Human Behavior And Social Network Simulation: Fuzzy Sets/Logic And Agents-Based Approach

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Plan

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- Human behavior
- Social network analysis
- Different approaches used in social simulation
- Our approach: The fuzzy simulation
  - Human behavior representation
  - Group behavior
- Conclusion
Introduction

- Human behavior models seek to reproduce the human behavior associated to several domain.

- Some models focus only on one or two human aspects.
  - Neglecting some psychological aspects;

  Importance of connecting a human behavior model to a social one.

- The aim of the research is to provide a theoretical and a methodological framework to:
  - Represent human behavior.
  - Analyze the social network.
Human behavior

Psychological aspects:
- Motivation
- Stress

Sociological aspects:
- Inter-operators relation
- Conflict

Flow diagram:
- Competences
- Knowledge
- Initial state
- Human behavior
- Final state
- Failure rate
- Repair time
The problem

Individuals “are treated as a pseudo-technological element and expected to behave in much the same fashion as an item of equipment.” (Baines et al. 2004)

The human behavior is more complex and this can justify the error margin between the simulation results and the reality.

Why?

• Understand and test the mechanisms of several psychological aspects.
Social network analysis

Why?

• Detect and evaluate relationships between individuals that may be part of a same network (group).

  Used in education, military domain, political science, ecology, social psychology, manufacturing systems, etc.

• Clarifying relationships that can exist among parts and members.

  Several social model are proposed.

  Implementation using computer programs and tools to exploit better their results.
Approaches of modeling

How?

• Some social models were inspired from the physical or biological field.
  – Cellular automata (Bagnoli, 1998): explore the relationship between micro assumptions and macro outcomes in social dynamics.


• Multi-agents systems: increase the realism of existing human behavior model.

• Fuzzy logic/sets: Integrate imprecise concepts in HBM.
Our approach

• Better representation of psychological aspects of human behavior:
  – Description with an oriented graph;
  – Facilitate the comprehension and the study of the behavior;
  – Useful information for managers;

• In manufacturing system context:

  Installation of appropriate actions to improve operators’ efficiency and productivity;

  Study the impact of such actions on operators’ behavior;
Our approach: The context

Group of workers

Manual task

Worker 2

Worker 1

Control

Technical aspects

Psychological aspects

Sociological aspects

Task 1 → Task 2 → ... → Task n-1 → Task n

Production process
Graphical representation

Description

\( E_1 \): Work conditions
\( E_i \): Precision at work

\( d_i(t) \) the evolution of the element’s degree \( E_i \)

The set of the linguistic values of \( d_i \):

\[ 1 \] Very weak
\[ 2 \] Weak
\[ 3 \] Moderate
\[ 4 \] Strong
\[ 5 \] Very strong

\( r_{li} \): Relation’s degree

\( i^{th} \) elements of a operators behavior.
Graphical representation

Human behavior model

External world

1-Capacity ;
2-Effort ;
3- Fatigue ;
4-Satisfaction ;
5- Work’s conditions ;
6-Motivation ;
7-Stress ;
8- Security sentiment;
9- Absenteeism;
10-Stability ;
11- Inaccuracy;

6 : Motivation
7 : Stress

r_{76}
The evolution of each element is calculated by:

\[ \frac{d}{dt} d_i(t) = r_{ii} d_i(t) + \sum_{l=1}^{n} r_{rl} d_l(t) \]

Where:
- \( d_i(t) \) is the degree of \( i^{th} \) behavioral element.
- \( r_{il} \) represent the degree of the relation connecting the elements \( E_i \) to \( E_l \).
- \( n \) is the number behavioral elements that compose the graph.
• In previous work (Elkosantini and Gien, 2006), the quantification of human behavioral aspects were considered as numerical numbers.

  The traditional approach does not express the real imperfection and vagueness of such variable.

  Use fuzzy sets / logics: More adapted formalism to integrate the imperfection aspects to such variables.

**Fuzzy or Qualitative Simulation**
Fuzzy simulation

• Linguistic variables of the model $d_i(t)$ will be defined as triangular fuzzy numbers.

• The previous differential equation is now a fuzzy differential equation.
Fuzzy differential equation and qualitative simulation

• Several studies decompose fuzzy computation and differential into the repetition of many intervals ($\alpha$-cut) computation.
Fuzzy differential equation and qualitative simulation

- The region of uncertainty of a system with \( n \) variables form an \( n \)-cube.
  - The region of uncertainty of a behavior model with 2 elements (\( n = 2 \)) is a square or rectangle.

Region of uncertainty at \( \alpha \)-cut: 3-cube
Fuzzy differential equation and qualitative simulation

- The simulation procedure: variation of the n-cube over the time
  - Sampling the external surface.
  - Numerical simulation of each point.

The problem became a repetition of a ordinary differential equation.
The results

- Solid lines correspond to the 4 vortex of the region of uncertainty dashed by the variables d1 and d2 points.

(Elkosantini and Gien, 2007)
Group behavior

- Study the social networks in the company;

- Complete the first analyze by studying the behavior of the group;

Integration of sociological aspect to the model: Conflict, communication, etc.
Group behavior

\[
\frac{d}{dt} Dg_k(t) = \sum_{i=1}^{n} \sum_{j=1}^{m} re_{i,k} d_{ij}(t) + re_{k,k} Dg_k(t)
\]

Fuzzy inference system

**R1:** IF Degree (Stress of Agent 1) is *Very low* AND Degree (Stress of Agent 2) is *Very low*
AND Degree (Fatigue of Agent 1) is *Very Low* AND Degree (Conflict) is *Low*
THEN Variation (conflict) is *Medium*

**R2:** IF Degree (Stress of Agent 1) is *Medium* AND Degree (Stress of Agent 2) is *Medium*
AND Degree (Fatigue of Agent 1) is *Low*
AND Degree (Conflict) is *Medium*
THEN Variation (conflict) is *High*

R3:…
Reasoning approaches:

- Different methods of reasoning under different fuzzy implication concepts exist:
  - Mamdani approach (also known as Max-Min method);
  - Larsen’s method;
  - Takagi-Sugeno model;
  - Kosko’s Standard Additive Model;

- *The Mamdani inference method, employing the max-min product composition to operate fuzzy if-then rules, is adopted.*
Reasoning approaches: Mamdani method
Conclusion

• The aim of the research is to provide a theoretical and a methodological framework:
  – Enable human behavior representation and simulation.
  – Study and analyze the psychological and sociological aspects of human behavior;

• Integrate the model in a MAS:
  – Simulate the behavior of a human and a group of individual.
  – Fuzzy logic/sets is used to describe the inter-agent relationships.

• Example: Simulate the behavior of a human worker in manufacturing system.