Atari Breakout with LTL_f / LDL_f Goals

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Introduction

Intro.

Q-Learning

Q-Learning brief description.

$$Q(S_t, A_t) \leftarrow Q(S_t, A_t) + \alpha\Big[R_{t+1} + \gamma \max_a Q(S_{t+1}, a) - Q(S_t, A_t)\Big]$$

SARSA

SARSA brief description.

$$Q(S_t, A_t) \leftarrow Q(S_t, A_t) + \alpha \Big[R_{t+1} + \gamma Q(S_{t+1}, A_{t+1}) - Q(S_t, A_t) \Big]$$

LTL$_f$ /LDL$_f$ non-Markovian rewards + integration in our project.

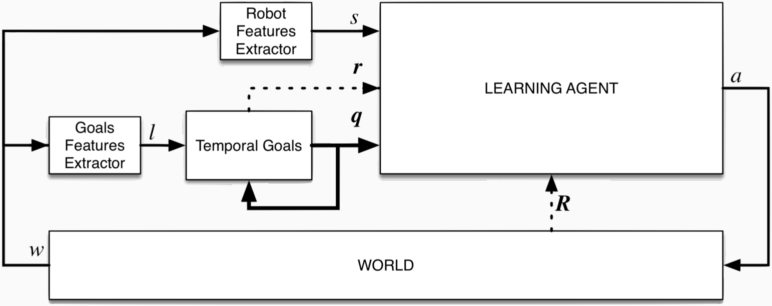


Figure 1: Pipeline describing how the agent is interacting with the world and how the robot features extractor and the goal features extractor are used in order to handle non-Markovian rewards.

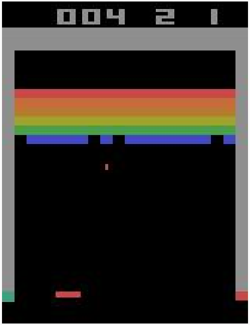
Results of the paper and our starting point.

PyGame Breakout (6×18)

Our results on 6×18 non-Atari Breakout + video.

Atari Breakout

Introduction to Gym + ALE
Differences with non-Atari Breakout (initial hypotheses)



Implementation

Atari Wrappers

Atari wrappers from OpenAI baselines:

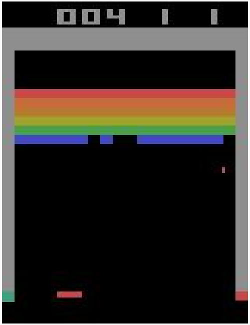
- `EpisodicLifeEnv`: make an "end of life" be the end of the episode resetting the environment only on the true game over, this helps in value estimation
- `FireResetEnv`: use "Fire" as starting action in order to launch the ball
- `MaxAndSkipEnv`: returns only the skip-th frame, this reduces the amount of frame the agent has to deal with (set to 4 in the main experiments)

Robot Features Extraction

- extracting **paddle position**
- extracting **ball position**
- features can be increased with **ball direction**
- **previous positions** could help the training too
- more features increase the state space
- OpenCV

Robot Features Extraction

Extracting **paddle position** from the observation: tensor of dimension $(210, 160, 3)$ where each value represents a color of the pixel.



Robot Features Extraction

Considering only the **lower part** of the observation which contains the paddle.

Robot Features Extraction

Converting the image to **gray-scale** in order to reduce the number of channels.

This makes it easier to apply a threshold function.

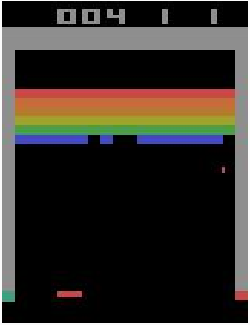
Robot Features Extraction

Determine the position of the paddle:

- apply a **threshold** function to obtain a black and white image
- find **contours**
- extract **centroid** of the paddle
- $\text{paddle}_x = 35$

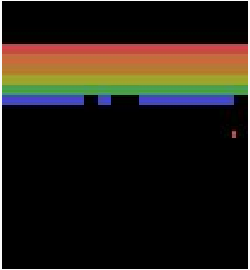
Robot Features Extraction

Similarly, extract **ball position** from initial observation.



Robot Features Extraction

Considering only the **upper part** of the observation which contains the ball.



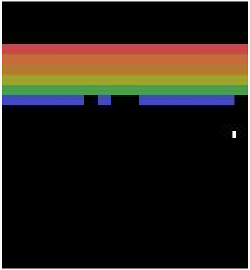
Robot Features Extraction

- `inRange` function to consider only pixels with the same color of the ball, obtain a black and white image
- remove the **remaining bricks** by checking sorrounding pixels, width of the ball is much smaller

Robot Features Extraction

Determine the position of the ball:

- find **contours**
- extract **centroid** of the ball
- $\text{ball}_x = 135, \text{ball}_y = 77$



Robot Features Extraction

Return the difference between the position of the paddle and the ball on the x axis and the position of the ball on the y axis:

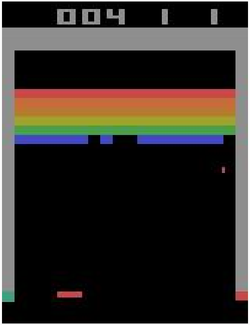
$$(\text{ball}_x - \text{paddle}_x + 143, \text{ball}_y) = (243, 77)$$

Goal Features Extraction

Extract a binary representation of the bricks from the observation:

$$
\begin{matrix}
1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1\\
1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1\\
1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1\\
1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1\\
1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1&1\\
1&1&1&1&1&1&0&1&0&0&1&1&1&1&1&1&1&0
\end{matrix}
$$

It will be used to evaluate fluents in temporal goals.



Temporal Goals

- string formula to break rows from top to bottom:

```
<(!l0 & !l1 & ... & !l5)*;
 ( l0 & !l1 & ... & !l5);
            ...
 ( l0 &  l1 & ... & !l5)*;
 ( l0 &  l1 & ... &  l5)>tt
```

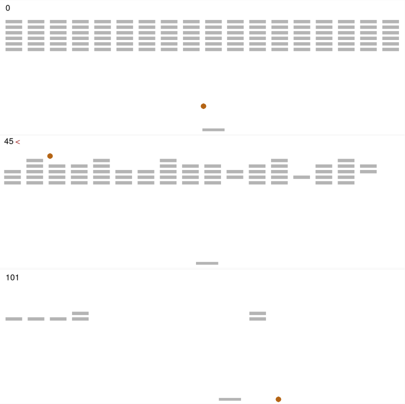
- parsed with `LDLfParser` (`FLLOAT`)
- `LDLfFormula` passed to abstract class `TemporalEvaluator`
- automaton is being created (`RLTG`, DFA built upon `Pythomata`) in order to create the extended MDP

Experiments

Experiments

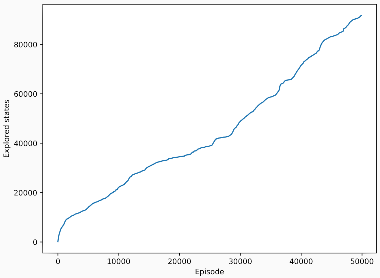
All the experiments.

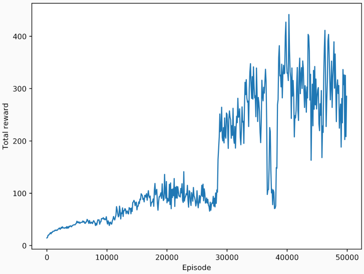
Experiments



Description.

Experiments



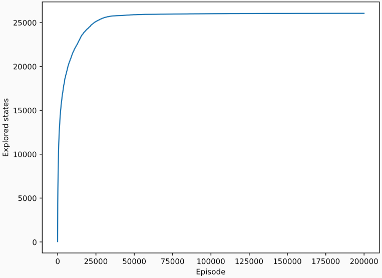


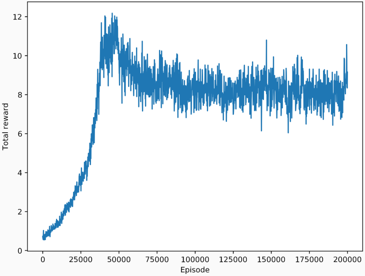
PyGame SARSA.

Experiments

Atari frames.

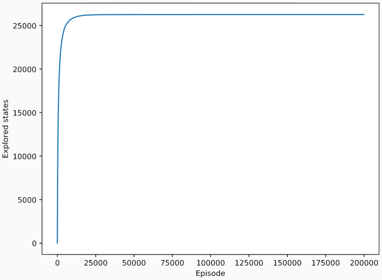
Experiments

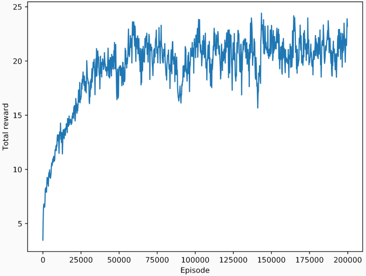




Atari Q-Learning.

Experiments





Atari SARSA.

Conclusion

Conclusion.

Q&A

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