Towards Fuzzy Agents with Dynamic Personality for Human Behavior Simulation

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This work is based on the personality knowledge as distilled from psychology.

(Ören and Ghasem-Aghaee, 2003a)
1. Fuzzy logic and fuzzy sets
2. Fuzzy personality knowledge
3. Definitions: Agents
4. Fuzzy agents with dynamic personality
5. Conclusions and ongoing work
1. Fuzzy Logic and Fuzzy sets

- Fuzzy logic developed by Lotfi Zadeh (1965).
- Zadeh suggests that it is possible to understand a statement as being 0.75 true or 0.5 true.
- He modified conventional set theory in which an individual could have a degree of membership which ranged over a continuum of values, rather than being either 0 or 1.
Fuzzy logic:

• Effective techniques for handling fuzzy uncertainties with well-developed mathematical properties.

• Provides an excellent way to represent and process linguistic variables.

  • Their use considerably improves the bridge between mathematical models and the associate physical reality (Klir and Yuan 1998).
Linguistic variables:

- It describes some concepts, that usually have vague or fuzzy values.
- We are not restricted to just absolute quantifier that represents a crisp value like one or two, but we are also concerned with relative quantifier that represents a fuzzy value, such as low, medium, high, most, or some.
### Linguistic variables with typical values

<table>
<thead>
<tr>
<th>Linguistic variables</th>
<th>Typical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative Emotionality</td>
<td>low, medium, high</td>
</tr>
<tr>
<td>Worry</td>
<td>low, medium, high</td>
</tr>
<tr>
<td>Anger</td>
<td>low, medium, high</td>
</tr>
<tr>
<td>Discouragement</td>
<td>low, medium, high</td>
</tr>
<tr>
<td>Self-consciousness</td>
<td>low, medium, high</td>
</tr>
<tr>
<td>Impulsiveness</td>
<td>low, medium, high</td>
</tr>
<tr>
<td>Vulnerability</td>
<td>low, medium, high</td>
</tr>
</tbody>
</table>
Fuzzy sets on worry
(each point in fuzzy set = membership value / degree of worry)

Low worry = (1.0/10, 1.0/20, 0.5/30, 0.0/40, 0.0/50, 0.0/60, 0.0/70, 0.0/80, 0.0/90, 0.0/100)

Medium worry = (0.0/10, 0.0/20, 0.0/30, 0.2/40, 1.0/50, 0.2/60, 0.0/70, 0.0/80, 0.0/90, 0.0/100)

High worry = (0.0/10, 0.0/20, 0.0/30, 0.0/40, 0.0/50, 0.0/60, 0.5/70, 1.0/80, 1.0/90, 1.0/100)
Fuzzy sets on worry
# Hedges in fuzzy logic

<table>
<thead>
<tr>
<th>Hedges</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>very</strong></td>
<td>( \mu_A(x)^2 )</td>
</tr>
<tr>
<td><strong>power (very very)</strong></td>
<td>( \mu_A(x)^n ) where ( n=3 )</td>
</tr>
<tr>
<td><strong>somewhat</strong></td>
<td>( \mu_A(x)^{0.5} )</td>
</tr>
<tr>
<td><strong>indeed</strong></td>
<td>( 2 \times \mu_A(x)^2 ) for ( 0 \leq \mu_A(x) \leq 0.5 )  ( 1-2(1-\mu_A(x))^2 ) for ( 0.5 &lt; \mu_A(x) \leq 1 )</td>
</tr>
</tbody>
</table>
Plan

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The knowledge in Tables 1-5 of Ören and Ghasem-Aghaee (2003a) is used to generate the fuzzy knowledge-base.

As an example, we represent the knowledge associated with the fantasy and feelings facets of Openness in the following table:
2. Fuzzy personality knowledge and personality descriptor

<table>
<thead>
<tr>
<th>facets</th>
<th>value</th>
<th>Personality descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fantasy</td>
<td>Low</td>
<td>focuses on here and now</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>occasionally imaginative</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>imaginative daydreams</td>
</tr>
<tr>
<td>Feelings</td>
<td>Low</td>
<td>ignores and discounts feelings</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>accepts feelings</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>values all emotions</td>
</tr>
</tbody>
</table>

(Howard & Howard, 2001a)
2. Fuzzy personality knowledge: Examples

- Group 1. Rules to represent *personality descriptors*
- Group 2. Rules to represent the value of the *personality factors*
- Group 3. Rules about the representation of *compound personality characteristics*
- Group 4:
  - Rules about the *behavioral approach to emotions*
  - Emotional rules about the *personality modifications*
- Group 5. Rules about the *Personality changes over time*
2.1 Fuzzy Personality Knowledge: Group 1

Rules to represent *personality descriptors* based on the values of the facets of each personality factor.

**Openness:**

IF fantasy is low
THEN dO_fantasy is *focuses_on_here_and_now*.

IF fantasy is medium
THEN dO_fantasy is *occasionally_imaginative*.

IF fantasy is high
THEN dO_fantasy is *imaginative*. 
2.2 Fuzzy Personality Knowledge: Group 2

Rules to represent the value of the *personality factors* based on the values of its facets.

IF fantasy is low
AND aesthetics is low
AND feeling is low
AND actions is low
AND ideas is low
AND values is low
THEN openness is *preserver*.
A more general way to determine the value of a trait:

degree of a facet = measured value * weight factor

degree(value) of a trait = degree(value) of the current dominant facet

<table>
<thead>
<tr>
<th>Condition</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>fantasy is low</td>
<td>20</td>
</tr>
<tr>
<td>aesthetics is medium</td>
<td>50</td>
</tr>
<tr>
<td>feeling is high</td>
<td>80</td>
</tr>
<tr>
<td>actions is low</td>
<td>20</td>
</tr>
<tr>
<td>idea is high</td>
<td>90</td>
</tr>
<tr>
<td>values is high</td>
<td>85</td>
</tr>
<tr>
<td>THEN openness is high</td>
<td>90</td>
</tr>
</tbody>
</table>

THEN openness is high 90
2.3 Fuzzy Personality Knowledge: Group 3

Representation of *compound personality characteristics*; some examples follows (l_style, d_style: abbreviations for learning style and decision style):

IF extraversion is high
AND negative emotion is low
THEN l_style is *independent*.

IF conscientiousness is low
AND agreeableness is medium
AND negative emotion is low
THEN d_style is *diplomat*. 
2.4 Fuzzy Personality Knowledge: Group 4

Types of expression:

2.4.1 Behavioral expression (short-term)

2.4.2 Personality expression (long-term)
2.4.1 Fuzzy Personality Knowledge: Group 4

Rules about the behavioral approach to emotions:

IF emotional_state is fear
THEN behavioral_expression is withdraw.

IF emotional_state is anger
THEN behavioral_expression is attack.

IF emotional_state is joy
THEN behavioral_expression is mate.
2.4.2 Fuzzy Personality Knowledge: Group 4

Emotional rules about the **personality modifications** (PT: abbreviation for personality trait):

IF emotional_state is fear
THEN PT_expression is **timid**.

IF emotional_state is anger
THEN PT_expression is **quarrelsome**.

IF emotional_state is sadness
THEN PT_expression is **gloomy**.

IF emotional_state is acceptance
THEN PT_expression is **trusting**.
2.5 Fuzzy Personality Knowledge: Group 5

**Personality changes over time** - From age 20 to age 30, openness, extraversion, and negative emotionality tend to decrease, while conscientiousness, and agreeableness tend to increase (Howard & Howard 2001a):

- IF PT_agreeableness is low
  THEN behavioral_expression is **challenger**.

- IF PT_conscientiousness is low
  THEN behavioral_expression is **flexible**.
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3. Definitions: Agents

3.1 Agents
3.2 Fuzzy agents
3.3 Agents with personality
3.4 Agents with dynamic personality
3.1 Definitions: Agents

- **Agents**: Agents are autonomous software modules with perception and social ability to perform goal-directed knowledge processing, over time, on behalf of humans or other agents in software and physical environments.

- The *core* knowledge processing abilities of agents include: reasoning, motivation, planning, and decision making.
Agent definition references:

• Wooldridge and Jennings (1995)
• Maes (1995)
• Franklin and Graesser (1996)
• Jennings and Wooldridge (1998)
• Ören (2001)
• AgentLink (2002)
• Ören and Ghasem-Aghaee (2003)
• …
Additional abilities of agents are needed to make them more intelligent and more trustworthy.

Abilities to make agents *more intelligent* include anticipation, understanding, learning, and communication in natural language.

Abilities to make agents *more trustworthy* as well as assuring the sustainability of agent societies include being rational, responsible, and accountable. These lead to rationality, skillfulness and morality (e.g., ethical agent, moral agent).
3.2 Definitions: Agents

**Fuzzy agents** are agents that can perform qualitative uncertainty reasoning with *incomplete and fuzzy knowledge* in some environment that contains linguistic variables.
3.3 Definitions: Agents

**Agents with personality** are *fuzzy agents* with characteristics such as openness, conscientiousness, extraversion, agreeableness, and negative emotions in line with the five-factor personality theories to model human behavior.
3.4 Definitions: Agents

Agents with dynamic personality are fuzzy agents with personality where personality knowledge is updateable.
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4. Fuzzy agents with dynamic personality

When at least **any one of the 30 facets** changes its value, the personality may be affected and the model may be updated.
Components of agent with personality

perception

- Reasoning (including fuzzy reasoning)
  - Inference engine
  - Fuzzy inference engine

Goal and goal processing components

Social ability
(communication with user, other agents)

Goal-directed knowledge processing components

Personality knowledge
Five Factor Model
(personality traits & facets)

Internal knowledge base for cognitive knowledge processing

External knowledge base

action
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5.1 Conclusions

- The personality knowledge as specified by thirty facets clustered in five traits of the current personality theory is used as a basis to represent the behavior of fuzzy agents. (Costa and McCrae 1992, Acton 2001, Howard and Howard 2001a, b)

- The modifications of the values of personality facets can be used to re-evaluate the personality knowledge of an agent to allow personality updates and hence representation of dynamic personality.
5.2 On-going Work

Ghasem-Aghaee & Ören:
- Simulation and Agents: Exploring the Synergy  (based over 250 refs)
- Functional Decomposition of Intelligent Agents with Personality  
  (with a taxonomy of 20 types of intelligence)

Ören & Ghasem-Aghaee:
- Agent Definitions and Agenthood: A Systematic Review, A Cluster Analysis, and A Proposal  
  (based on 32 definitions)
- Intelligent Agents, Simulation, and Human Behavior  
  (a book)
We have seen

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- Conclusions and on-going work