Improving Convolutional Neural Network Image Classification Using Alternative Forms of Neural Networks

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Problem

Neural Networks

The heart of deep learning problems, neural networks (NN) are inspired by the human brain. My goal is to hone in on a classic problem involving the use of Convolutional Neural Networks (CNN) for image classification.

Image Classification

In the context of this paper, Image Classification refers to the ability to tease the CIFAR-10 dataset of images into their corresponding labels and check for neural network accuracy.

Problem statement

The goal is to use a neural network to test alongside and against a CNN based on a variety of a evaluative conditions including accuracy, runtime, and consistency.

Challenges deep-dive

Challenge 1

Learning how to create a CNN and other NNs

Having no experience with neural networks I've learned how to create them and pit them against each other in order to find results.

Challenge 2

Time is Finite

In my research I've come to find that neural networks have the potential to run for times as long as an hour, which meant a limited time to produce results.

Challenge 3

Outcome

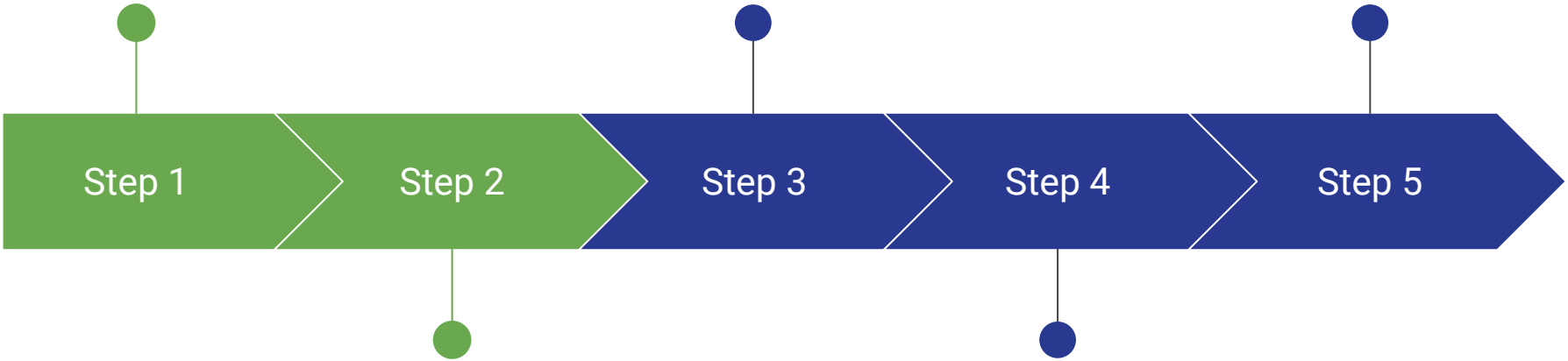
In achieving results there comes the point where I have to argue whether or not CNNs are the best method for image classification or not, and this comes through evaluating results.

Solution

Approaching the problem

In order to successfully complete this task I'm using two alternative neural network to compete with Convolutional Neural Networks. Time constraints limited the amount of neural networks I was able to explore in order to have sizable competition.

Implementation


Go into Google Colab and create a notebook for the software I'll implement.
Create 2 more competing neural networks and obtain results.
Describe my methods, processes, and findings in an IEEE formatted research paper.
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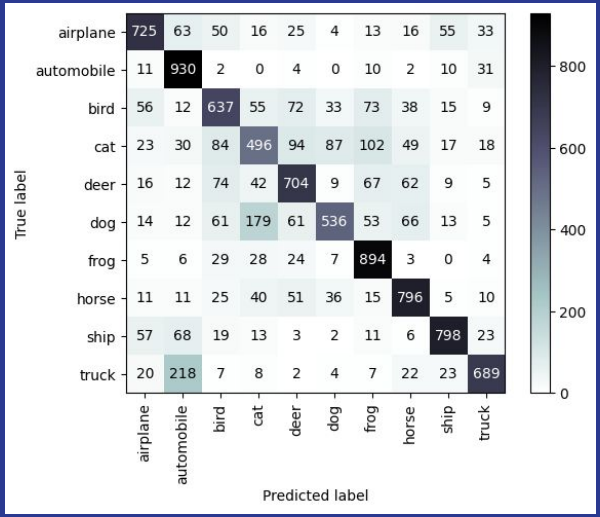
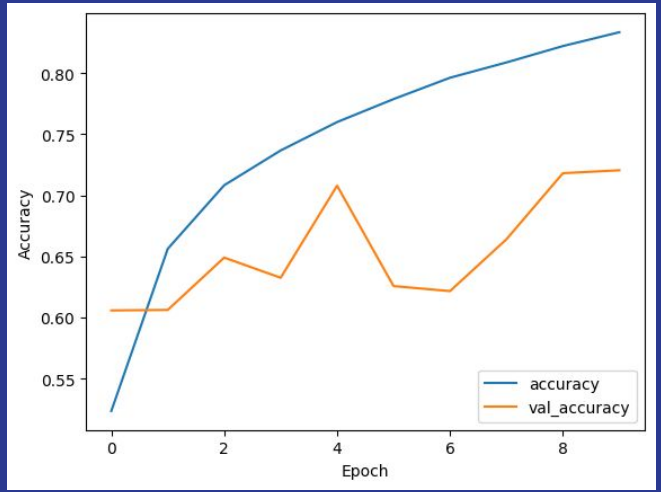
Convolutional Neural Network

Results Demonstration

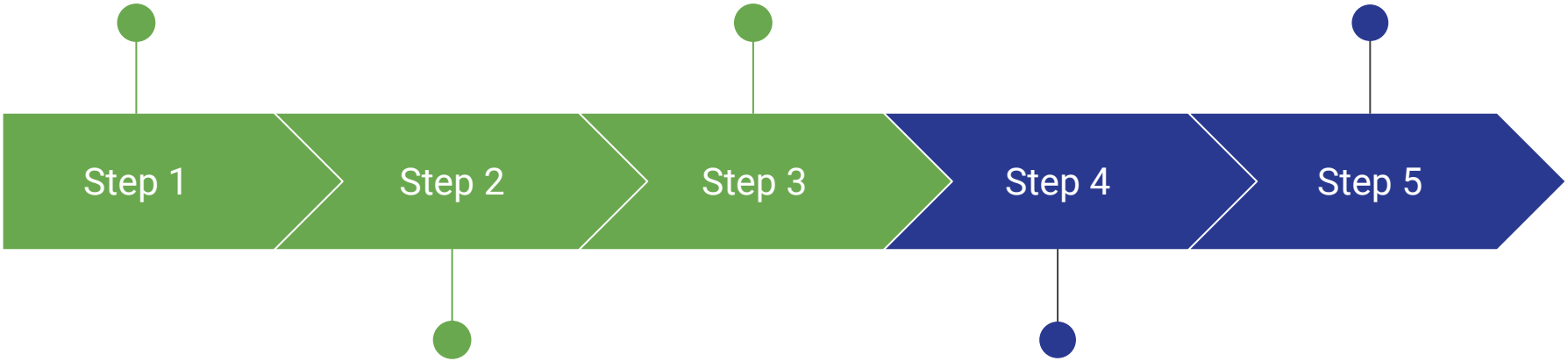
Through a number of alterations to the model layers eventually I found an optimization that I deemed acceptable, the following slide demonstrates the accuracy and results of the Convolutional Neural Network.

Training the CNN: Results Overview





I achieved a validation accuracy of 72.57%. The maximum accuracy achieved was 84.65%. The runtime for the CNN averaged 2 minutes and 28 seconds.



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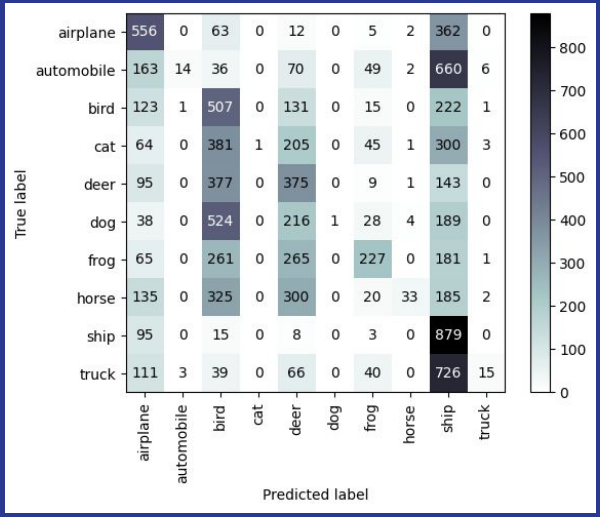
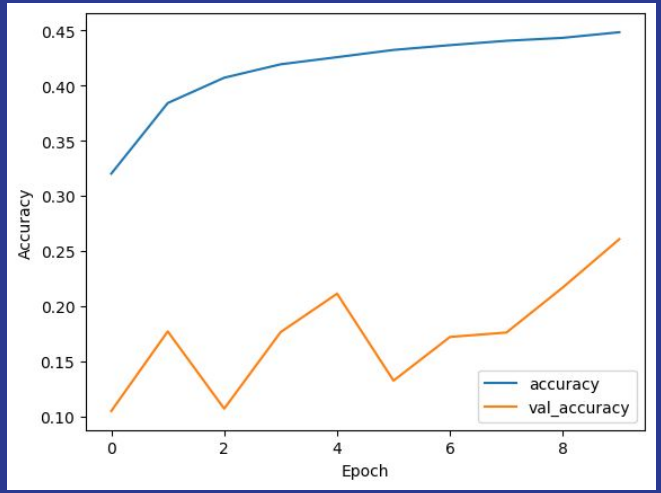
Residual Neural Networks

Results Demonstration

The Residual Neural Network (ResNet) was not much more challenging than the CNN in terms of demonstrating results. I will note that there were some differences in how I was allowed to interact with model layers that were notable.

Training the ResNet: Results Overview





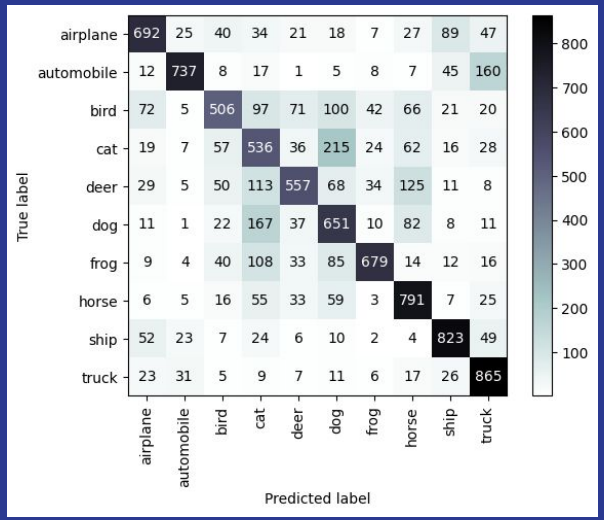
I achieved a validation accuracy of 26.08%. The maximum accuracy achieved was 44.92%. The runtime for the CNN averaged 5 minutes.

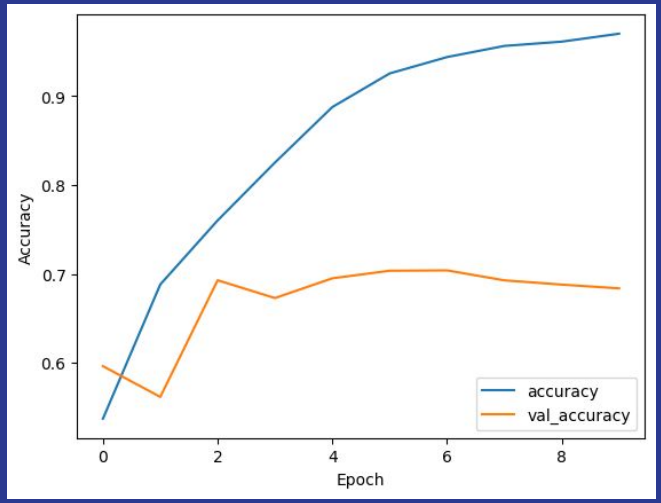
Capsule Neural Networks

Results Demonstration

The Capsule Neural Network (CapsNet) was far more difficult than the previous two Neural Networks. Building the model and demonstrating the confusion matrix showed major friction that resulted in delaying the project majorly. The CapsNet had to use various optimizations in order to even have a runtime.

Training the CapsNet: Results Overview





I achieved a validation accuracy of 67.98%. The maximum accuracy achieved was 96.85%. The runtime for the CNN averaged 3 minutes.

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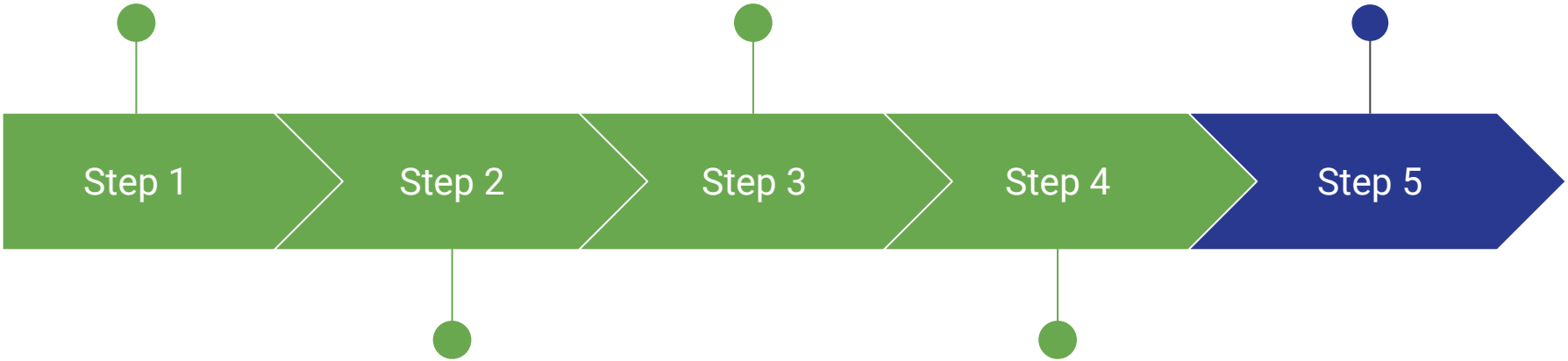

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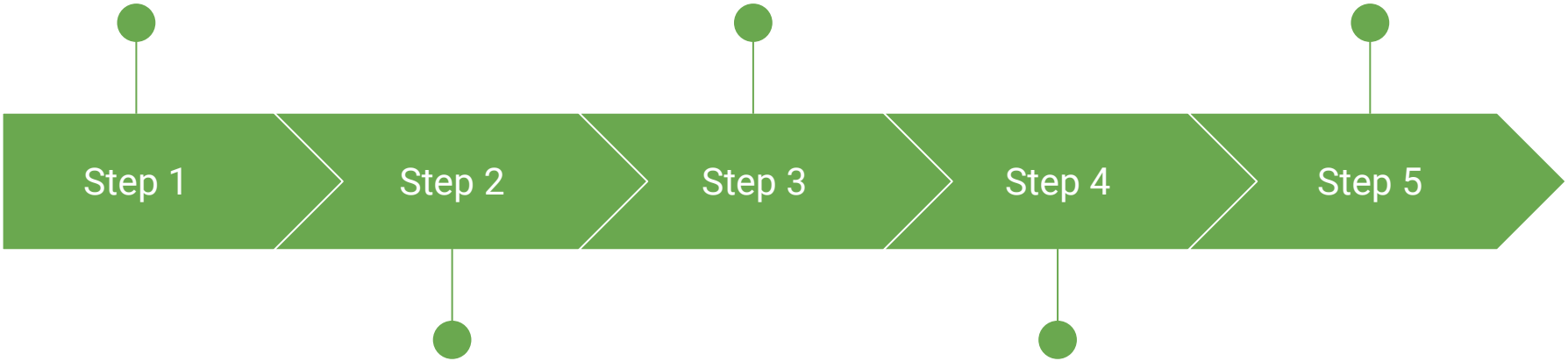
Results Comparison And Evaluation

Here we can see that there is a clear majority in the green with Convolutional Neural Networks. And we see that the worst performance overall came from the Residual Neural Network. However we do see one interesting thing, we see that the Capsule Neural Network outperformed the Convolutional Neural Network in Accuracy by a highly respectable 12.2%.

	Validation Accuracy	Accuracy	Runtime
Convolutional Neural Network	72.57%	84.65%	~2 min
Residual Neural Network	26.08%	44.92%	~5 min
Capsule Neural Network	67.98%	96.85%	~3 min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Progression and Failures Along the Way

As you can tell the Alternative Neural Networks were not successful in achieving greater validation accuracy than the Convolutional Neural Network with the given restrictions of 10 epochs and 10 model layers. This was done intentionally to test the degree of power of a neural network with limited potential. I think it is important to notice however that the CapsNet,was able to achieve greater accuracy than the CNN. The Residual Neural Network, unfortunately, did not perform even close to standard. It required the most work to get it to the point where it could achieve anything over 10% validation accuracy. It was a good attempt, however, with the restrictions given it could not perform to its true colors. You might've noticed that I used a CapsNet, the original progress plan stated I would use a Siamese Network, and if it failed I would switch to CapsNet. The Siamese Network took far too long for the time restriction to be properly adapted for the CIFAR dataset. Equally, the plan was to have an Attention Mechanism in addition to the other Neural Networks, and again, due to time restrictions, it was not incorporated into the competition. This is all expanded on in the IEEE paper.

Thank You!