Agent Technology for Addressing Military Applications that have Dynamically Changing Rules Using Human Reasoning Processes

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Executive Summary:

Many military applications deal with dynamic situations. This paper discusses human reasoning applied to dynamically changing rules-based systems. A technology will be discussed which allows human "experts" to put their expertise into devices or into software enterprise applications. It will explain how this technology can be applied to military applications where data (from the environment, military commanders, satellites, databases, etc…) might change, and where actions need to be taken accordingly based on that changing data. In addition, many military applications need to have solutions where the actions are fully explainable so that the system can be audited and tuned by human observers. The technology described in this paper provides auditable and explainable decisions.

When humans make judgmental decisions that involve multiple domains, they balance the impact of different actions until they determine that they are choosing the best overall response. When humans make these decisions they are dealing with information from a variety of sources. A single piece of information may impact different parts of the overall problem domain with differing levels of significance. When making subjective decisions, humans are also considering time and space impacts to the problem domain. In addition, a human might be thinking about the problems facing them at the moment, so future issues may seem less important to them at the time.

KEEL® Technology

KEEL Technology is a unique approach for collecting human-like decision-making. It allows human "experts" to put their expertise into devices or into software enterprise applications. KEEL Technology provides an alternative to conventional expert systems, neural nets, fuzzy logic and neural-fuzzy systems because it has a small memory footprint and because it is fully explainable.

The process of utilizing this decision-making technology in an application can be explained as follows: First a problem(s) is identified where human reasoning is necessary. Then, the human "expert" or experts use the KEEL Toolkit to graphically define the reasoning process (rules). It should be noted that while they are designing the process, the expert can visualize the system operation *while* they are creating the set of adaptive rules.

After the expert defines and tests the system, the graphical design is translated into conventional source code using a menu item in the KEEL Toolkit. This design is referred to as a decision-making "engine". The code which is generated (C, Java, Microsoft Visual Basic 6, Microsoft Visual Basic .NET, Microsoft C#, Macromedia Flash MX, or PLC Structured Text) can then be passed on to the software engineers to incorporate into the product application. The code from the KEEL engine has a very small footprint (about 2k in size), so it can be inserted into very small devices, as well as into enterprise software applications. [The code manipulates data in tables (inputs/outputs, etc.) so it is always about 2k in size. The tables can be large or small depending on the number of items in the system application.]

KEEL "engines" reason by iteratively analyzing the data by manipulating the data in tables until a stable overall answer (set of actions) is achieved. The result is a set of actions or decisions that are fully explainable at any time. Each KEEL "engine" can perform an autonomous decision-making function. A complete system may have one engine or many engines. The engines can be scheduled (by the system) to operate individually, or they can be "glued" together using Compsim's KEEL Function Block software.

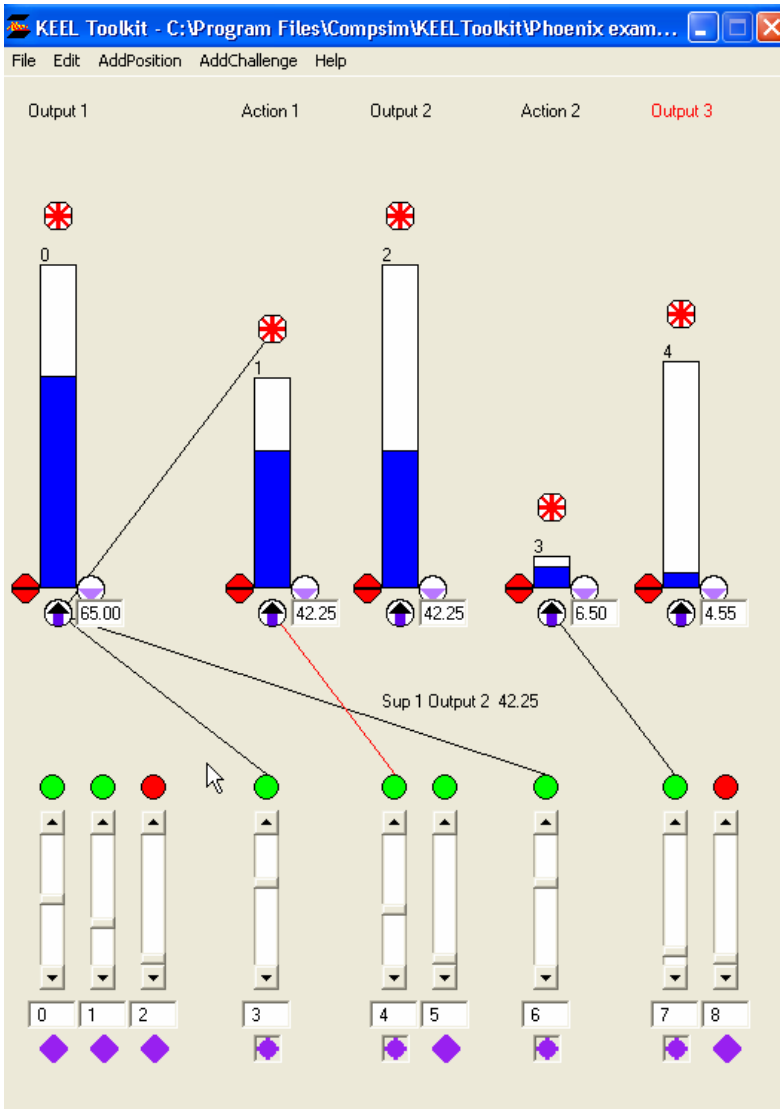
One example where one or more KEEL engines might be deployed in a military application can be described using a recent solicitation posted by the Army: A04-055 (TITLE: Command Decision Modeling in Distributed Combat Simulation, TECHNOLOGY AREAS: Information Systems, Battlespace).

- The Objective of this request is stated as follows: "To provide an asymmetric, non-scripted, adaptive model of battlefield decision-making to the Command, Communications, and Control Grid (C3Grid) of the Modeling Architecture for Technology, Research, and Experimentation (MATREX) distributed simulation environment."
  - This objective describes how KEEL Technology works in a nutshell. KEEL Technology is not conventional code (IF/THEN/ELSE code). It is graphical "source code". If the engines are employed as autonomous software "agents" they can dynamically adjust to the environment. Using a set of rules these agents can emulate the "thinking" or "reasoning" process of humans; producing outputs such as "actions" or messages which are explainable and auditable.

- From the REQUIREMENTS section: "The rapid explosion in information circulating on the modern battlefield presents a huge challenge to the decision makers and warfighters who must plan and dynamically adapt to changing circumstance and new information, often under conditions of time pressure, uncertainty, and stress."
  - A KEEL engine can respond to dynamically changing pieces of information. Modeling systems as relationships between data items, rather than as explicit scenarios, should allow a KEEL engine to respond like a human expert. Because the reasoning model is completely visible, it can be audited and corrected / extended as necessary.

Example of the Graphical Source Code

As previously mentioned, the KEEL Toolkit allows judgmental rules to be defined using graphical source code language. Inputs can be defined that either support or block a decision (or action). The importance of a decision (or action) is indicated by the size of the graphic representation, and it can be defined so that it changes dynamically by the system. Relationships between actions are defined by "wiring" the information items together.



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