ATNoSFERES revisited

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from ATNoSFERES...

- Evolving finite automata
- Use of an automaton for control
- Equivalence between an ATN and a rule-based LCS
- Application in partially observable environments (POMDP)

... to ATNoSFERES-II

- Modifications
- Results
- Analysis

Conclusion
Augmented Transition Network

- labelled graphs
- grammars, in natural language processing [Woods, 1970]
- then, descriptions of interactions and behavior in multi-agent systems
Stack-Based Gene Expression [Landau and Picault]

- genotype: bit-string
- structure built according to a context-sensitive grammar (stack language)
  - locality
  - quasi-continuity
Building an ATN

connect node connect cond act dupNode node

interpreter

ATN

<empty>
Building an ATN

**connect**  **node**  **connect**  **cond**  **act**  **dupNode**

**interpreter**

**ATN**

0
Building an ATN
Building an ATN

ATN

connect node connect

interpreter

Landau, Sigaud, Schoenauer

ATNoSFERES revisited
Building an ATN

ATN

\[ \text{c} \]

\[ \text{a} \]

\[ \text{0} \]

\[ \text{connect} \]

\[ \text{node} \]

\[ \text{0} \]

\[ \text{0} \]
Building an ATN

**ATN**

- **0**
- **c**
- **1**
- **a**

**Evolving finite automata**
Use of an automaton for control
Equivalence between an ATN and a rule-based LCS
Application in partially observable environments (POMDP)

**Introduction**
from ATNoSFERES...
...to ATNoSFERES-II

**Conclusion**

Landau, Sigaud, Schoenauer
“Maze” environment

- goal: reach $F$ from any start cell
- local perception only
ATNoSFERES in use

Local perception

Current situation

Matching

Selected action

Selected action

Landau, Sigaud, Schoenauer

ATNoSFERES revisited
Learning Classifier System [Holland]

<table>
<thead>
<tr>
<th>Classifiers list</th>
<th>Condition</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[#00#0#1#]</td>
<td>[N]</td>
</tr>
<tr>
<td>[#1010##1]</td>
<td>[S]</td>
<td></td>
</tr>
<tr>
<td>[#10##1#1]</td>
<td>[E]</td>
<td></td>
</tr>
<tr>
<td>[10###101]</td>
<td>[NE]</td>
<td></td>
</tr>
<tr>
<td>[0#10#0#0]</td>
<td>[W]</td>
<td></td>
</tr>
</tbody>
</table>

Local perception:

```
1 0 1
1 0 1
1 0 1
```

Current situation:

```
[01010111]
```

Matching:

```
Condition: [#00#0#1#] | Action: [N]
Condition: [#1010##1] | Action: [S]
Condition: [#10##1#1] | Action: [E]
Condition: [10###101] | Action: [NE]
Condition: [0#10#0#0] | Action: [W]
```

Selection:

```
[#10##1#1]
```

Selected action:

```
[E]: move toward East
```

Landau, Sigaud, Schoenauer
LCS with memory

- Local perception
- Internal state
- Current situation
- Matching
- Condition
- Action
- Selection
- Action sélectionnée
  - [E]: move toward East
  - [#0]: zero 2nd bit of internal state

- Classifiers list:
  - [#00#0#1#][1#] [N][##]
  - [#1010##1][0#] [S][#1]
  - [#10##1#1][01] [E][#0]
  - [10##101][00] [NE][10]
  - [0#10#0#0][##] [W][1#]
  - ...
Formal equivalence between an ATN and a LCS with memory

- by restricting to one action per edge
- Pittsburgh-style LCS, with internal states
Formal equivalence between an ATN and a LCS with memory

- by restricting to one action per edge
- *Pittsburgh*-style LCS, with internal states
Behavioral sequences

- chain of actions, similar to ACS [Stolzmann]
- equivalent to *not* restricting to one action per edge
- performs poorly in some kinds of POMDP [Landau and Sigaud, to appear]

- ...extension not considered
Behavioral sequences

[1#0][101][001] ...

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Example of partially observable environment

- ideal policy (unreachable)
- colored arrows = perceptual aliasing
Comparisons with some LCSs

- with XCSM and XCSMH:
- with ACS:
Genotype representation

- **bit-string → integer string**
  - number of token no longer constrained to $2^N$
  - bit-flip mutation → uniform mutation
Genotype representation

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Language

- stack operators: all → node or labels
  - operators concerned: Swap, Roll, Unroll, Del, Dup
  - more flexibility
- conditions: possibly contradictory → non-contradictory
  - no longer syntactically unmatchable edges
  - like classical rule-based LCSs
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Default node action

- goes random $\rightarrow$ finishes trial
  - action raised when no edge is matched
  - default edge action seems to have less impact
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Experiments for Maze10

**ATNoSFERES vs ATNoSFERES II on Maze10**

- **AoS AoS2**
  - fitness (mean steps to food)
  - XCSM
  - XCSMH
  - optimal

Experiments for Maze10
Experiments for E1

- ACS (BSmax=1)
- ACS (BSmax=2)
- optimal

Fitness (mean steps to food)
ATNoSFERES vs ATNoSFERES II on E2

Experiments for E2

- ACS
- optimal

Fitness (mean steps to food)
Best ATN for Maze10

- 19 edges (3 nodes) that were never matched (reached) are not represented
Best policies

Error compared to best attainable policies: 1, 2, 3
Genotype representation

- Most significant variable
  - exploration bias with bit-flip mutation and binary string encoding
    - left-most bit was a label indicator
    - 0... : stack manipulation and structure building tokens
    - 1... : label tokens
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Size of automata

- genotype length : 300 tokens $\rightarrow$ at most 300 nodes
- but we do not observe bloat in automata
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Conclusions

- ATNoSFERES significantly outperformed
  - number of nodes not fixed in advance
  - parsimony in number of nodes
  - stable policies / no ad hoc exploration/exploitation compromise
  - best to-date policies on some POMDP LCS benchmarks
- ... but needs far more trials than Michigan-style LCSs to do so (1000x)
  - Pittsburgh-style LCS
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Future Works

- make it a Michigan LCS
- investigate the “anti-bloat” observations
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