Cognitive Modeling For Real Time Operational Decision Support Systems

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Outline

1. Introduction
2. Cognitive Modeling
3. Case Study: Rolling Stock Fleet Management in Brazil
4. Conclusions and Future Work
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More failures

- When applied to real time operational processes
- “the perfection sought by car scheduling systems is simply unachievable. So, we think railroads should stop trying to make real-time car scheduling systems work and should direct their attention instead to continuous improvement in shipment cycle times.” (Lang et al. (2000))
Without DSS

Solving problems

- Negotiating based on insights
- Own mental models
- As complexity increases, no longer capable in the time available
Solving problems

Failures are caused by conceptual misfits (Blandford et al., 2007)
DSS as IAS

Solving problems

- Cognitive distributed system (Giere and Moffatt, 2003)
- Intelligence Augmentation System (IAS) (Fischer, 2006)
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Andre, Ricardo and Rodrigo
Cognitive Modeling For RTODSS
Cognitive Modeling

5W1H

1. What? Methodology to design RTODSS
2. Who? Software engineers
3. When? In the inception phase of the system
4. Why? To better understand and reengineer the cognitive flows, considering the DSS inserted in the process and to guarantee that all concepts manipulated by the human agents are identified to be present in the system and its interface.
5. Where? Ethnographical activity
6. How? The cognitive flow of the human agents which solve the real time operational problem without the aid of DSS are modeled in terms of cognitive activities (decisions) and concepts manipulated, grounded on C.S. Peirce semiotic theory
Cognitive Flow Diagram

- Model the correct sequence of activities and concepts
- Classify and reengineer the sequence
- Activity diagram with stereotypes
After modeling the cognitive flow

- Activities are classified and redistributed among the agents
- Concepts from the Peircean semiotic theory are borrowed and reinterpreted mathematically (Gudwin and Queiroz, 2007)
  - Random tasks (firstness)
  - Mechanical tasks (secondness)
  - Intelligent tasks (thirdness)
Mathematical semiosis (Gudwin and Queiroz, 2007)

- **Random tasks (firstness)**
  - $S(t+1) = \text{Random()}$
  - left to computer agents

- **Mechanical tasks (secondness)**
  - $S(t+1) = f(S(t))$
  - $S(t+1) = f(S(t)) + \text{Random()}$
  - left to computer agents

- **Intelligent tasks (thirdness)**
  - $S(t+1) = f(S(t+T))$
  - $S(t+1) = f(E(S(t+T))(t))$
  - $E(.)$ is an estimation of the future state of $S(t+T)$
  - team of computer agents and human agents
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Rolling Stock Fleet Management in Brazil

Problem

- Provide cars and locomotives, in real time operation to form the trains

Objectives

- Maximize the attendance of the transportation demand;
- Minimize cars movements;
- Minimize delay in the trains births and departures;
- Adherence to the timetable;
- Minimize the number of locomotives used and their movements;
- Adherence to the locomotive maintenance plan.
Rolling Stock Fleet Management in Brazil

After Cognitive Modeling

- System under construction
- Inception phase - premisses as user requirements of the system
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Conclusions and Future Work

Conclusions

- The use of Pierce’s work seems to be innovative and useful

Future Work

- There needs to be more evidence of the usefulness of the approach
- Measure empirical indicators
  - Uninterrupted real time operation
  - Operational gains for the railroad company
  - Ratio of interactions between human and computer decision agents that led to official plans that were successfully executed, over time.
Bibliography

Bibliography

Decision Support Systems

DSS

- Computational systems which help users to make better decisions
Introduction

RTODSS project failures

- Success depends on how well they interact
- Agents must share the same ontology
- System works, but the project fails - not used in practice
- Failures are caused by conceptual misfits (Blandford et al., 2007)

Conceptual misfit - text messages for groups of people
Cognitive Flow Diagram

Why activity diagrams?

- Conditional and parallel behavior
- Widely adopted by development teams to think and communicate
- Focus in how concepts are manipulated in many threads
Focus on Car Distribution

- Input: transportation demands (100 tons of soya)
- Output: car movement requests
- Rules
  - Create the minimum car movement requests;
  - Answers the requests by due date order;
  - Prioritize the most important client requests;
  - Consider the routine of the yards, like human habits and hours to load and unload cars;
  - Answer as many client requests as possible in the same train.
Iron Ore Pellet Stock Yard Management

- Problem: the stack piled for a specific client does not have the appropriate quality
- Solution: reclaiming plan - Blend with other piles
- Which ones should be blended and reclaimed?
Iron Ore Pellet Stock Yard Management

- **Problem**: the stack piled for a specific client does not have the appropriate quality
- **Solution**: reclaiming plan - Blend with other piles
- **Which ones should be blended and reclaimed?**

![Diagram showing the stock yard management problem and solution](image)
Iron Ore Pellet Stock Yard Management

- Problem: the stack piled for a specific client does not have the appropriate quality
- Solution: reclaiming plan - Blend with other piles
- Which ones should be blended and reclaimed?
Applying Cognitive Modeling - 4 attributes considered
Applying Methodology - 4 attributes considered
System avoiding Conceptual Misfits