We apply reinforcement learning on the classical game PACMAN; we study and compare Q-learning, Approximate Q-learning and Deep Q-learning based on the total rewards and win-rate. While Q-learning proved to be quite effective on smallGrid, it was too expensive for larger grids. In Approximate Q-learning, we handcraft 'intelligent' features which are fed into the game. To ensure that we don’t miss important features, we implement a Convolutional Neural Network (CNN) that can implicitly ‘extract’ the features.

**Methods**

We can try to minimize the following loss function:

\[
L(s, a) = (r + \gamma \max_{a'} Q(s', a') - Q(s, a))^2
\]

We start by implementing Q-Learning for Pacman based on the Berkeley's Pacman project [1].

**Approximate Q-Learning**

The Q function is approximated by a combination of features \(f_i(s, a)\) extracted from the game states

\[
Q(s, a) = \sum_i w_i f_i(s, a)
\]

where the weights are updated by:

\[
w_i \leftarrow w_i + \alpha \cdot (r + \gamma \max_{a'} Q(s', a') - Q(s, a)) \cdot f_i(s, a)
\]

**Deep Q-Learning**

The Q-values for different state and action pairs are computed with a Convolutional Neural Network (CNN) that can implicitly “extract” the features using the pixel data from a downsampled image of a state \(s\). The neural network architecture comprises three convolutional layers followed by a fully connected hidden layer.

We perform ablative analysis to select the most important features in terms of total reward, win-rate and conclude that the best features are: number of scared, active ghosts one step away, eat food if there are no active ghosts nearby. The number of active ghosts one step away and eat food features are essential for winning a game and hence we do not include them in the analysis.

<table>
<thead>
<tr>
<th>Component</th>
<th>Average Score Win Rate</th>
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<tr>
<td>Overall System</td>
<td>1698</td>
</tr>
<tr>
<td>inv. min. distance active ghost</td>
<td>1583</td>
</tr>
<tr>
<td>min. distance active ghost</td>
<td>1591</td>
</tr>
<tr>
<td>min. distance capsule</td>
<td>1591</td>
</tr>
<tr>
<td>no. scared ghosts 2 steps away</td>
<td>1455</td>
</tr>
<tr>
<td>no. scared ghosts 1 step away</td>
<td>1438</td>
</tr>
<tr>
<td>distance to closest food</td>
<td>1397</td>
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**References**