Building an Autopoietic Knowledge Structure for Natural Language Conversational Agents

Yahoo! JAPAN Research
Kiyoshi Nitta
knitta@yahoo-corp.jp
(2008.10.28d)
Autopoietic Systems

- system S
- self-reproducing processes
- interactions

Environment

- system S'
- interactions
1st Step to be an Autopoietic System

1. Divide the interpreter module into a matching engine and executing functions.
2. Let these executing functions to have the ability to operate on rules.
Our Rule-Based Conversational Agent

Conversational Agent System

- Dialogue Script Tracer (DST)
- Communication Interface
- Mapped Functions
- Augmented Semantic Network KS

User

Communication Network

match
trigger
execute
reply
operate

Copyright (C) 2008 Yahoo Japan Corporation. All Rights Reserved.
Augmented Semantic Network
## Data Structure and Semantics

<table>
<thead>
<tr>
<th></th>
<th>Semantic Network (SN)</th>
<th>Augmented Semantic Network (ASN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Structure</strong></td>
<td>Directed Graph DG=(V, E)</td>
<td>Augmented Directed Graph ADG=(E)</td>
</tr>
<tr>
<td></td>
<td>V={v₁, v₂, …}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E={e₁(vᵢ, vⱼ), e₂(vₖ, vᵢ), …}</td>
<td>E={e₁(eᵢ, eⱼ), e₂(eₖ, eᵢ), …}</td>
</tr>
<tr>
<td><strong>Semantics</strong></td>
<td>Each semantic definition of V and E elements is defined independently.</td>
<td>Semantic definitions are aggregated to classes. (described below)</td>
</tr>
</tbody>
</table>
ASN Semantics

I. edge semantics
II. a priori classes
III. custom classes
IV. data
I. Edge Semantics

Edge $e_e$ expresses the relationship from $e_s$ to $e_d$. 
II. A priori Classes

Vertex $v_{\text{class}}$ means that its instance vertices are classes, and vertex $v_{\text{ins}}$ means that its instance edges are instance relations.
III. Custom Classes

Vertices $v_{kw}$, $v_{msg}$, and $v_{sel}$ mean trigger keyword, reply message, and selection branch classes, respectively.

Vertex $v_{rel}$ means possible script direction class, and vertex $v_{sm}$ means reply message class for selection branches.
IV. Data

Every data element has at least one edge that connects from a semantically defined class vertex to the element.
Difference between SN and ASN

**ASN**

\[V_{kw} \rightarrow kw_1 \rightarrow rel_1 \rightarrow msg_1 \rightarrow V_{msg}\]

**SN**

\[kw_1 \rightarrow rel_1 \rightarrow msg_1\]
Autopoietic Behavior
Self-reproducing processes of autopoietic systems require ontology modifications.

The ontology is fixed. The ontology can be modified.
Achievement and Future Tasks

• current progress:
  – Implemented base classes for dialogue scripts that modify the data. (programming language reflection)
  – Trying to build enhanced classes for dialogue scripts that also modify the custom classes.

• open questions:
  – Can the class set finite?
  – Even if it is finite, how should we evaluate whether the system is autopoietic or not?
Thank you!