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# Deep learning-based classification of paved road shoulder for the Namibia B2 highway

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Abstract

Background – Namibia like other sub-Saharan African countries is currently suffering from insufficient investment levels to support higher growth and maintenance programs in the transportation sector. Which can lead to a lack in support of governing and private agencies that monitor and maintain the road network. Often times poorly maintained and diminishing roadways are associated with constrained mobility, significantly raised vehicle operating costs, increases in crash severities, crash rates and their associated human and property costs, and aggravated isolation, poverty, poor health, and illiteracy in rural communities. All of which some regions in Namibia struggle with. Traditionally, routine road safety audits should be conducted by the governing road agency to monitor and maintain roadways, but without sufficient investment and the required professionals to conduct them it is unlikely for this practice to be undergone in low- and middle-income countries. This typically leaves roadways in disrepair and without proper road safety features. In many cases the presence of various road side safety features (i.e., paved road shoulder, clear zone, rumble strips, guardrails, etc.) of adequate quality can help mitigate higher crash severity and occurrence, both of which Namibia suffers from. Thus, there is a need to develop a low cost open-source technique for road safety feature detection to supplement the lack of professionals and recognize diminishing areas of the road network.

Aim – The objective of this study is to fill this need by doing just that, developing a low cost open-source technique for road safety feature detection for Namibia. For the purposes of this study the selected feature that was observed is paved road shoulder conducted on the B2 highway in Namibia. Paved road shoulder is a simple road side safety feature which has shown to improve safety and reduce the occurrence of both run-off-road and rollover crashes. Additionally, this study aims to provide appropriate recommendations that are country specific but by extension may be applicable to similar road environments.

Methodology – This study treats paved road shoulder classification as a computer vision problem. Initially 1,283 Google Street View images on the B2 highway in Namibia are labeled according to three classifications of paved road shoulder width: 0) no road shoulder, 1) road shoulder up to two feet, 2) road shoulder greater than two feet. The paved road shoulder classification model was based on a pre-trained Xception network which itself is based on the Inception architecture. Due to there being so few data, data augmentation techniques were applied to training images with Keras. All training was conducted on a mobile Nvidia3070Ti graphics card using Keras and TensorFlow. The trained model was then applied to test images to measure performance.

Results – Final results from training indicated an accuracy of 0.81 with a validation accuracy of 0.79. Scores from the model's application to the test images were calculated from the confusion matrix and are as follows, accuracy: 0.82, balanced accuracy: 0.80, recall: 0.82, precision: 0.84. The results for classes 0,1, and 2 were 0.90, 0.91, and 1.0, respectively. Initial model results on the test images indicated there was difficulty distinguishing between the lack of road shoulder and minimal road shoulder. Because of the models poor performance in distinguishing classes 0 and 1, the model was also evaluated combining classes 0 and 1 to one class, "0/1", the new class contained minimal to no paved road shoulder. The accuracy, precision, recall, and the AUC were all 1.0 when combining class 0 and 1.

Conclusions – The approach used in this study like similar techniques has the potential to be applied to the detection of various road safety features. The model may be better at distinguishing classes 0 and 1 than humans as labeling the image's width of paved road shoulder would be highly subjective and difficult to distinguish particularly when covered by sand or weathered. More data would improve results. Additionally, the kind of neural network proposed in this study is an easy way of classifying roads and may have the potential to be used as a supplementary tool to ease the cost of conducting regular road safety audits in low- and middle-income countries and more specifically Namibia.