CURE-TSR : Challenging Real and Unreal Environments for Traffic Sign Recognition

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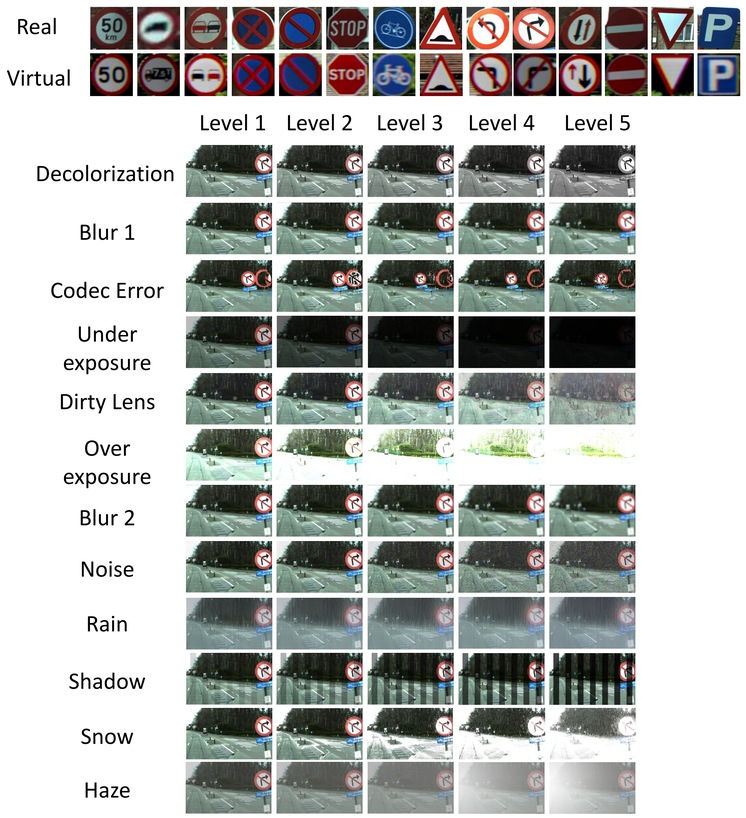
Introduction

- In this paper, we investigate the robustness of traffic sign recognition algorithms under challenging conditions.
- Existing datasets are limited in terms of their size and challenging condition coverage, which motivated us to generate the Challenging Unreal and Real Environments for Traffic Sign Recognition (CURE-TSR) dataset. It includes more than two million traffic sign images that are based on real-world and simulator data.
- We benchmark the performance of existing solutions in real-world scenarios and analyze the performance variation with respect to challenging conditions.
- We show that challenging conditions can decrease the performance of baseline methods significantly.
- We also investigate the effect of data augmentation and show that utilization of virtual data along with real-world data enhances the average recognition performance.

Dataset Generation and Visualization

- In order to create realistic challenging scenarios, we generate challenging condition types and levels for entire scenes.
- The traffic signs are then cropped from such scenes.
- Each row in the figure below corresponds to a challenging condition and each column corresponds to a certain level of the condition.



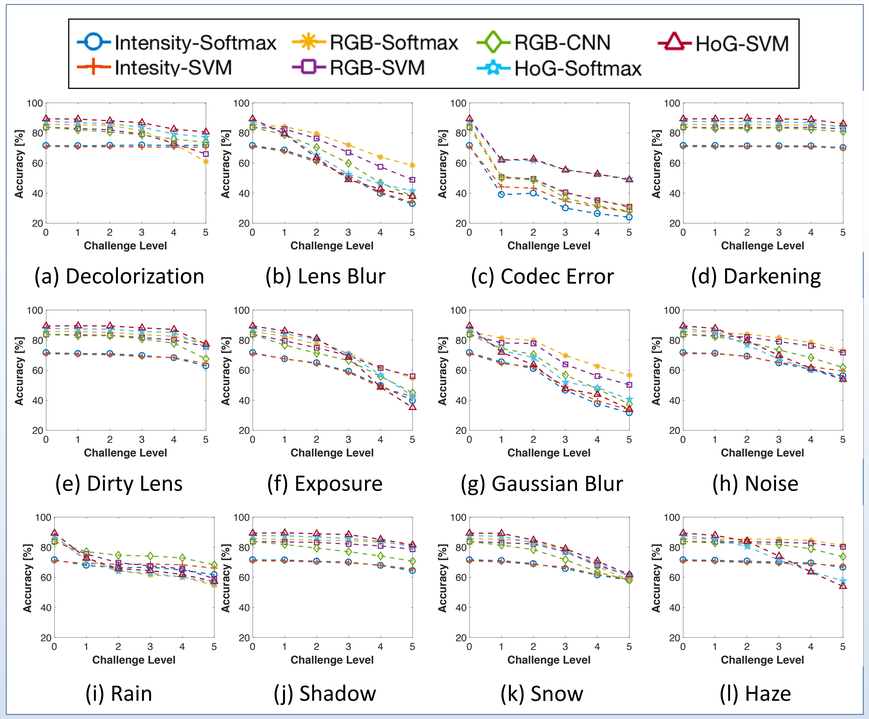
Dataset – Number of Images

Image Types	Training	Testing
Real Challenge-Free	7,292	3,334
Real Challenge	437,520	200,040
Virtual Challenge-Free	19,610	8,210
Virtual Challenge	1,078,550	451,550

Dataset - Usage

- To study traffic sign recognition under challenging conditions
- Studying data augmentation techniques when traditional augmentation techniques fail.
- Studying regularization techniques when data is imperfect.
- Domain adaptation between virtual and real-world images.

Dataset - Performance Benchmarks

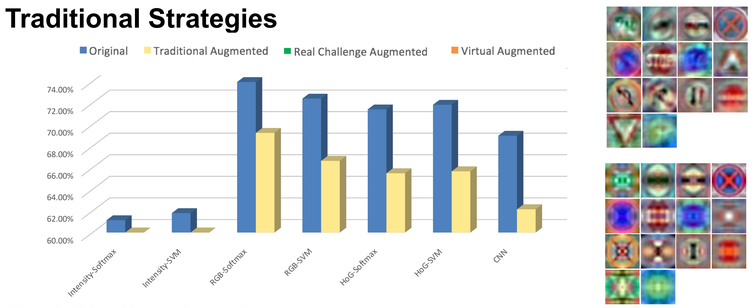


Dataset – Performance Benchmark Observations

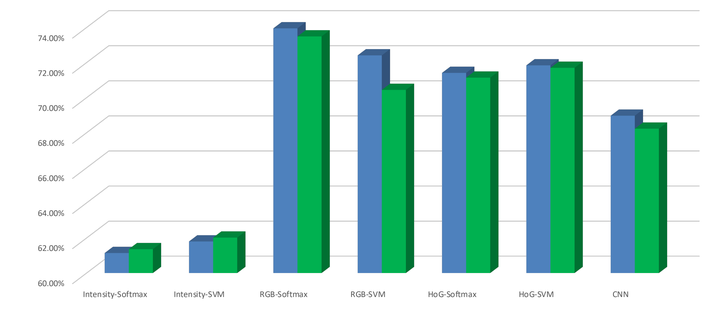
- Challenging conditions perturb original representation space to deceive classifier.
- Different challenges have their different and characteristic degradation slopes.
- Decolorization, Darkening and Shadow have relatively consistent performance across challenge levels and algorithms.
- Lens blur, Codec error, Exposure and Gaussian blur show severe performance degradation.

Data Augmentation

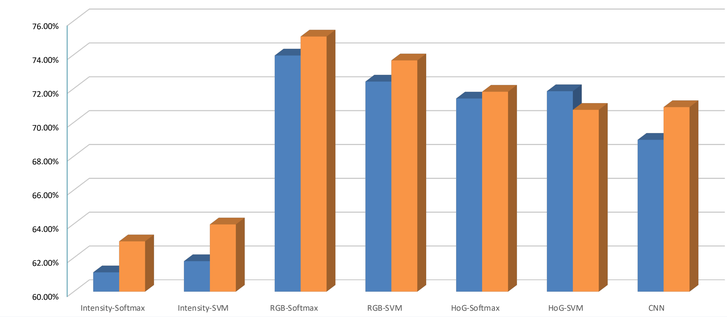
Traditional Strategies



Real Challenging data



Virtual data



Contributions

- We introduce the most comprehensive publicly-available traffic sign recognition dataset with controlled challenging conditions.
- We provide a detailed analysis of the benchmarked algorithms in terms of their recognition performance under challenging conditions thereby identifying the vulnerabilities of algorithms.
- We provide images that originate from captured sequences as well as synthesized sequences, that lead to a better understanding of the relationship between real-world and virtual data in terms of algorithmic performance. This understanding can be utilized to generate algorithmically invariant virtual datasets and minimize the need for real-world data collection that require significant resources.
- We use diverse data augmentation methods and show that utilization of limited virtual images along with real-world data can enhance the recognition performance even when the domain difference is not addressed.