Using Neural Networks to Approximate and Optimize Non Differentiable Objective Functions

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1. Team

The team is just myself. I will do the data collection, model coding, evaluation and report writing. This will involve writing data loading utilities for each task, and training an evaluation scripts for each task. The majority of the work will probably involve debugging and iteratively developing the machine learning modules which train the neural networks.

2. Shared Work

This project is not shared with another course.

3. The Problem

The problem I intend to investigate is how to optimize non-differentiable objective functions. This is useful in areas where the performance we care about is not directly in line with a mathematical optimization function or specification of a function is unknown. This can be seen in classification where we might care about accuracy, precision, and recall, object detection where we are about bounding box intersection over union, or in reinforcement learning where we care about maximizing an unknown reward function. In all of these cases we want to maximize an non-differentiable function and current methods use hand engineered proxies. I propose learning the surrogate objective function with a neural net.

4. Data

I will use MS-COCO, and imagenet/tiny-imagenet for object detection and classification experiments and openAI gym and roboschool environments for reinforcement learning experiments.

5. Methods

I will use a general framework with two neural networks. One, the critic, which approximates the objective function given predictions as the input and the true cost as the label. The other, the actor, makes predictions and is optimized to make the the critic predict high scores. I intend to show that actor/critic methods in RL, and GANS can both be seen as special cases of this setup. I will use Public implementations of DDPG, GANs, and state of the art object detectors as starting points for my project. I will try to frame them all to be sub-classes of my general idea.

6. Literature

I will read in the area of actor/critic in RL, especially DDPG [2] and related architectures. I will read about GANs, especially ones where the discriminator also takes in various forms of inputs like Cycle GAN. [4] I will also explore optimization literature such as in Grathwohl et al. (2018) [1]

7. Evaluation

I will evaluate tasks based on the relative performance of comparable models where one is trained on the learned objective surrogate and the other trained on a commonly used hand engineered surrogate. For example a classifier trained with softmax/crossentropy loss vs one trained with a neural net approximating precision at 10. Or for the object detector one trained on a learned IoU surrogate vs one trained with the YOLO loss function. [3] I hope that on some models the methods trained with learned objectives will outperform traditional methods.

References

[1] W. Grathwohl, D. Choi, Y. Wu, G. Roeder, and D. Duvenaud. Backpropagation through the void: Optimizing control variates for black-box gradient estimation. *ICLR*, 2018.

[2] T. P. Lillicrap, J. J. Hunt, A. Pritzel, N. Heess, T. Erez, Y. Tassa, D. Silver, and D. Wierstra. Continuous control with deep reinforcement learning. *ICLR*, 2016.

[3] J. Redmon, S. K. Divvala, R. B. Girshick, and A. Farhadi. You only look once: Unified, real-time object detection. *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pages 779–788, 2016.

[4] J.-Y. Zhu, T. Park, and P. I. A. A. Efros. Unpaired image-to-image translation using cycle-consistent adversarial networks. *ICCV*, 2017.