Chapter 5 – HUMAN TASK REPRESENTATION IN M&S

Session Chair: Dr. Laurel Allender
Army Research Laboratory
Human Research & Engineering Directorate
Attn: AMSRD-ARL-HR-SE
Aberdeen Proving Ground, MD 21005-5425
USA

Presenter: Dr. Oshin Vartanian
Defence Research and Development Canada
1133 Sheppard Avenue West
Toronto, Ontario M3M 3B9
CANADA

5.1 BACKGROUND

The representation of human behaviour in M&S begins with the question of how to best represent the tasks being performed, that is, the activities being carried out that constitute behaviour. How should the steps and sub-steps of activity, the overt and the 'black box' aspects of a task, the motor and the cognitive decision making elements of a task be translated into M&S software? How should you begin? Given that most of the models of human behaviour in use today have roots in the human factors community, task representation typically begins with some form of task analysis. Subject matter experts (SMEs) are used to develop a structured 'list' that captures the tasks of interest. Task analysis methods vary with respect to the details depending on whether it is a mission-function-task decomposition, a cognitive task analysis, a goal-directed task analysis, a work-centred approach, etc., but the general result the same. Generally, tasks are modelled as a sequential or networked series of steps of behaviour on the order of seconds or minutes. For many purposes, when the tasks to be represented are orderly and operators follow procedures, this may suffice; however, there are several factors that may influence human task representation in M&S and humans often deviate from procedures, often with good reason.

5.2 DISCUSSION

5.2.1 Expertise and Learning

Two related factors that influence how a task is to be represented are expertise and learning. There is new evidence emerging from research using brain imaging such as functional Magnetic Resonance Imaging (fMRI) that shows that experts have an overall lower brain activation during performance of the tasks of interest than do non-experts, suggesting that individual steps have become one larger step or 'chunk'. This result is consistent with the finding reported in the naturalistic decision making literature (see Klein for additional insight: Zsambok & Klein, 1997) that experts very often cannot express the detailed steps they performed as a part of a larger task. This is both problematic and interesting for HBR. On the one hand, SMEs are a main source of information about the tasks to be performed, but if they cannot verbalize what the steps or procedures are, then the task analysis is incomplete in some sense. On the other hand, the difference between novices and experts (going from many task steps to a single, more efficient task step) may be important to represent directly. Discussion of this topic at the RSM covered the role of implicit judgement,

limited deliberation (not 'over-thinking' a decision), recognition-primed decision making, pattern-matching in expert decision making and the associated implications for task representation in M&S. Most of the discussion referenced military decision making but pertinent examples from economic decision making (e.g., buying a car) were given as well.

In addition to experts thinking of the task in a unitary fashion, as a 'chunk', rather than as a series of sub-steps, there is evidence that, since they are actually using fewer cognitive resources, they are better able to 'multi-task' and attend to other aspects of the environment, which, in turn makes them better able to detect anomalies and to do error correction, all of which would need to be accounted for in a model of expert performance. The matter of pattern-matching raised the question of whether this simplifies the modelling process or creates new difficulties. A model that includes pattern-matching, ideally, would include matching based not only on surface features, but also based on temporal, relational and procedural features characteristic of analogical reasoning theories (Thagard, 2005). What about the case when a novel pattern of events unfolds that does not have a match? It was suggested that a two-system or hybrid model that includes both symbolic and subsymbolic processes (such as ACT-R: Anderson & Lebiere, 1998) may be useful for this level of modelling.

Modelling expert performance, however, begs the question of how the expertise was gained in the first place. So, the question is, could a model of expert behaviour be created by having the model learn in the same fashion as a person? This could be accomplished by repeated exposures to the tasks to be learned, with a representation being built up and modified over time. Some modelling approaches offer the capability to learn, although they are not in widespread use as of yet.

5.2.2 Context

Another factor that will influence task representation is context and, specifically, the degree to which context is 'hard-coded' versus one more element the HBR must draw from the M&S environment. On the surface, humans implicitly understand the nature of a task without it being described in detail, without it being broken down into sub-tasks and small steps. The challenge arises when the task is to be represented computationally. At home, the task 'wash the dishes' evokes the entire context (the dishes are dirty, that hot water, a basin, soap, and so on) is available and the motions follow as a matter of routine. However, language is ambiguous; different cultures will have different interpretations of the same general task language. The humorous military example was given of the task 'secure the building', which is interpreted differently by the different services.

- The Army would surround the building with defensive fortifications, tanks and concertina wire.
- The Marine Corps would assault the building, using overlapping fields of fire from all appropriate points on the perimeter.
- The Navy would turn out the lights and lock the doors.
- The Air Force would take out a three-year lease with an option to buy the building.

The RSM discussion covered two points: One, that representing context – including the immediately prior history, the training, social, and cultural background being instantiated, the ability of humans to sort through the ambiguities of language – are challenges for high fidelity task representation; Two, that ensuring a common understanding of the nature of the task representation between the SMEs, the customer, the modeller, and others in the modelling community is a problem of semantics and of perspectives that must be dealt with directly at the beginning of a modelling effort and revisited throughout the project to ensure a good outcome. For example, the definition of a 'rule' differs depending on the modelling approach being used. A suggestion

from the RSM attendees for distinguishing between rules and pattern matching (which may be implemented as a logical rule in the software) was that perhaps rules can be expressed explicitly as opposed implicit pattern-matching that might be expressed sub-symbolically or via a neural network.

5.2.3 Goal-Directed Representations

A third factor is the degree to which tasks should be represented as goal-directed versus as a set of steps that are executed essentially in order once the series is initiated. A goal-directed representation better enables an HBR to switch priorities based on new or additional information available in the M&S. Goal directed representations may also better characterize naturally occurring errors such as errors of commission and to have more flexible error recovery, to perform multi-tasking requirements in a realistic fashion, etc. A related aspect of a goal-directed task representation (such as Hierarchical Task Analysis, HTA: Annett, 2003; Annett & Duncan, 1967) is whether the representation is of the precise methods to be accomplished (e.g., these six steps in this exact order) or of the end result (e.g., 'take the hill'). The goal-directed approach allows for variability in methods employed to achieve the end, but also requires a more complex model. It was asserted by an RSM attendee that goal-directed modelling 'does not come for free', as has been found with the BDI (beliefs, desires, intentions) approach to agent modelling.

Additionally, the degree to which the methods are modelled in detail versus only as the end product can be thought of in a nested fashion: the details of the process at one level of granularity constitute the window into the black box of the higher level, and, in turn, the details at that level could be exploded into greater detail at the next level. For example, the 'task' of sending a message could be modelled as a series of steps (turn on system, type, check, press send), or the task could be modelled as just that, a single action that takes a certain amount of time in the aggregate. Or, if it fits the purpose of the model, the task of sending a message could be modelled at the level of milliseconds and involve the processes of perception, recall from memory, essentially simultaneous motor actions, errors, error correction, etc.

5.2.4 Emotion

A final factor identified by the RSM attendees as influencing the nature of human task representation in M&S is emotion. The literature on the role of emotion in decision making is of increasing interest to the military modelling community with new emphasis on operations other than war and effects based operations. Positive versus negative emotions seem to play an important role in memory and decision making. To some degree, emotions can be considered a stressor or a performance moderator with task and context-specific dependencies indicating a positive versus a negative outcome.

5.3 CONCLUSIONS

The choice of task representation is influenced by numerous factors in the application area – expertise and learning, context, goal-directed representation, and emotion. There are other factors as well, many of which are linked to the other discussion topics in the RSM: which human factors to represent, variability, moderators, and modelling at the individual versus team or group level. It can be concluded that the outlook for task representation is good for HBR, with a solid base having been established with a task network modelling approach. However, in order to represent the more complex aspects of human behaviour that underlie complex decision making in the full range of military operations, the additional factors discussed at this RSM must be incorporated into the HBRs being used in common practice.