Solving OpenAI's CarRacing environment using Deep Reinforcement Learning and Dropout

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Abstract

Deep Reinforcement Learning methods have seen many successes in recent years, ranging from solving classical video games to beating world class Go players. However, little progress has been made on the front of generalizability: successful models are trained for narrow, well-defined tasks, often using a vast amount of compute time. These models perform well in their specific task, but slight perturbations in the environment often cause disproportionate decrease in performance. Regularization methods have not yet been shown successful in tackling this issue of overfit. In this paper we attempt to give such a positive example, by applying the DDQN-algorithm with Dropout to solve OpenAI's CarRacing environment, using only a small subset of the state space for training.

1 Introduction

OpenAI Gym is a set of Reinforcement Learning testbeds including many classical video games and control problems. OpenAI Gym's CarRacing environment - from here on referred to as the 'car racing game' - is a simple, top-down view racing game as shown in Figure 1. The agent has control of a race-car, and its goal is to visit the tiles making up the randomly generated track, as fast as possible. At each time step, the *reward* is -0.1 if no tile was visited and $\frac{1000}{Number\ of\ tiles}$ otherwise. The *state* is represented as 96 by 96 RGB screenshots of the screen. The game ends if the agent visits all tiles on the track or the number of passed frames exceeds 1000. This environment is considered solved as per OpenAI's guidelines, if an average score of over 900 is achieved over 100 consecutive games. The car racing game was recently solved by [1], however to the best of our knowledge it is unsolved using RL methods.

2 Method

Our method uses the DDQN-algorithm as first described in [2], a simple extension of the celebrated DQN-algorithm, proposed in [**?**]. The architecture of the Q-network is that described in the original paper [**?**]

3 Experiments

Notice that the track is made up of distinct tiles. The reward signal is -0.1 for every frame passed and $\frac{1000}{N}$ for every tile visited, where N is the total number of tiles on the track. Thus the goal of the

*Use footnote for providing further information about author (webpage, alternative address)—*not* for acknowledging funding agencies.

Preprint. Work in progress.

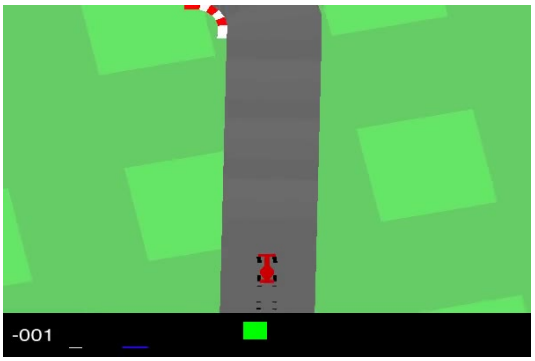

Figure 1: Screenshot of the car racing game.

game is to finish the track as fast as possible, without missing any of the tiles. The actions come in the form of an array of three numbers. In the array, the first number indicates steer, the second number indicates acceleration and the third number indicates deceleration. The steer coordinate is continuous from -1 to 1 while the acceleration and the deceleration are continuous from 0 to 1. For example, if the agent finishes in 732 frames and never leaves the track doing so, the reward is 1000 - 0.1*732 = 926.8 points. The episode finishes when all tiles are visited or more than 1000 frames pass. As per OpenAI's guidelines, the environment is solved when an average score of 900 or more is achieved over 100 episodes.

We chose this environment for several reasons: first, the car racing game is similar to real life autonomous driving; second, the game environment can be easily altered, allowing for interesting exploration of robustness of Deep RL methods; third, according to the leaderboard on OpenAI's website, no one has successfully solved the game.

To be able to iterate faster, we created four different types of training environment of varying complexity: random short tracks, fixed one track, fixed three tracks and random tracks. In the random short track environment, there are 50 tiles for the agent to finish while in the other environments, there are approximately 300 tiles. Random short tracks and random tracks environment display randomly generated tracks for each episode while the other environments display the same one (fixed one track) or three tracks (fixed three tracks).

4 Submission of papers to NIPS 2018

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`https://cmt.research.microsoft.com/NIPS2018/`

Please read the instructions below carefully and follow them faithfully.

4.1 Style

Papers to be submitted to NIPS 2018 must be prepared according to the instructions presented here. Papers may only be up to eight pages long, including figures. Additional pages *containing only acknowledgments and/or cited references* are allowed. Papers that exceed eight pages of content (ignoring references) will not be reviewed, or in any other way considered for presentation at the conference.

The margins in 2018 are the same as since 2007, which allow for $\sim 15\%$ more words in the paper compared to earlier years.

Authors are required to use the NIPS LaTeX style files obtainable at the NIPS website as indicated below. Please make sure you use the current files and not previous versions. Tweaking the style files may be grounds for rejection.

4.2 Retrieval of style files

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The only supported style file for NIPS 2018 is `nips_2018.sty`, rewritten for LaTeX 2_ε. **Previous style files for LaTeX 2.09, Microsoft Word, and RTF are no longer supported!**

The LaTeX style file contains three optional arguments: `final`, which creates a camera-ready copy, `preprint`, which creates a preprint for submission to, e.g., arXiv, and `nonatbib`, which will not load the `natbib` package for you in case of package clash.

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The formatting instructions contained in these style files are summarized in Sections 5, 6, and 7 below.

5 General formatting instructions

The text must be confined within a rectangle 5.5 inches (33 picas) wide and 9 inches (54 picas) long. The left margin is 1.5 inch (9 picas). Use 10 point type with a vertical spacing (leading) of 11 points. Times New Roman is the preferred typeface throughout, and will be selected for you by default. Paragraphs are separated by ½ line space (5.5 points), with no indentation.

The paper title should be 17 point, initial caps/lower case, bold, centered between two horizontal rules. The top rule should be 4 points thick and the bottom rule should be 1 point thick. Allow ¼ inch space above and below the title to rules. All pages should start at 1 inch (6 picas) from the top of the page.

For the final version, authors' names are set in boldface, and each name is centered above the corresponding address. The lead author's name is to be listed first (left-most), and the co-authors' names (if different address) are set to follow. If there is only one co-author, list both author and co-author side by side.

Please pay special attention to the instructions in Section 7 regarding figures, tables, acknowledgments, and references.

6 Headings: first level

All headings should be lower case (except for first word and proper nouns), flush left, and bold.

First-level headings should be in 12-point type.

6.1 Headings: second level

Second-level headings should be in 10-point type.

6.1.1 Headings: third level

Third-level headings should be in 10-point type.

Paragraphs There is also a `\paragraph` command available, which sets the heading in bold, flush left, and inline with the text, with the heading followed by 1 em of space.

7 Citations, figures, tables, references

These instructions apply to everyone.

7.1 Citations within the text

The `natbib` package will be loaded for you by default. Citations may be author/year or numeric, as long as you maintain internal consistency. As to the format of the references themselves, any style is acceptable as long as it is used consistently.

The documentation for `natbib` may be found at

`http://mirrors.ctan.org/macros/latex/contrib/natbib/natnotes.pdf`

Of note is the command `\citet`, which produces citations appropriate for use in inline text. For example,

```
\citet{hasselmo} investigated\dots
```

produces

Hasselmo, et al. (1995) investigated…

If you wish to load the `natbib` package with options, you may add the following before loading the `nips_2018` package:

```
\PassOptionsToPackage{options}{natbib}
```

If `natbib` clashes with another package you load, you can add the optional argument `nonatbib` when loading the style file:

```
\usepackage[nonatbib]{nips_2018}
```

As submission is double blind, refer to your own published work in the third person. That is, use "In the previous work of Jones et al. [4]," not "In our previous work [4]." If you cite your other papers that are not widely available (e.g., a journal paper under review), use anonymous author names in the citation, e.g., an author of the form "A. Anonymous."

7.2 Footnotes

Footnotes should be used sparingly. If you do require a footnote, indicate footnotes with a number[2] in the text. Place the footnotes at the bottom of the page on which they appear. Precede the footnote with a horizontal rule of 2 inches (12 picas).

Note that footnotes are properly typeset *after* punctuation marks.[3]

7.3 Figures

All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction. The figure number and caption always appear after the figure. Place one line space before the figure caption and one line space after the figure. The figure caption should be lower case (except for first word and proper nouns); figures are numbered consecutively.

[2] Sample of the first footnote.

[3] As in this example.

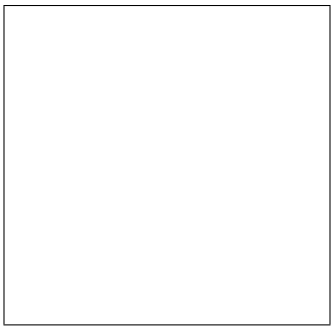

Figure 2: Sample figure caption.

Table 1: Sample table title

	Part	
Name	Description	Size (μm)
Dendrite	Input terminal	$\sim$100
Axon	Output terminal	$\sim$10
Soma	Cell body	up to 10^6

You may use color figures. However, it is best for the figure captions and the paper body to be legible if the paper is printed in either black/white or in color.

7.4 Tables

All tables must be centered, neat, clean and legible. The table number and title always appear before the table. See Table 1.

Place one line space before the table title, one line space after the table title, and one line space after the table. The table title must be lower case (except for first word and proper nouns); tables are numbered consecutively.

Note that publication-quality tables *do not contain vertical rules.* We strongly suggest the use of the `booktabs` package, which allows for typesetting high-quality, professional tables:

`https://www.ctan.org/pkg/booktabs`

This package was used to typeset Table 1.

8 Final instructions

Do not change any aspects of the formatting parameters in the style files. In particular, do not modify the width or length of the rectangle the text should fit into, and do not change font sizes (except perhaps in the **References** section; see below). Please note that pages should be numbered.

9 Preparing PDF files

Please prepare submission files with paper size "US Letter," and not, for example, "A4."

Fonts were the main cause of problems in the past years. Your PDF file must only contain Type 1 or Embedded TrueType fonts. Here are a few instructions to achieve this.

- You should directly generate PDF files using `pdflatex`.
- You can check which fonts a PDF files uses. In Acrobat Reader, select the menu Files>Document Properties>Fonts and select Show All Fonts. You can also use the program `pdffonts` which comes with `xpdf` and is available out-of-the-box on most Linux machines.

- The IEEE has recommendations for generating PDF files whose fonts are also acceptable for NIPS. Please see `http://www.emfield.org/icuwb2010/downloads/IEEE-PDF-SpecV32.pdf`
- `xfig` "patterned" shapes are implemented with bitmap fonts. Use "solid" shapes instead.
- The `\bbold` package almost always uses bitmap fonts. You should use the equivalent AMS Fonts:

  ```
  \usepackage{amsfonts}
  ```

  followed by, e.g., `\mathbb{R}`, `\mathbb{N}`, or `\mathbb{C}` for $\mathbb{R}$, $\mathbb{N}$ or $\mathbb{C}$. You can also use the following workaround for reals, natural and complex:

  ```
  \newcommand{\RR}{I\!\!R} %real numbers
  \newcommand{\Nat}{I\!\!N} %natural numbers
  \newcommand{\CC}{I\!\!\!\!C} %complex numbers
  ```

  Note that `amsfonts` is automatically loaded by the `amssymb` package.

If your file contains type 3 fonts or non embedded TrueType fonts, we will ask you to fix it.

9.1 Margins in LaTeX

Most of the margin problems come from figures positioned by hand using `\special` or other commands. We suggest using the command `\includegraphics` from the `graphicx` package. Always specify the figure width as a multiple of the line width as in the example below:

```
\usepackage[pdftex]{graphicx} ...
\includegraphics[width=0.8\linewidth]{myfile.pdf}
```

See Section 4.4 in the graphics bundle documentation (`http://mirrors.ctan.org/macros/latex/required/graphics/grfguide.pdf`)

A number of width problems arise when LaTeX cannot properly hyphenate a line. Please give LaTeX hyphenation hints using the `\-` command when necessary.

Acknowledgments

Use unnumbered third level headings for the acknowledgments. All acknowledgments go at the end of the paper. Do not include acknowledgments in the anonymized submission, only in the final paper.

References

[1] David Ha and Jürgen Schmidhuber. World models. *CoRR*, abs/1803.10122, 2018.

[2] Hado Van Hasselt, Arthur Guez, and David Silver. Deep reinforcement learning with double q-learning. In *AAAI*, volume 2, page 5. Phoenix, AZ, 2016.