

Surface Status Classification Utilizing Image Sensor Technology and Computer Models

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Abstract:

This thesis is devoted to various methods for determining the status of a road surface. Information about the surface is obtained from various sensors, and this information must be analyzed to classify road conditions appropriately for road users, road maintenance staff and automated warning systems.

In the first phase of the research, a few traditional road-mounted sensors were analyzed regarding their ability to determine the road conditions and the impact on their measured values when they were exposed to contamination agents such as glycol and oil. The rest of the thesis is directed towards non-contact methods for determining the status of the road surface. Traditional camera technology together with computer models have been used to find a method that can remotely determine the conditions of the road surface. In addition to images from these cameras working in the visible range, data from the Swedish Transportation Administration road weather stations have been used to develop road statusclassification models. Field observations have also been performed to get the ground truth for developing these models. In order to improve the ability to accurately distinguish between different surface statuses, measurement systems involving sensors working in the Near-Infrared (NIR) range have been utilized. The final section of this thesis describes the development of an imaging method for classifying road conditions based on a novel NIR camera technology. As a concluding part of the thesis, the performance of the developed NIR camera system will be evaluated. The data retrieval for this evaluation was carried out during the winter 2013-2014.

The research is mainly based on empirical studies. To begin with, literature studies have been carried out to find the latest state of the art research and technology. A large part of the research has involved planning and setting up laboratory experiments to test and verify hypotheses that have emerged from the literature studies. Finally, the laboratory experiments and results have been verified by performing field tests.

The performance of traditional sensor technologies was evaluated and it was discovered that some of them could be used even with future user-friendly deicing chemicals. The findings from using visual camera systems to determine the road status showed that they provide previously unknown information about road conditions. However, it was found that some road status conditions, such as black ice, could not be addressed accurately using traditional meteorological data and visual cameras. By utilizing sensors operating in the NIR spectra, it was found that by using spectral analysis of NIR images it was possible to detect and classify road conditions that have not been possible to detect before. When using images covering different spectral

regions together with advanced computer models it was possible to correctly classify the road conditions of a road surface area. These results led to the development of an NIR spectral imaging system for road condition classification. Finally, two prototypes of this novel and cost-effective NIR imaging system for road status classification were evaluated during a field test. The field test was performed during the winter 2013-2014 using two prototype units installed at the roadside of E14 at both sides of the border between Sweden and Norway. The results from this field test showed that this new NIR spectral imaging system provides previously unknown knowledge about situations when the road conditions differ in and between the wheel tracks.