Leveraging AlexNet for Enhanced Detection of Icy Roads

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Abstract

This paper explores the application of the AlexNet convolutional neural network architecture for the detection of ice on the roads. Given the significant impact of road conditions on vehicular safety, accurate and real-time detection of ice formation is critical. We adapt AlexNet, a proven deep learning model, to analyze and interpret road surface images, aiming to improve the accuracy and reliability of icy road detection.

1 Introduction

Icy roads pose a significant risk to vehicular safety, necessitating reliable detection methods. Traditional methods, while effective to a degree, lack the real-time analysis capability. The advent of deep learning offers a promising alternative. This paper introduces AlexNet, a convolutional neural network, as a solution to this problem, leveraging its powerful image recognition capabilities.

2 Background and Literature Review

2.1 Icy Road Detection: Current Methods

The current methods of this concept is a company called Intelligent Vision Systems. This brand uses optical icing detection technology to monitor road conditions through the use of photodetectors and thermopiles to make radiance measurements to detect potentially hazardous road conditions. The limitation I see with this products is that drivers aren't always going to be able to look back and forth from the road to the camera to see if there is a hazard in front of them.

2.2 Convolutional Neural Networks

Convolutional Neural Networks consist of layers like convolutional layers for feature extraction, pooling layers for dimensionality reduction, and fully con-

nected layers for classification. CNNs are widely used in applications such as object detection, image classification, facial recognition, medical image analysis, and augmented reality. Their main advantages include efficient feature learning, robustness to image variations, and scalability for large-scale image data.

2.3 AlexNet: An Overview

Key features of AlexNet's architecture is the input (227x227x3 sized images), convolutional layers, activation functions, pooling layers, normalization, fully connected layers, and the output. There are five convolutional layers with varying filter sizes (11x11 to 3x3) for feature extraction. AlexNet is highly relevant in the domain of image-based tasks as it marked a turning point in the adoption of deep learning for complex image recognition tasks, introducing several key techniques and inspiring a wave of innovation in neural network design and application.

3 Methodology

3.1 Data Collection

The image dataset of road conditions I am using is a collection of images from Google. I have 25 images of roads with snowy or icy conditions, and another 25 with no hazardous conditions at all, just clear roads. I then put all 50 pictures into a Google Slides document so they are all placed together for use.

3.2 Preprocessing

In terms of preprocessing, I used the code "transforms.Normalize(means, stds)" because it adds a normalization process that adjusts the pixel values in the image so that the resultant distribution has a specified mean and standard deviation. This process ensures that the model sees data that's consistently scaled and distributed, which often leads to better training and generalization performance. In terms of resizing, I used the code "transforms.Resize(size)" because prepares datasets for training and inference in machine learning models, particularly when dealing with datasets that contain images of varying dimensions. By ensuring that all images have the same dimensions, it simplifies the processing and analysis pipeline. My images were sized to 224 x 224.

3.3 Model Architecture

Adapting AlexNet for icy road detection involves careful consideration of the unique features of road imagery and the specific characteristics of icy conditions. It requires adjustments at various levels of the network, including the input layer, convolutional layers, and fully connected layers, as well as adaptations in data preprocessing and training strategy. For example, road images, especially those from vehicle-mounted cameras, might have different resolutions than the

ImageNet dataset AlexNet was originally designed for so an adjustment might help with the resolution of the road imagery.

3.4 Training

To achieve accurate results, AlexNet is trained on a large dataset of road images, both with and without ice. This training allows the network to learn the distinguishing characteristics of icy roads. The model would be validated and tested on separate sets of images to ensure its reliability and accuracy in real-world conditions. Training the model multiple times, increases the accuracy of the results and decreases the loss.

4 Results

By training the model multiple times, I was unable to get a consistent accuracy and loss percentage, but I was able to achieve accuracy percentages between 83 percent and 90 percent.

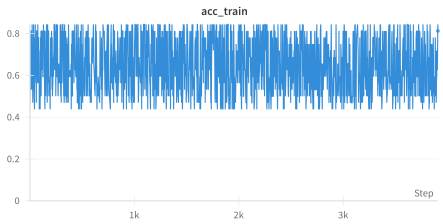

Figure 1: Accuracy

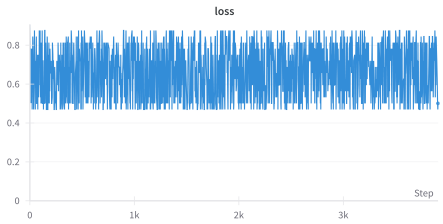

Figure 2: Loss

Figure 3: Run Summary

5 Discussion

The model seems to be very effective with it's results, giving over 75 percent accuracy each run. I think Google Colab was a great platform to run this model, but for larger datasets, a platform with more storage would probably be better, because the larger the dataset, the more likely there is to be an error when running the code. In terms of how well this model works for image recognition, traditional methods would be less effective in this process.

6 Conclusion

To summarize, the AlexNet model performed well in detecting whether the images of roads had ice on them with a 83 percent accuracy.For future research, I would propose adjusting the input layer resolutions, filter sizes, and fully connected layers to help the network better capture the unique textures and patterns of icy roads. I would also recommend further research into using more convolutional layers to detect certain conditions like black ice, which is harder to be seen.

References

Ice Vision Intelligence GitHub
Ice Vision Intelligence Colab
Weights and Biases