Motivated Learning as an Extension of Reinforcement Learning

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Motivated Learning (ML)
- ML paradigm uses neural structures that self-organize and form ‘pain centers’ which correspond to internal motivations.
- A ML system uses artificial curiosity to explore, and creation of abstract motivations to learn efficiently and purposefully. It increases the internal complexity of representations and skills.
- At every step, the agent finds an action (actions) that satisfies its abstract pains and this may result in new motivations. Gradually, the agent learns values of various states and actions for various motivations.
- ML effectively implements and manages a hierarchy of goals without explicit reward for different stages of hierarchy.
- Any form of reinforcement learning (e.g., hierarchical reinforcement learning with subgoal discovery) can be used to resolve abstract pains.
- ML enables active learning through interaction with the environment.

Computational Model and Simulation

Motivated Learning vs Reinforcement Learning

Simulation Framework
We have developed a unified framework to conduct computational experiments with both learning systems:
- Motivated learning based on Goal Creation System, and
- Reinforcement learning using RL Q-Learning Algorithm.
Our goal was to compare their performance in terms of learning speed and task completion ability.

Meaningful sensory-motor pairs and their effect on the environment.

<table>
<thead>
<tr>
<th>Id</th>
<th>SENSORY</th>
<th>MOTOR</th>
<th>INCREASES</th>
<th>DECREASES</th>
<th>PAIR ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Food</td>
<td>Eat</td>
<td>Sugar level</td>
<td>Food supplies</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Grocery</td>
<td>Buy</td>
<td>Food supplies</td>
<td>Money at hand</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Bank</td>
<td>Withdraw</td>
<td>Money at hand</td>
<td>Spending limits</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Office</td>
<td>Work</td>
<td>Spending limits</td>
<td>Job opportunities</td>
<td>21</td>
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<tr>
<td>4</td>
<td>School</td>
<td>Study</td>
<td>Job opportunities</td>
<td>Social contacts</td>
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<tr>
<td>5</td>
<td>Party</td>
<td>Play</td>
<td>Social contacts</td>
<td>Social contacts</td>
<td>36</td>
</tr>
</tbody>
</table>

Task Specification
- Complex, dynamically changing environment
In base experiment environment consist of six different categories of resources. Five of them have limited availability. One, the most abstract resource is inexhaustible.

In further experiments there are more kinds of available resources.

- Hostility of environment
Environment is not only complex and dynamic. It is also hostile. It means that amount of available resources is limited. We control environment’s hostility using two different functions:

\[
\begin{align*}
\text{f}_{a}^{d}(k_{a}) &= \frac{1}{1 + e^{-k_{a}}} \\
\text{f}_{a}^{d}(k_{a}) &= s^{0.5}
\end{align*}
\]

where:
- \(c\) – scaling factor - describes a resource declining rate
- \(k_{a}\) – number of times a resource was used

Problem: determine which action should be performed at specific situation and renew this resource which is most needed at this very moment by performing selected action.

Find mappings from sensory inputs to motor output

RL vs ML

Motivated Learning

Simulations

Task completion ability in complex environments

In a complex, dynamically changing environment, the ML works fine, while the reinforcement learning fails to perform and learn these complex relations.

Conclusions and future work

- Future work includes combining motivated learning to set abstract motivations and manage goals with reinforcement learning to learn proper actions.
- Motivated learning will provide a self-organizing system of internal motivations and goal selection.
- Reinforcement learning will be used to train machine in solving specific goals and subgoals.
- This will allow to test motivated learning on typical reinforcement learning benchmarks with large dimensionality of the state/action spaces.
- Any form of reinforcement learning e.g., hierarchical reinforcement learning with subgoal discovery can be used.
- Other forms of learning can be used instead of RL, for instance Pavlovian learning proposed by O’Reilly [3].
- The proposed approach enriches machine learning by providing natural goal oriented motivation, that may lead to increased machine intelligence.

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References