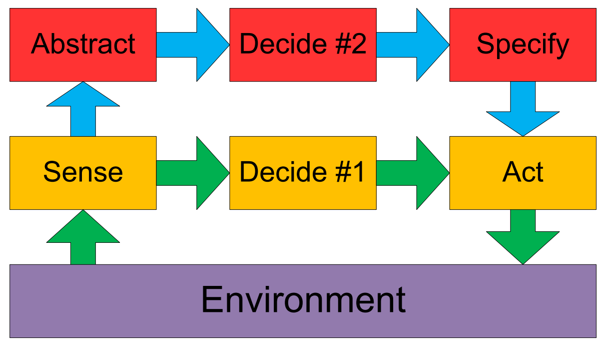

Figure 1: Abstracting and specifying as a methodology for combining decision-making models

Following this methodology, in Miller, Unrau & Kramer (2010), a motivation framework was used to specify waypoints that controlled the actions of Bohemia Interactive VBS2's AI. In recent work, a civilian model was developed by integrating a motivation framework with Presagis' STAGE. The AI in STAGE controlled the entity navigation using cost-minimization routing. The higher-level process modified the terrain feature costs based on observed military activity. In this fashion, the motivation framework specified *how* the STAGE AI should act.

The abstraction and specifying processes can also be discussed as 'translation' interfaces. In a conventional interface example (figure 2) two components transfer entity information.

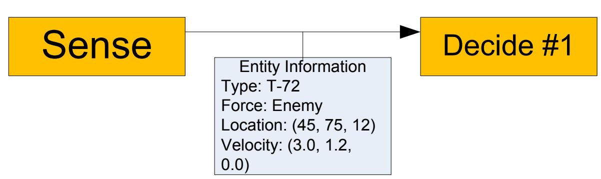

Figure 2: A conventional interface

Critically, the two components must agree exactly on the details of this interface, and the *Decide #1* component receives information exactly as it is sent from the *Sense* component, tightly coupling the internal representation frameworks of the two components. In figure 3 we introduce a 'translation' interface. As before, a *Sense* component produces information on detected enemies. Now, an ontology formally specifies the relationship between *Sense* concepts such as *Type* and *Force*, and *Decide #2* concepts such as *Threat-Level*. Importantly, the ontology bridges differences between the inputs and outputs of the two components, and the data received is not identical to the data sent.

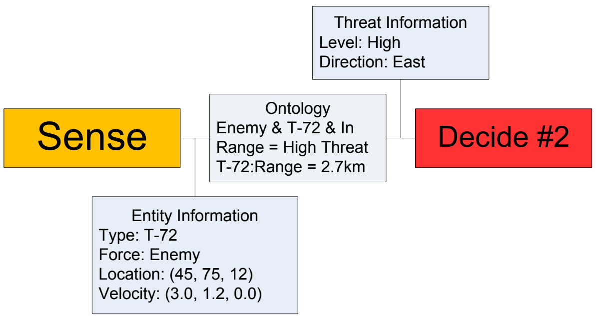

Figure 3: Definition of a 'translation' interface

Software is required to make this interface work. For instance, a reasoner could be used to deduce the inputs for the *Decide* component based on the ontology and the outputs of the *Sense* component. Alternatively, the ontology could be used to specify a Bayesian inference network that relates the *Sense* outputs to the *Decide* inputs in a probabilistic fashion.

The short example above outlines a methodology for integrating multiple, dissimilar sensory and motor element into a single HBM. Translating interfaces compartmentalize functionality, enabling re-use and scalability. The methodology can be summarized as follows: 1) Define the full scope of the HBM; 2) Define a set of simple models that together address the full scope; 3) Define the model inputs and outputs in concepts that are natural for the models; 4) Define ontologies that relate the defined concepts; 5) Integrate the simple models with translating interfaces. For re-use in a new application, the following process is applied: 1) List the concepts defined by the existing models; 2) Relate these concepts with ontologies; 3) Unsatisfied mappings now define additional models or synthetic environment elements required to complete integration.

The next step of this research is to introduce standardization through military specific information exchange and messaging standards such as the Coalition Battle Modelling Language (Blais, Galvin, & Hieb, 2005) and the Military Scenario Definition Language (MSDL Product Development Group, 2008).

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