Forward Collision Risk Assessment for High-Speed Unmanned Ground Vehicles using ConvLSTM

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Abstract

- Leveraging the power of Convolutional Long Short-Term Memory (ConvLSTM) neural networks, we have developed a model trained on sequences of images captured from UGV-mounted cameras.
- Our objective was to accurately distinguish between collision-prone and non-collision sequences.
- Rigorous experimentation and optimization, show that a commendable classification accuracy of 93% can be achieved and demonstrate real-time prediction using Nvidia Tesla P100 and V100 GPUs.
- High accuracy and swift inference underscores the potential of ConvLSTM in advancing safety measures for high-speed UGVs, cementing its role in the next generation of autonomous navigation systems.

Motivation

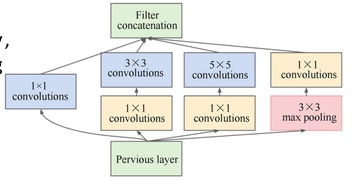
This research introduces a cutting-edge approach for the real-time assessment of forward collision risks in high-speed UGVs.
Forward collision warning (FCW) is an important feature in driver assistance and automated driving systems, where the goal is to provide correct, timely, and reliable warnings to the driver before an impending collision with the vehicle in front.
This substantial result showcases the potential of ConvLSTM in enhancing the safety measures for high-speed UGVs and furthering the capabilities of autonomous systems.

$$\textbf{Recall} = \frac{True\ Positives}{True\ Positives + False\ Negatives} \quad \textbf{Precision} = \frac{True\ Positives}{True\ Positives + False\ Positives}$$

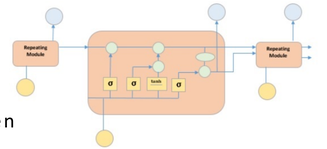
The metrics "Recall" and "Precision" evaluate the performance of the model. Recall assesses the model's ability to correctly identify the positive class, while Precision gauges the proportion of instances labeled as positive that are truly positive. Given that collisions are infrequent events, the occurrences when they do happen are of paramount importance and warrant close attention.

Approach

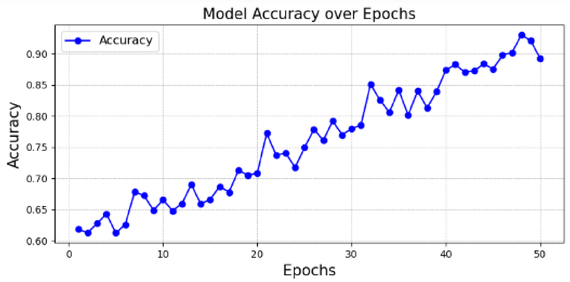
An Inception Module is an image model block that aims to approximate an optimal local sparse structure in a CNN. Put simply, it allows for us to use multiple types of filter size, instead of being restricted to a single filter size, in a single image block.

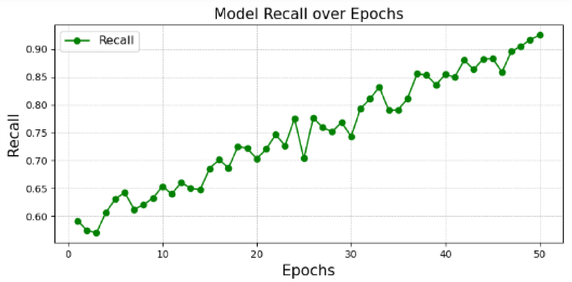


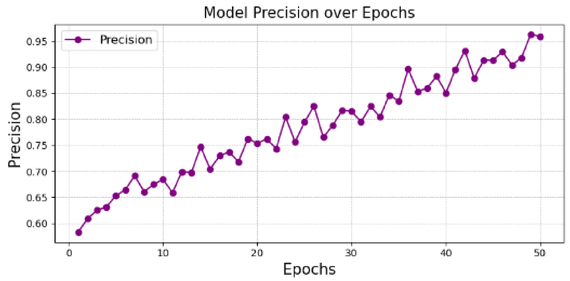
The image features are passed to the LSTM layers. It is a special kind of recurrent neural network that is capable of learning long Term dependencies in data. This is achieved because the recurring module of the model has a combination of four layers interacting with each other.

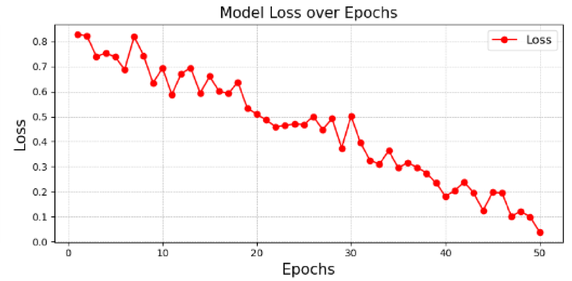


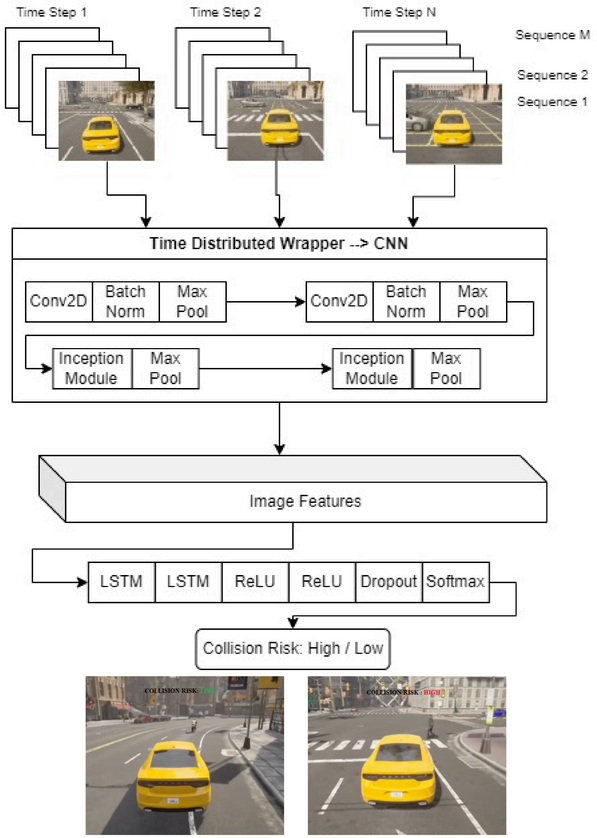
The model takes as input a sequence of images, performs multiple operations and uses the sigmoid function to output a number between 0 and 1, classifying the collision risk as “High” or “Low”.











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