Knowledge Enhanced Electronic Logic for Embedded Intelligence

Technology Overview

What is it?

Compsim's KEEL® (Knowledge Enhanced Electronic Logic) Technology can be used to put human-like decision-making in products or software applications. KEEL technology can be considered an "expert" system that uses the decision-making skills of a human as the basis of judgmental decisions. The KEEL Toolkit provides the mechanism to collect and test those reasoning skills before deployment in the final product.

KEEL is:

- A development environment
- A model for accumulating supporting and objecting arguments in order to make a decision or take an action
- A small footprint engine that processes sensors or other inputs according to the design of a system created in the development environment
- A method for implementing the cognitive model as an analog circuit

What defines a good KEEL application?

- Human experts are required to interpret information to make the best decisions or take the most appropriate actions
- Devices must operate autonomously and make judgmental decisions on their own
- Devices can make control decisions when human operators are not present
- Repetitive judgmental decisions are prone to error
- Judgmental decisions by trained operators are potentially "tricked" into overlooking critical attributes
- Human experts take too long to make judgmental decisions
- Applications where the judgmental decisions must be explained
- Complex situations where it is uneconomical to develop and maintain straight line code (IF, THEN, ELSE)
- Situations where the environment is dynamic and the importance of information changes and the system must react to change
- Situations where there is an advantage to be able to create one design and execute it on multiple platforms: device, software simulation, web
- When the small memory footprint of a KEEL engine is an advantage
- Where architectural issues may prohibit other solutions (KEEL technology is architecture independent: localized, distributed, web based, multiprocessor…)

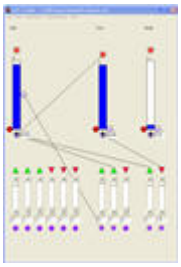
Why is it special?

Using the KEEL toolkit, a human (i.e., a "Domain Expert") can document how to analyze problems and take actions. The resulting code can be embedded into a device, a software application or demonstrated on the web. Special characteristics include:

- Decisions or actions are explainable
- Graphical development tools focus on subjective "right brain" reasoning
- Generating a small memory footprint makes it possible to add human like reasoning to very small devices
- Interactive development environment allows the designer to get immediate feedback in the reasoning process
- A single design can be deployed in a variety of environments
- Architecture independent (simple stand-alone applications, client-server, distributed)
- Easy to integrate into existing systems (simple API)

Interactive Demo:

(Click Here)



How does it work?

The KEEL Toolkit allows a human (i.e., a "Domain Expert) to interactively model a decision-making process. The designer gets immediate feedback from the design, as the thinking process operates while the design is being created.

A variety of tools assist the designer in documenting the model. When the design is ready to be integrated into the final product, it is translated from the graphical model to conventional code (C, C++, C++ .NET, Microsoft C#, JAVA, JavaScript, Octave(MATLAB), Python, Microsoft Visual Basic Version 5/6, Microsoft Visual Basic .NET, VBScript, Macromedia's FLASH 2/3, and PLC Structured Text) that can be provided to the software engineer for system integration. The isolation of the decision-making model from the native source code simplifies maintenance. If a logging function is integrated into the application (according to the KEEL XML schema), any decision that is logged can be read back into the development environment so decisions or actions can be reverse-engineered.

KEEL technology attempts to mimic the way that humans balance input information to make decisions. In this manner, a KEEL engine operates like an analog computer. It accumulates supporting information and balances this with objecting or blocking information. Individual considerations interact with other decisions or actions in a web of relationships that are balanced to achieve the best overall set of actions for the system. In a KEEL system, the importance of information is likely to be constantly changing.

The importance of information can be controlled from external events or can be controlled as part of an internal process.

The output from a KEEL engine can be binary (YES/NO or ON/OFF), or it can be relative (do x amount of action 1 and y amount of action 2…). Events can be triggered. The number of inputs and outputs from a KEEL engine are limited only by the resources available.

The output of the KEEL Toolkit is two or three small subroutines and a series of tables that define values and relationships between information. There is no textual processing in the KEEL engine itself, only an evaluation of information. Any display and control functions are defined external to the KEEL engine.

Competitive Technologies:

Unlike neural nets and fuzzy logic, the KEEL logic can be easily visualized and explained. The use of a pattern matching approach to cognitive solutions could present a problem when it is important to validate the decisions or actions. With pattern matching there is no "reasoning" taking place other than to suggest that there is some degree of a matched pattern. When patterns are similar, but not the same, there is a risk that the wrong choice is made purely because the patterns are somewhat similar. A mechanism that uses an organized *process* is more likely to give a correct response. KEEL technology provides such a process.

Technical Basics

KEEL technology:

- Utilizes a "network" of ideas
- Accumulates support and blocking mechanisms like exciting and inhibiting synapses in the brain
- Creates an analog accumulation of the support and blocking signals that can define the strength of the output
- Does not utilize pattern recognition, which would require pattern training, but is based on rules defined as relationships between actions (or decisions)
- Utilizes a human expert to define the relationships between information and to validate the reasoning model
- Allows analog inputs to define relative or valued information as inputs to the architecture
- Does not blur the data with a fuzzification / defuzzification process

- Creates a solution that can be reviewed and understood by humans (not just mathematicians or software engineers)
- Creates decisions and actions that can be explained or recreated based on logged data. (Note: the process is explainable because all relationships are visible during the development process using the KEEL Toolkit)
- Allows any idea to interact with other ideas

Technology Comparison

	Neural Nets	Fuzzy Logic	Bayesian Belief Nets	AI – Forward / Reverse Chaining	KEEL
General Concept	Pattern matching	Geometric Fuzzification / Defuzzification	Probabilities of Probability	Trial and Error	Dynamic adjustment to Importance of data (genetic)
Source of Understanding	Patterns	Human Designer	Human Designer / Statistics	Human Designer	Human Designer
Pattern Training Required	Major Problem	No	No	No	No
Explainable Decisions	No	Difficult	Difficult	Somewhat	Fully Explainable
Small Memory Footprint	No	No	No	No	Best
Performance	Determined by application	Determined by application	Determined by application	Worst	Determined by application
Suitable for Control	Yes	Yes	Probability not	Probably not	Yes
Interactive Development	No	Maybe	Somewhat	Maybe	Yes
Portable design (device, software, web)	Probably Not	Probably Not	Probably Not	Probably Not	Yes (one design, many output formats)
Weaknesses	Pattern training required; Decisions not “explainable”; Does not handle “surprise” conditions	Difficult to explain reasoning; Somewhat arbitrary design concepts	Statistics may not be available for non-linear systems; Difficult to explain	Fragile / brittle- hard to maintain; Does not handle “surprise”	

Potential Applications:

KEEL technology can be applied in: Military, Automotive, Governmental, Medical, Industrial Automation, Home Automation, Homeland Security, Financial Systems, Enterprise software, Semiconductor, Network Management, and Electronic Gaming markets.

- Military
  - Unmanned Vehicles
  - Actionable Rules of Engagement and Policy Execution
  - Command and Control Automation
  - Data Fusion / Information Interpretation
  - Portable Training Tools
  - Diagnostics / Prognostics

- Automotive
  - Telematics
  - Attentive Systems
  - Diagnostics / Prognostics (localized, distributed, global)
  - Factory Test
  - Adaptive Control
  - Embedded Maintenance
  - Fleet Management

- Governmental
  - Economic Modeling

- Medical
  - Intelligent Medical Equipment
  - Embedded Treatment
  - Equipment Diagnostics / Prognostics
  - Automated Information Analysis
  - Patient Monitoring

- Industrial Automation
  - Diagnostics / Prognostics
  - Intelligent Work Flow
  - Automated Asset Management
  - Supervisory Control

- Home Automation
  - Diagnostics / Prognostics
  - Security Systems

- Homeland Security
  - Airport Security
  - Automated Supervisory Control
  - Objective Information Analysis
  - Profiling / Modeling

- Financial Systems
  - Explainable Loan Approval
  - Objective / Explainable Insurance Pricing
  - Objective Stock Brokerage Analysis
  - Economic Modeling

- Enterprise Software
  - Data Mining / Analysis
  - Resource Allocation / Load Balancing

- Semiconductor
  - Resource Allocation
  - Custom Circuits

- Network Management
  - Resource Allocation
  - Network Diagnostics
  - Active Security

- Electronic Games
  - Unscripted Games
  - Intelligent Toys

Contact:

Compsim LLC is a provider of next generation cognitive technology for application in automotive, industrial automation, medical, military, governmental, enterprise software and electronic gaming markets. The company is headquartered in Brookfield, Wisconsin.

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