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Error Detection in Neural Networks Using Spatio-Temporal Correlation

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Object detection, a critical feature for autonomous vehicles, 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 or unexpected behaviors. The high computational requirements of CNNs combined with the need to perform detection in real-time allow little margin for implementing error detection.

In this project, an extremely efficient error detection solution for CNN is presented, based on the observation that, in the absence of errors, the differences between the input frames and the detection provided by the CNN should be strictly correlated. In other words, if the image between two subsequent frames does not change significantly, the detection should also be very similar. Similarly, if the detection varies considerably from a frame to the next, then the input image should also have been different. Whenever input images and output detection don't correlate, it is possible to detect an error. To compare the inputs, the Sum of Squared Differences algorithm is used and to compare the output, the Precision and Recall scores are used.

After formalizing and evaluating the inter-frame and output correlation thresholds, the detection strategy is implemented and validated, utilizing data from previous radiation experiments and fault-free executions of the neural networks. Exploiting the intrinsic efficiency in processing images of devices used to execute CNNs, up to 80\% of radiation-induced errors were detected while adding low overhead. The error detection method is still being tested in fault-free environments, with the goal of detecting incorrect detections made by the neural networks in normal circunstances.