CSE 573: Computer Vision and Image Processing (Spring'24)

Milestone 1

Team Details

Team Name – Pixel Swarm

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1. Project Details

Project Title - Meta-Heuristics vs. Backpropagation: A Fresh Look at CNN Model Parameter Optimization for Image Classification

Team Name – Pixel Swarm

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2. Problem Statement & Method Details

Abstract:

Most of the Neural Network models are trained using gradient based backpropagation technique to optimize model parameters which are prone to be stuck at local optimal value rather than reaching the globally optimal parameters. There are various techniques to improve the simple Stochastic Gradient Descent (SGD) like Learning Rate Scheduling and Momentum, but these techniques does not resolve the aforementioned limitation. In this project, we aim to compare Backpropagation with Meta-Heuristic Optimization Algorithms by analyzing their performance on training CNN models for Image Classification tasks. There are a few population-based meta-heuristic algorithms like Particle Swarm Optimization (PSO) and Grey Wolf Optimization (GWO) which can achieve globally optimal parameters and so, we aim to check the feasibility of such optimization techniques in CNN model architectures.

Problem Statement:

The aim of this project is to analyze the performances of meta-heuristic optimization algorithms in contrast to gradient-based backpropagation techniques for Convolutional Neural Network model training.

Method Details:

a. **Meta-Heuristic algorithms** - Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Grey Wolf Optimization (GWO), and Ant Colony Optimization (ACO).
b. **CNN model architectures** - AlexNet, VGG-16, and ResNet-50. As all the above three models have been trained on Image Classification task of the ImageNet challenge (ILSCRC), we'll be using the classification task of ILSVRC 2017 as our dataset for model training and model inferencing.
c. **Dataset** - ILSVRC 2017 (Image Classification)

Project Analysis:

Since we are trying to change the model optimization techniques we intend to perform analysis on the following two grounds:

1. **Quality of model training** – Based on the model inferencing performed on models trained with different optimization techniques, we will be comparing the qualities of trained model.
2. **Computational Cost** – Since most of the deep-CNN models are computationally expensive we will be analyzing the computational resources required by the novel optimization techniques in contrast to gradient-based backpropagation techniques.

3. Project Plan

Project Plan:

Step 1 – Research (3 Weeks):

Since we are planning to compare one of the most fundamental components of modern Computer Vision algorithms and replace it with something very novel, we start by understanding the basics of the meta-heuristic algorithms and plan how to implement them optimization algorithm.

Step 2 – Building Basic Code (4 Weeks):

At this step we'll start coding the basic components of our computer program like optimization algorithms, model architectures, and training steps.

Step 3 – Model Training and Inference (3 Weeks):

At this step we will begin model training using different optimization techniques and compare their performances.

Step 4 – Project Analysis and Wrap-up (2 Weeks):

Since there is a lot of potential research work in this field, we'll avoid going into those depths right-away ad finish semester project in the last 2 weeks by finishing the write-ups and preparing the final GitHub repository.

Current Status:

We are half-way through our research phase. We've revised our concepts of Convolutional Neural Networks, read the papers concerning our meta-heuristic algorithms and are currently planning the implementation of our possible next steps.