Dynamic Sample Selection Strategy in Active Learning

Project Summary Report

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# Introduction

Active learning is a special case of machine learning which gives the learning algorithm some control over the learning process, by letting it actively decide which examples it will learn from. More precisely, given a pool of unlabeled example the algorithm decides which one to label and to feed into the learning process. Active learning is most useful when labeling examples is costly, because then smart selection of which example to label can save resources and effort. There are few algorithms for active learning in neural networks, and most of those algorithms do not integrate the learning procedure of the neural network with the active learning. This fact can cause the active algorithm to be efficient in the beginning of the process but not in later stages or vice versa, depending on the algorithm. For example, we can think of an active learning algorithm for SVM for classification of several classes. In the beginning it might choose examples in places in the space it has no information on, e.g. far from examples with known classes. But as the classification progresses, we might want the algorithm to choose examples with the smallest margin (i.e. closest to the decision boundary) and thus be more accurate. To perform such a task, traditionally we would need to set hyperparameters that will determine the algorithm's choice of the next example to classify – low-information areas vs. more accuracy in known areas. SelectiveNet‎[1] is a neural network architecture used for classifying images or for regression, which has an additional output. That output states the “confidence level” in the classification (or regression) of the example.

In this project we will try to use this mechanism to determine which example to label next, by training the net on labeled examples and using it on examples that are not labeled. Then we will choose the examples (from the unlabeled ones) which have the smallest “confidence level” in their prediction by the current classifier, to be labeled next. By using the mechanism of SelectiveNet, we let the neural network decide where it has the least information to determine a classification. Our hypothesis is that the decision will be adaptive to the stage of the active learning, and will achieve better results through the process, without the need to set any hyperparameters manually.

# Problem Setting

The goal in active learning is to design and analyze learning algorithms that can effectively choose the samples for which they ask the teacher for a label. Utilizing this technique allows reaching high quality results while maintaining low data requirements. This is relevant in cases where data is expensive, scarce, cumbersome (as in hi-res images), and also when data is too plentiful, making training unnecessarily long when the same results could be achieved faster by choosing which datapoints to train on as part of the training process.

The algorithm used for choosing which samples to request the real label for is therefore a major parameter in the performance of the neural network. Additionally, many of the commonly used algorithms have varied performance across different learning problems, such as those with a "XOR"-like structure[2]. Estimating the performance of the selection algorithm or formulating a supervising algorithm to choose between several such algorithms, could be a place where development could lead to great improvements in accuracy and consistency across different learning tasks.

# Our Method

We intend to classify images from the CIFAR10 database and measure our network's accuracy as a function of the number of samples trained on. As a baseline, we will train a NN which selects its next samples randomly, and a NN which selects its samples using the Softmax Response[3] method. Our experiments use SelectiveNet's confidence measure, and additionally we run two experiments combining two confidence measures. In each of these SelectiveNet's confidence measure is combined with a confidence derived from a reconstruction loss generated by an autoencoder that's added to SelectiveNet's architecture and is trained together with SelectivNet's other heads. The reconstruction loss from the autoencoder is converted into a confidence measure for sample via the formula:

In the earlier stages of training, more weight is given to the autoencoder's confidence measure than to SelectiveNet's original confidence . The weighted confidence is calculated as follows:

Where represents the shift in importance from reconstruction loss to selective confidence, and changes in constant steps from 0 to 0.6, meaning that the weight distribution changes from 0.8/0.2 to 0.2/0.8.

# Results

# Discussion

# Bibliography

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[3] L. Pietro Cordelia, C. De Stefano, F. Tortorella, and M. Vento, “A Method for Improving Classification Reliability of Multilayer Perceptrons,” *IEEE Trans. Neural Networks*, vol. 6, no. 5, pp. 1140–1147, 1995.