ECE 239AS Project Proposal

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Abstract

Both leveraging transfer and avoid catastrophic forgetting is a key obstacle to achieving human-level intelligence. Progressive Neural Networks provides an approach that can avoid forgetting and can leverage the prior knowledge via lateral connections to previously learned features. In our project, we plan to implement Progressive Neural Networks and deploy it on Atari games and Labyrinth to simulate its performance. Because of the nature of Progressive Neural Network, it usually suffers a gigantic network size problem. Therefore we plan to improve the Progressive Neural Network by limiting the size of it.

Question 1

What is the problem that you will be investigating? Why is it interesting?

The problem we are investigating is that many learning and decision-making models inside an agent are not compatible in other environments. This is a waste of resource in that we need to design and train a particular model for each specific task. Thus we want to find a more general model such that it can leverage previously learned knowledge and avoid forgetting. It is particularly interesting because only by achieving the memorization can an agent truly touch the human-level intelligence. This brings us to a novel neural architecture called progressive neural networks.

Question 2

If relevant, what data, simulator or real-world RL domain will you be looking at? If you are collecting new datasets, how do you plan to collect them?

This paper experiments their model especially on different games during evaluation. Therefore, the input data would likely be image pixels from the games. We would be using modules like pong game environment from the openAI gym library and maybe alter the games in various ways to test the model thoroughly.

Question 3

What method, algorithm or theoretical analysis are you proposing? If there are existing implementations, will you use them and how? How do you plan to improve or modify such implementations? If you are addressing a theoretical question, how do you plan to make progress?

The progressive neural networks has been proposed and implemented by Google DeepMind. The algorithm is well-suited for such learning-without-forgetting task. However, one issue related to the model is that it is often engineered very large in order to add sufficient learning capacity to the network. Therefore, we want to improve it so that the network won't grow as the expected capacity increases, or at least it grows sub-linearly. To tackle this challenge, our initial plan is to draw some ideas from knowledge distillation and try to add some architecture to prevent information loss.

Question 4

What literature have you already surveyed or will be examining to provide context and background?

As far as we surveyed, the following paper provide very solid background to our problem.

1. Playing Atari with Deep Reinforcement Learning [3]
2. An Introduction to Inter-task Transfer for Reinforcement Learning [5]
3. Distillation [1]
4. Learning without Forgetting [2]
5. Policy Distillation [4]

Question 5

How will you evaluate your results? Qualitatively, what kind of results do you expect (e.g. plots or figures)? Quantitatively, what kind of analysis will you use to evaluate and/or compare your results (e.g. what performance metrics or statistical tests)?

We would be evaluating the model on a set of Atari games and Labyrinth which is a 3D maze game. First, we would be evaluating the Progressive Neural Networks model on a set of synthetic Pong games (a type of Atari game) where the visuals and gameplay would be set differently to ensure there would be enough variation to fully test the model. "Noisy" version of the Pong game adds noises to the input, "Black" or "White" versions change the background of the game to be those colors. There are also other variations that we would be exploring. Second, the model will be tested on randomly chosen Atari games. Those Atari games have entirely different visuals and required strategies so that the model can be tested thoroughly on different settings. Lastly, we would be evaluating the model on Labyrinth which is a 3D maze game. It is different from other games because the input would be images that only gives the player partial observability.

We expect to get similar results compared to the paper we would be summarizing. The plots and figures experiment results can be found in the paper.

Performance of the model would be evaluated by measuring the area under the learning curve which is the average score per episode during training. There would also be a transfer score defined as a relative performance comparison with some baselines.

References

[1] HINTON, G., VINYALS, O., AND DEAN, J. Distilling the knowledge in a neural network. *arXiv preprint arXiv:1503.02531* (2015).

[2] LI, Z., AND HOIEM, D. Learning without forgetting, 2016.

[3] MNIH, V., KAVUKCUOGLU, K., SILVER, D., GRAVES, A., ANTONOGLOU, I., WIERSTRA, D., AND RIEDMILLER, M. A. Playing atari with deep reinforcement learning. *CoRR abs/1312.5602* (2013).

[4] RUSU, A. A., COLMENAREJO, S. G., GULCEHRE, C., DESJARDINS, G., KIRKPATRICK, J., PASCANU, R., MNIH, V., KAVUKCUOGLU, K., AND HADSELL, R. Policy distillation. *arXiv preprint arXiv:1511.06295* (2015).

[5] TAYLOR, M. E., AND STONE, P. An introduction to intertask transfer for reinforcement learning. *Ai Magazine 32*, 1 (2011), 15–15.