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Tolerância a Falhas Aplicada no Treinamento de Redes Neurais

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Abstract

Object detection is performed today using Convolutional Neural Networks (CNNs). Errors in a CNN execution can modify the way the vehicle sense the surrounding environment, potentially causing accidents.

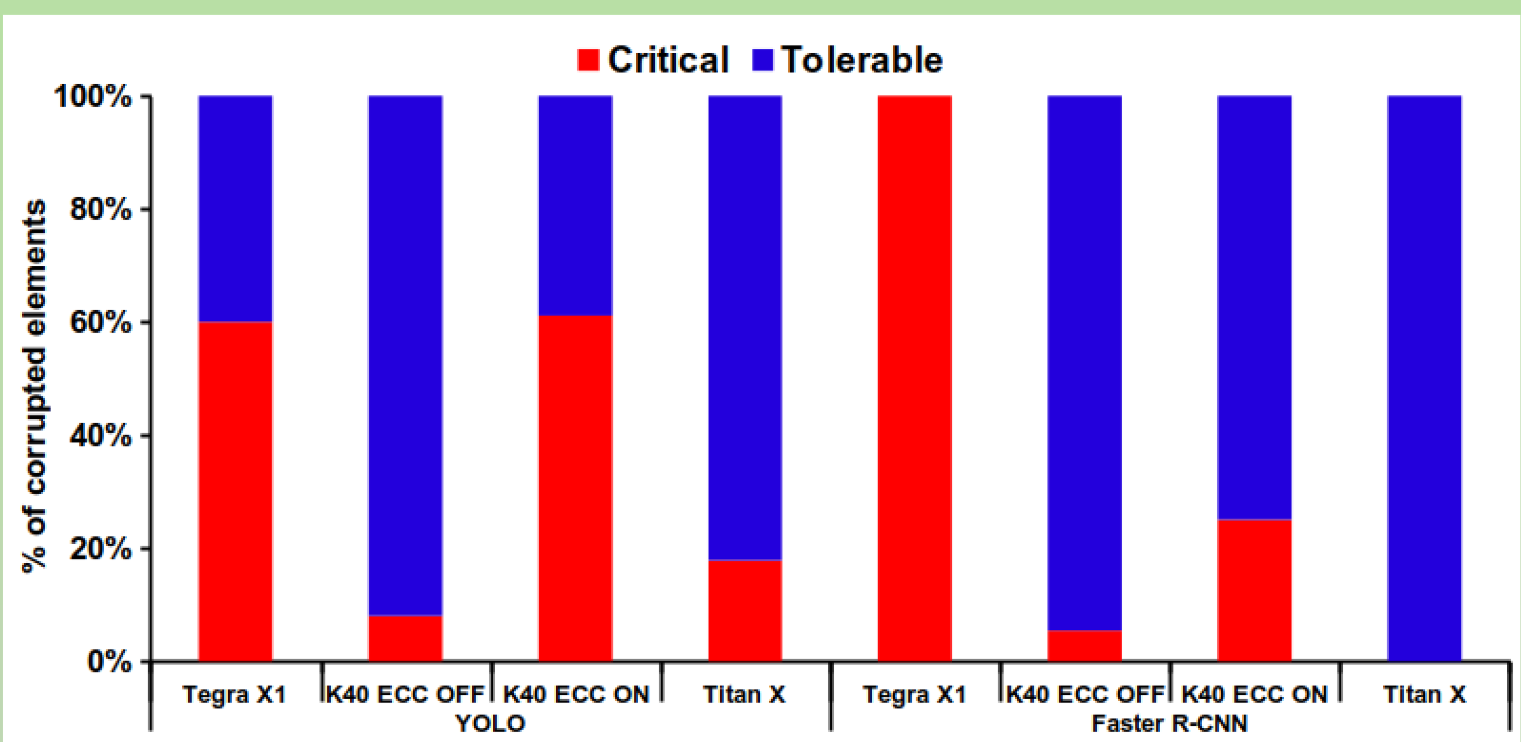
In this paper, we present an error detection solution for CNN based on the correlation between subsequent frames and the respective detected objects.

We implemented and validated the detection strategy, utilizing data from previous radiation experiments.

Background

Convolution Neural Networks (CNNs) are a class of Deep Neural Networks (DNNs) that efficiently perform object detection. CNNs are extensively used in today's self-driving vehicles to detect objects in real-time.

Not all the SDCs are \textit{critical} for object detection. SDCs that modify the probability in such a way that does not impact an object's rank or changes the coordinates of a low-probability BB are not considered critical. Additionally, an SDC that changes the BB coordinates but still allows a sufficiently good detection can also be considered as tolerable.

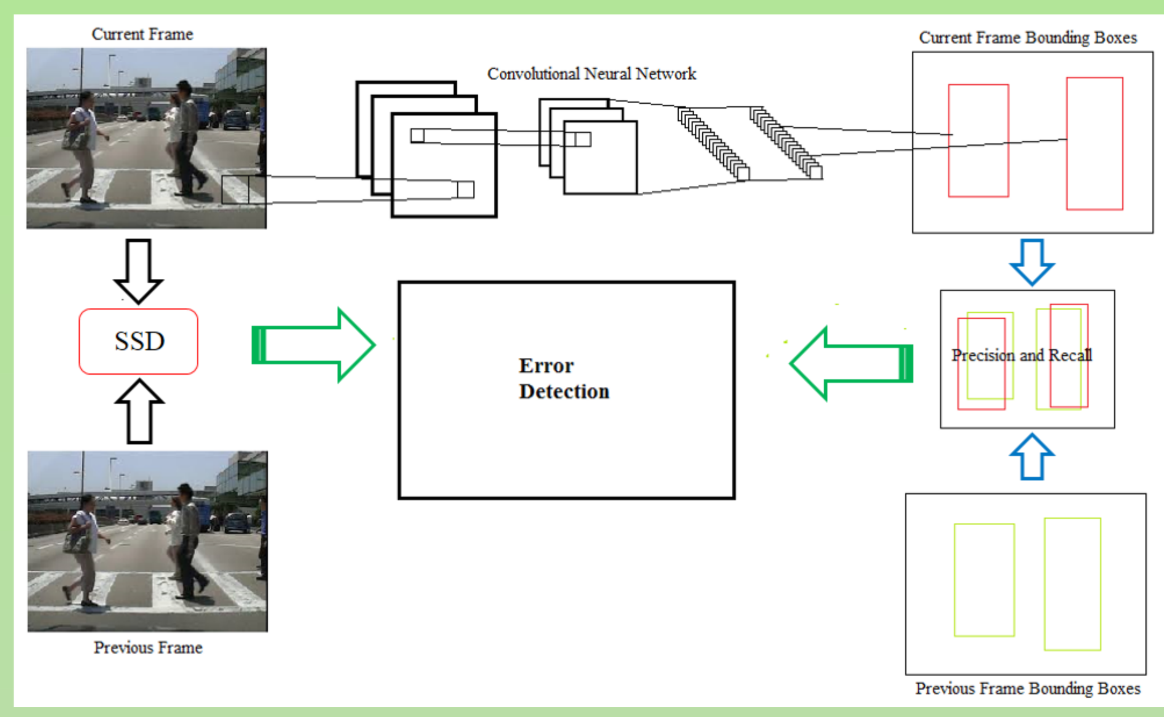


The figure shows the percentage of critical errors (i.e., detection is significantly modified) and tolerable errors (i.e., detection is sufficiently good) observed during the radiation experiments.

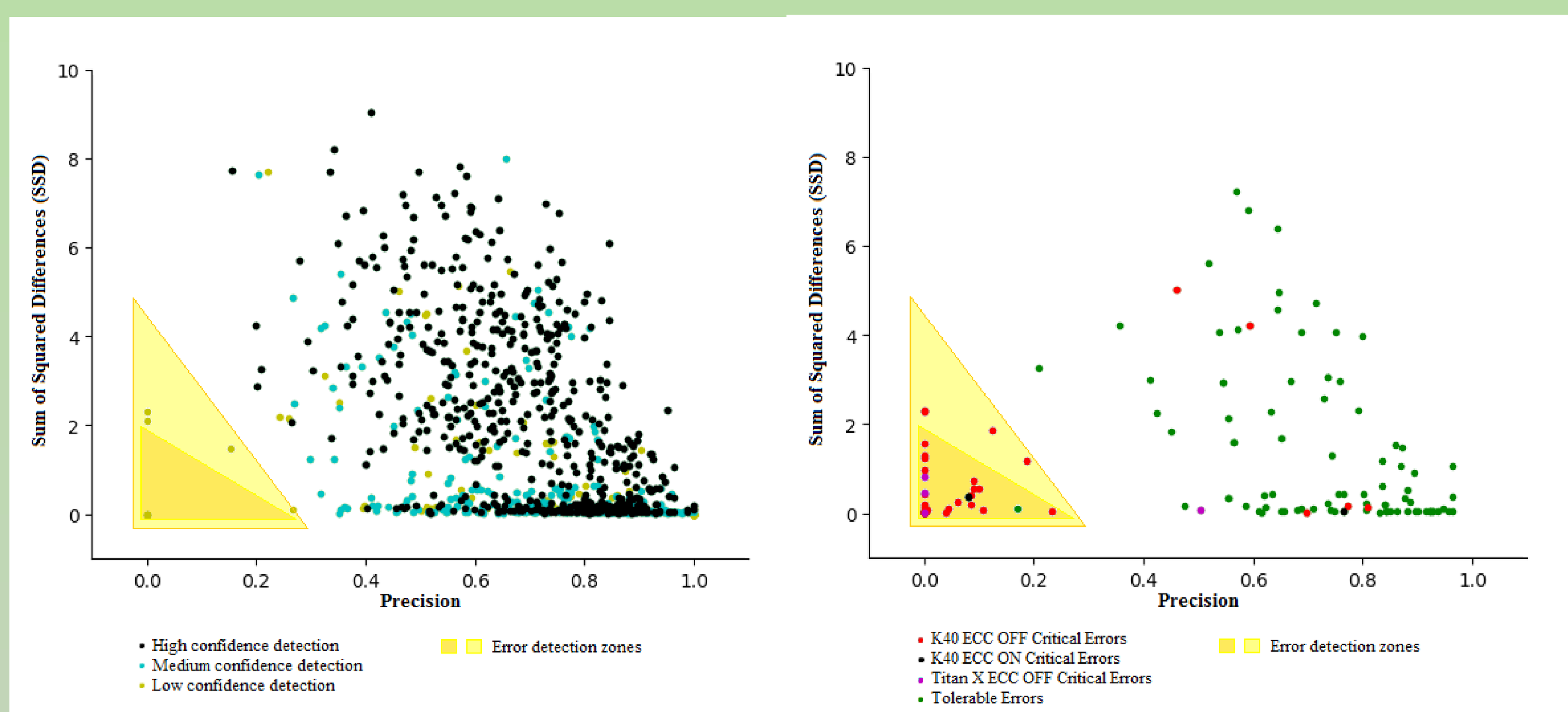
Idea

If nothing moves on a video, the frames will be very similar and the outputs of the CNN will also be very similar. On the other hand, if all the objects in a scene move a lot, both the detection and the input image will change significantly.
We aim at demonstrating that the correlation between the input variation and the output variation can be fruitfully exploited to detect errors.

To compare images, we will use a standard image comparison algorithm, the Sum of Squared Differences (SSD). To compare the detection of a frame with the detection computed for the previous frame we measure the Precision and Recall between the Bounding Boxes of the two outputs. With both measures taken, we find out which combinations can never occur.



Results



We first evaluate the feasibility of the approach by analyzing the frames and detection correlation of a fault-free execution. Then, we run our strategy based on the data sample and prove that we can detect up to 80% of experimentally observed critical errors.

Future Work

In future work, we plan to implement other fault tolerance techniques, including training the neural network in different ways, so that it becomes naturally more resilient to errors. We will do that by finding more stable areas on the error function during training.