Deep Learning Based Recognition of Paved Road Shoulder for the Namibia B2 Highway

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Introduction

- Namibia suffers from a high number of crash types that begin with leaving the roadway, namely rollover crashes and collision with fixed objects.
- Road shoulder can greatly reduce the occurrence of specific crash types and their associated higher severity outcomes.
- For low- and middle-income countries (LMIC), conducting routine road safety audits to locate areas missing such road safety features is not always an option.
- Therefore, it is particularly important to carry out research on cost-effective road feature recognition methods and provide appropriate strategies to make road safety more accessible.

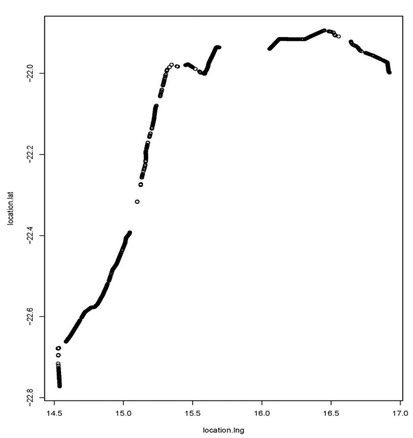
Objective

- The primary objective of this study was to investigate the potential of leveraging open source street view images of a Namibian highway to develop a cost-effective classification system capable of automatically classifying road shoulder presence and width.

Research Tasks

- Create an annotated image dataset with three categories, namely no road shoulder present, less than 2 foot of road shoulder, and greater than 2 foot of road shoulder present, leveraging existing Google Street View images along the B2 highway in Namibia.
- Training and validation of deep learning models using the newly created dataset.
- Compare and evaluate the performance of the classification models in terms of several performance measures.

Data collection



Sample Google Street View image locations on the B2 Highway

Data preparation

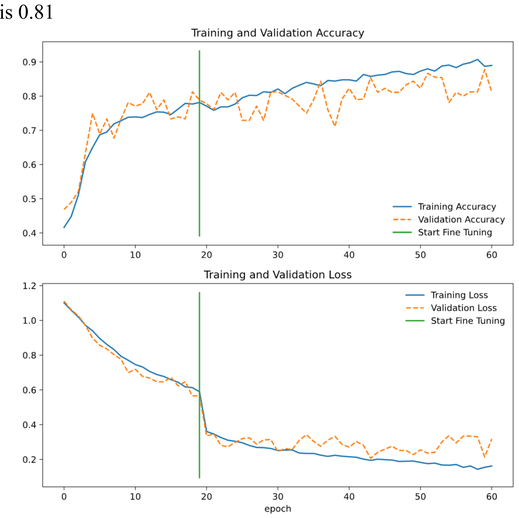
Sample classified road shoulder images. Class 0: no road shoulder; Class 1: < 2 feet; Class 2: > 2 feet.

Model Description

- The Deep-Artificial Neural Network (DANN) road shoulder classification model was based on a pre-trained Xception network which itself is based on the Inception architecture.
- The base model had 20,861,480 parameters that had been pre-trained on the image net database.

Training Performance

- Final training accuracy is accuracy: 0.89 and the validation accuracy is 0.81



Top: Training and validation accuracy as a function of the epoch, Bottom: Training and validation loss

Performance evaluation

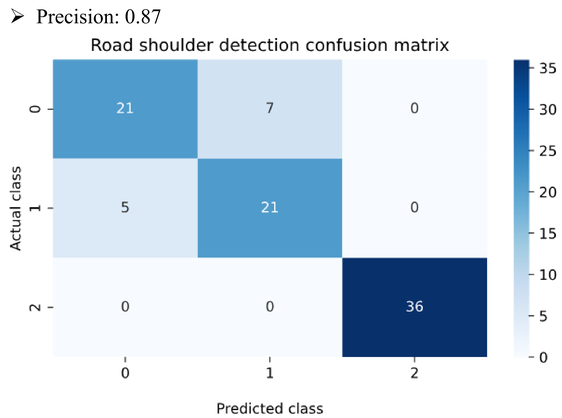
The performance of the road shoulder classification model was assess using the following measures:

- $Accuracy = \frac{TP+TN}{TP+TN+FP+FN}$
- $Recall = \frac{TP}{TP+FN}$
- $Precision = \frac{TP}{TP+FP}$
- $F1-score = 2 \times \frac{Precision \times Recall}{Precision+Recall}$

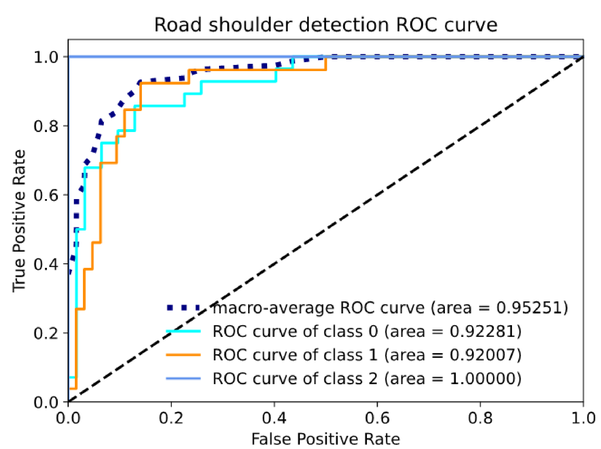
Model 1 performance

Performance of Model 1:

- Accuracy: 0.87
- Recall: 0.87
- Precision: 0.87

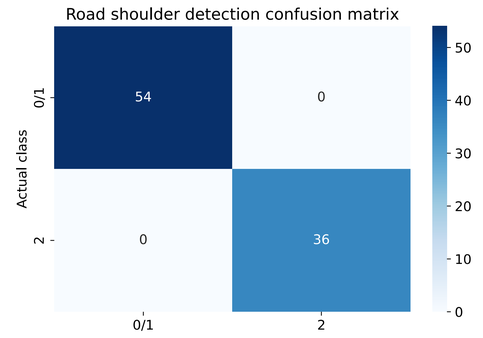


Confusion matrix from test data for 0, 1, and 2 classes

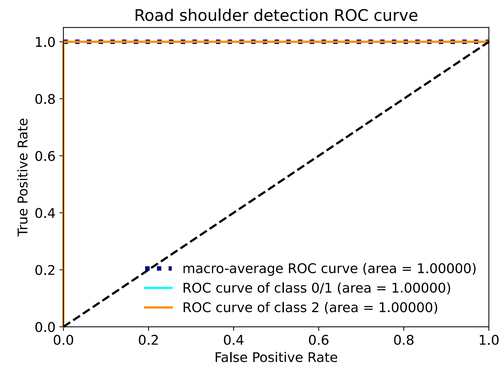


Receiver operating characteristics (ROC) curve from test data for 0, 1, and 2 classes

Model 2 Performance



Confusion matrix from test data for combined 0/1 and 2 classes



Receiver operating characteristics (ROC) curve from test data for combined 0/1 and 2 classes

Conclusions & Practical Application

- While the classification model 1 using three categories of road shoulder width produced an accuracy of 0.87, the classification model 2 using only two categories of road shoulder produced a much improved accuracy of 1.0.
- This kind of neural network can give LMIC authorities a cost-effective method of classifying their roads based on presence or condition of road safety features.
- The road environment information generated from the classification model can be used to supplement areas of road safety audits or integrated into an Advanced Traveler Information System (ATIS) and can be made accessible for road users via TMC website or mobile app, to improve their driving behavior and safety on crash prone roads.

Contact Information

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