

ISA EXPO 2005 Technical Conference

Heuristic Reasoning in Batch Processing



<http://www.compsim.com>

Tom Keeley

Helena Keeley



Knowledge
Enhanced
Electronic
Logic

The Human's Role in Batch Process Industry

- Load Raw Material
- Prepare and Refine Recipes
- Schedule PM
- Schedule Production
- Oversee Production
- Fix Broken Equipment
- Make Mistakes!

Equipment Role in Batch Processing Systems

- Move Material
- Move Data
- Load Material at Appropriate Times
- Transform Material
- Display Process Information
- Fail / Break!

Industry Response to Human Error and Device Failure

■ Automation

- Take people out of the process loop
- Automate common operations
 - Sensors and Actuators
 - Process Controllers control continuous processes
- Redundancy
 - Addresses catastrophic equipment failures

But! People are still involved. Equipment still exists...

- When Process Facilities Fail they have the potential to Fail Big!
 - Economic impact
 - Health impact (employees and community)
- Operator error accounted for 50-70% of failures in electronic systems
- Human errors during maintenance functions are a common source of system outages
 - Stressful situations, time pressures, alarms, inconvenience

Human Error

- Lack of Attention (Situation Awareness)
 - 20 minute limit
- Fail to Perceive
 - Inability to understand the situation
- Memory
 - Short term memory (7 +/- 2 items)
- Logical Reasoning
 - Poor judgment

Focus of Automation Today

- Automation Today
 - Increase Production
 - Increase Quality
 - Keep Humans out of harms way (sometimes)

Human Machines

- Automation Today DOES NOT
 - Address Judgmental Decisions that have been left to human operators and supervisors

Automating Judgmental Reasoning (The problem)

- Addressing dynamic environments
 - Everything changes. A decision or action one instant may not be appropriate the next.
- Addressing non-linear variables
 - The world is non-linear
- Multi-Dimensional problem domains
 - Solutions to one part of the problem cannot be made without considering how any adjustment might impact other parts of the problem

Roadblocks to the Automation of Judgmental Reasoning?

- Human inattention is not a problem for computers (computers don't get tired)
- Perception is not a problem for computers when input data comes from sensors (computer programs identify how each sensor should be handled)
- Short term memory is also not a problem for automation equipment (for all intensive purposes, memory is free)
- The primary reason for not automating human judgment has been the inability to program *judgment*.

Automating Safety Critical Systems

- Requires Completely Explainable Auditable Decisions and Actions
- May preclude some cognitive technologies:
 - Artificial Neural Nets (ANN), because ANNs are pattern-matching rather than logical (they don't explain their decisions or actions).
 - Fuzzy Logic, because it is not easily explainable or auditable (the geometric fuzzification /defuzzification blurs the data).

Other Alternatives

- Conventional “Sequential” Programming Languages – IF, THEN, ELSE languages: C, C++, Java, RLL
 - Solving dynamic, non-linear, multi-dimensional, inter-related problem sets using conventional languages is difficult or impossible: develop, test, maintain, understand.
 - It just takes too long to get it right. Attempting to get it right may introduce more problems than leaving the problems to human judgment of the operators and supervisors.

Defining Judgment

- Judgment is a data fusion problem
- Judgment involves interpreting the importance of input data based on the instantaneous environment
- Judgment involves balancing alternatives to choose the best alternative(s)
 - Which can be obtained by adjusting multiple variables, each of which interacts with one or more other variables.
- Judgment is more of an “image processing function” – a right-brain activity

Examples of “Judgmental Problems”

- Steering a car around a corner, controlling the accelerator, brakes, and radius of turn, while considering surface conditions, whether you have started to slide, traffic, pedestrians.
- We would suggest this is a balancing act that is continuously repeated throughout the turn.
 - All data is fused and processed at once
- We would suggest that this is NOT a sequential process that is addressed by mentally calculating a formula.
 - One doesn't drive a car, by processing each input sequentially

Providing a way to Program Judgment

- Eliminates the roadblock that has existed with conventional programming techniques and enables the automation of judgmental decisions.
- Allows safety critical systems to be addressed by providing a way to create completely explainable and auditable decisions and actions.
- Demands that the methodology addresses complexity concerns that have blocked conventional coding techniques from this domain in the past.

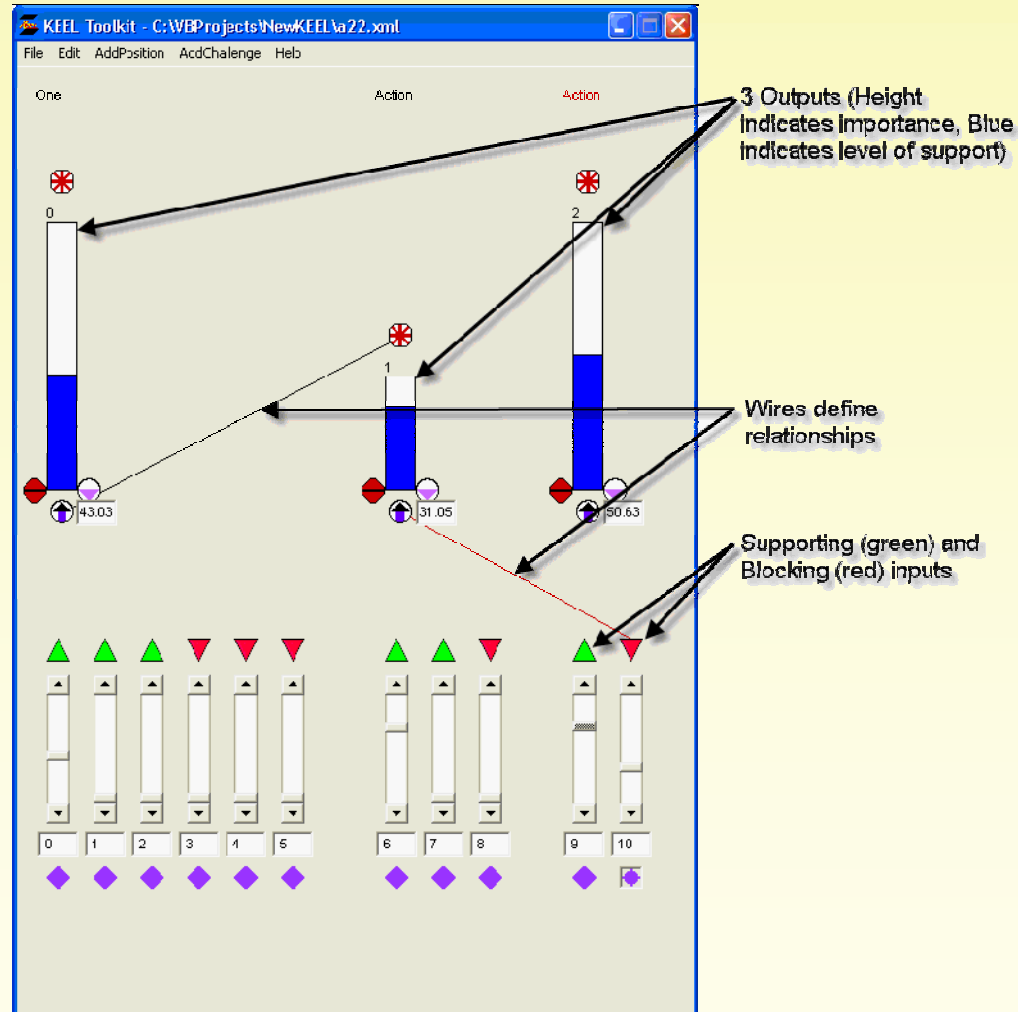
Knowledge Enhanced Electronic Logic (KEEL[®])

- KEEL is an umbrella term that encompasses:
 1. a mechanism for describing judgmental policies that can be explicitly explained and audited,
 2. a web (vs tree) model for fusing multiple information sources,
 3. an architecture for implementing human-like reasoning in devices and software applications,
 4. a programming paradigm for rapid development and test of human-like reasoning.

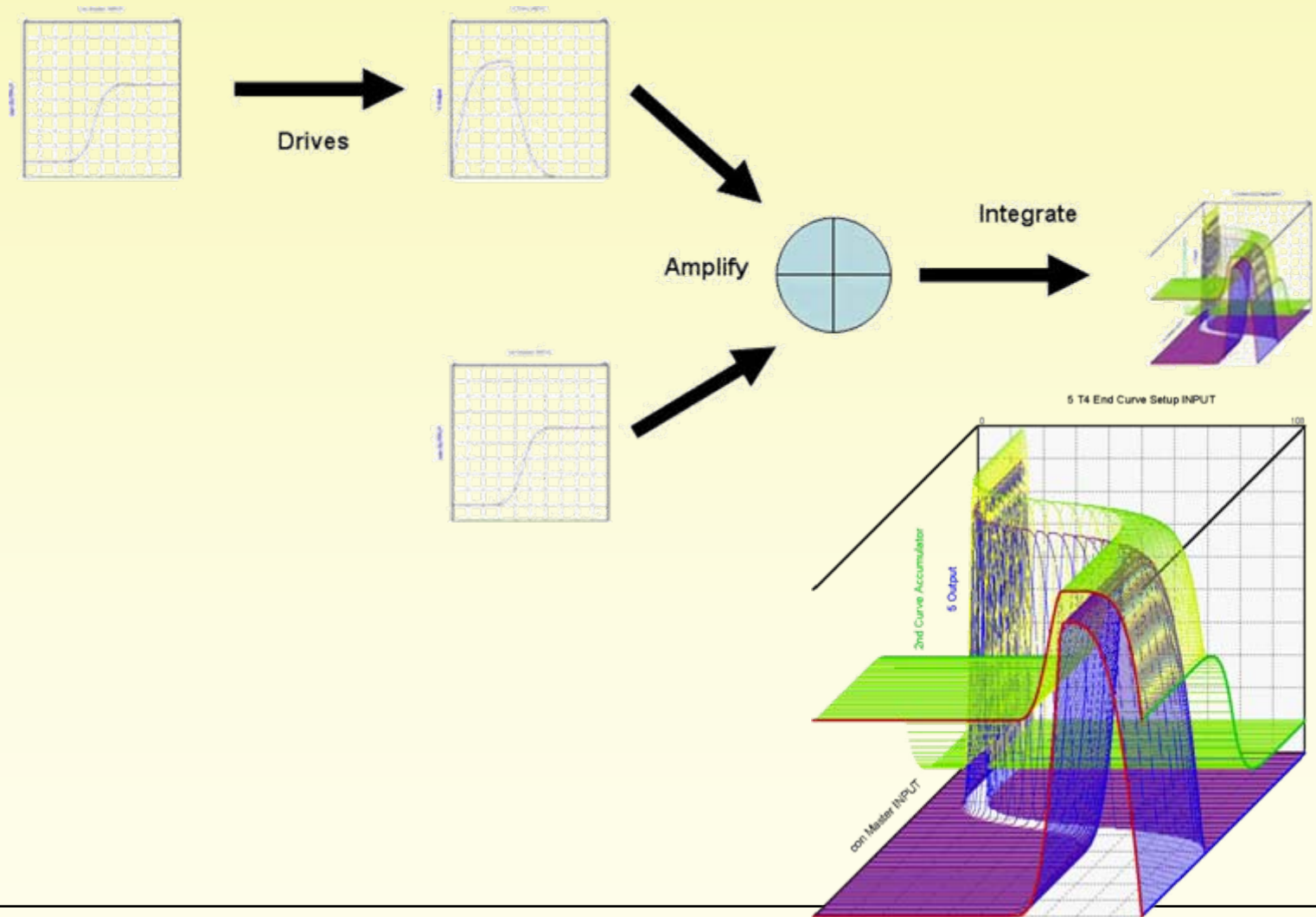
KEEL Development Paradigm

- Includes the KEEL Dynamic Graphical Language
 - Judgment is an “image processing” function, so a language made up of graphical objects is appropriate.
 - The “dynamic” state of the language satisfies the need to get immediate feedback on the performance of the cognitive model

A Dynamic Graphical Language



Process (Thinking in Curves)



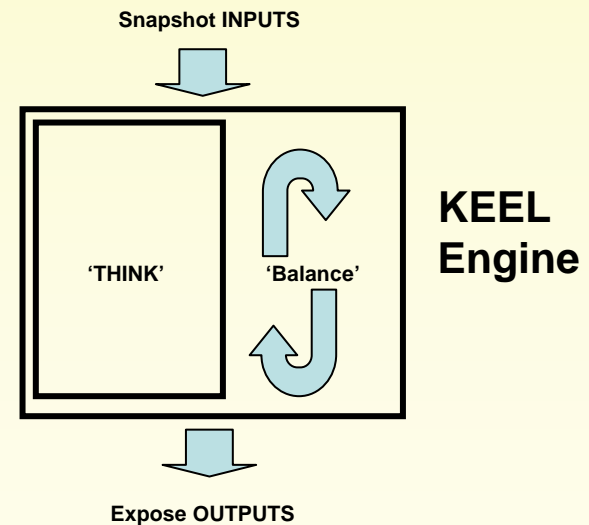
Sequential Logic vs Reasoning

- Sequential Logic

- IF THEN ELSE
- WHILE DO

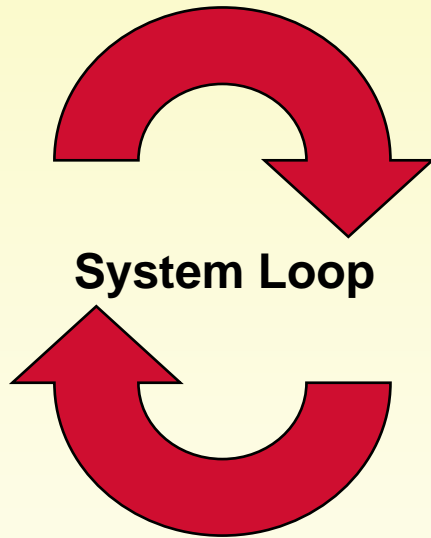
- Judgmental Reasoning

- Identifying how data items change in importance (curves)
- Identifying how information items impact other data items (curves)



A Complete System has Both

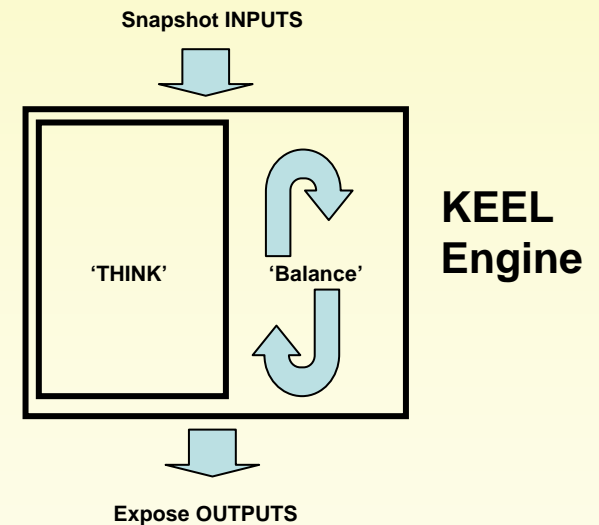
- Sequential Logic



- Polled
- Change of State
- Event Driven
- Scanned



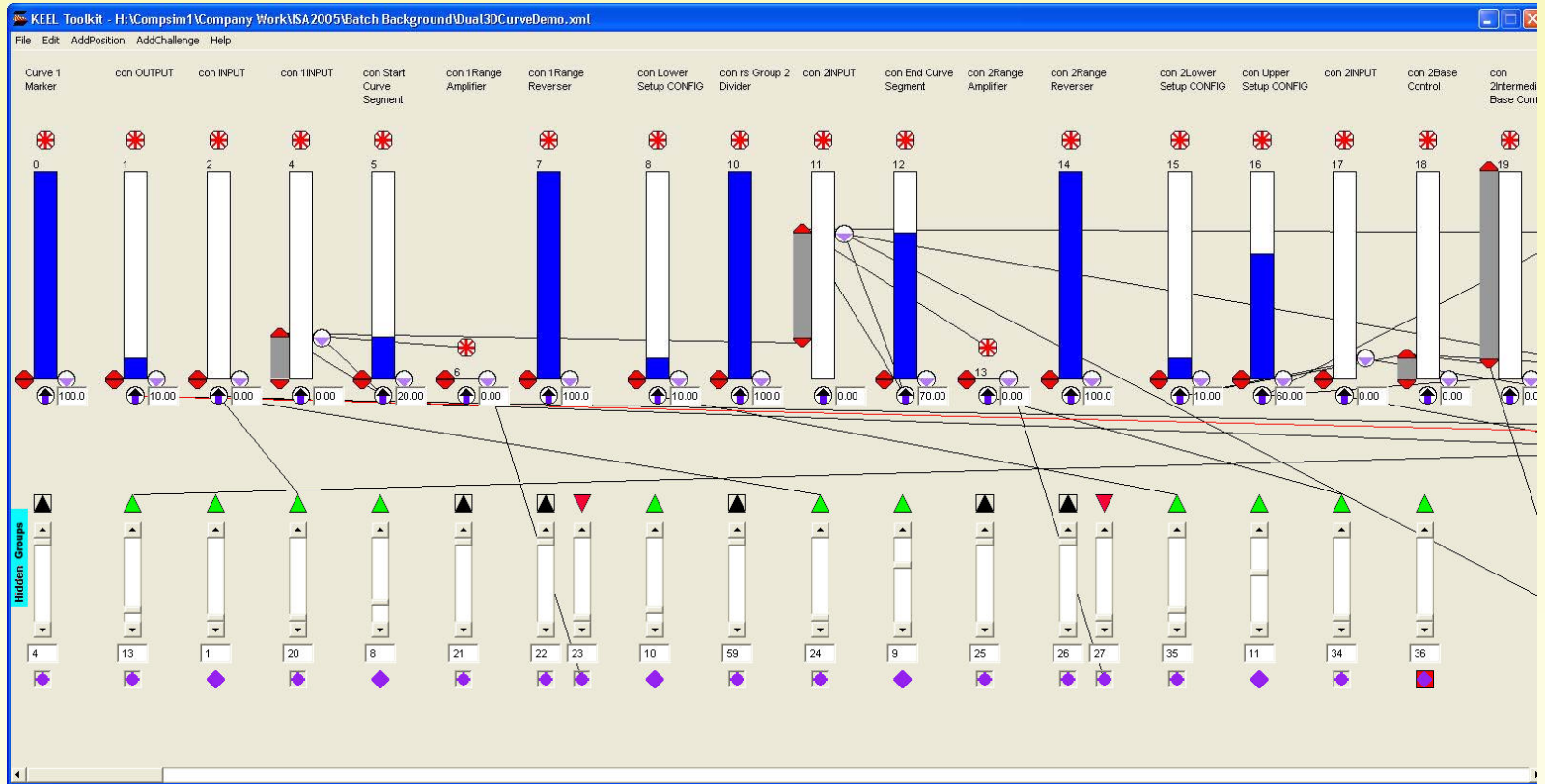
- Judgmental Logic



Policy Definition

- Humans are “trained” how they “should” operate equipment and how they “should” react to system and environmental changes.
- This is commonly handled by class room training and by written procedures.
- We would suggest that the human written and verbal language is too granular to accurately describe “exactly” what to do and when to do it. Because humans are “human” we have given them some latitude for failure.

Policy Definition



You can test drive the “dynamic graphical language” at:

<http://www.compsim.com/demos/d25/batchdemo.htm#batchprocessing>

Summary

- It is wrong to assume that human failure is accepted as inevitable in complex batch processing systems, and that it is just a management problem.
- It is now possible to “automate” judgmental decisions and reduce errors; human related errors that have previously been considered beyond the capabilities of automation.
- Only a dynamic graphical language can effectively describe judgmental reasoning in a manner that is completely explainable and auditable.
- Complete systems that address human error will include both sequential logic AND judgmental logic (Left brain AND Right brain).