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Examiner's report
Pavel Najman's PhD thesis on "Vehicle Speed Measurement Using Stereo Camera Pair"

The thesis deals with the challenging problem of measuring the speed of vehicles using a stereoscopic approach. It makes two major contributions to the field. First, a novel two-stage approach for the calibration of a stereoscopic camera pair that is suitable for surveillance applications is proposed. Second, a novel vehicle speed measurement is proposed. Both approaches bear a common core processing pipeline which has been tailored for vehicle applications. The two approaches have been evaluated and compared against the state of the art to demonstrate the advance in the field as well as its industrial potential. Critically, the method has been demonstrated to meet the official requirements by the OIML thus demonstrating its practical relevance to the industry.

The thesis is 64-page long and consists of eight chapters plus a bibliography section. The thesis is well written and follows a logical progression: after an introduction of the problem (Chapter 1) and a survey of the relevant literature (Chapters 2-4), the proposed approaches for stereo camera calibration and vehicle speed measurement are formulated (Chapter 5), before being experimentally validated (Chapter 6). The final chapters reflect on possible applications and future work (Chapter 7) and conclude the thesis (Chapter 8). In addition to the thesis, a 37-page PhD thesis summary is provided as well as a list of publications by the candidate. Below, I provide a more detailed review of each chapter.

Chapter 1 provides a general introduction to the research and its context. It defines the main scientific goal and the research question. The main contribution and the structure of the thesis are clearly outlined.

Chapter 2 introduces the necessary background pertaining to image acquisition and processing including camera modelling and stereoscopic image processing. It also introduces the selected object detection and tracking methods. This provides a solid foundation for the development of the novel approaches later on in the thesis.

Chapter 3 conducts a comprehensive survey of existing speed measurement approaches splitting them into intrusive and non-intrusive technologies, and in each case providing a classification

based on the measurement modality. The chapter also covers the regulatory aspect of speed measurement which provides the rationale for the hypothesis that was formulated in the introduction.

Chapter 4 narrows down the survey to the specific area where the thesis is making a contribution, namely stereoscopic speed measurement and long-distance calibration. Considering the limited number of previously proposed solutions, the thesis concentrates on giving a detailed description of each of the proposed approaches discussing in each case their capabilities and shortcomings.

Chapter 5 is the core methodology chapter of the thesis where the two major advances over the state of the art are presented. The first major contribution is the introduction of a novel approach for speed measurement. This builds on a number of advanced signal processing and computer vision techniques which have been carefully tailored and integrated into an innovative pipeline that for the first time is capable of meeting the OIML requirements as will be evidenced in the subsequent chapter. The second major contribution is the introduction of a novel long-distance stereo camera calibration approach which splits the process into two phases, namely an off-site calibration which targets the static parameters followed by an on-site calibration dealing with parameters likely to vary during transport or installation. The two approaches share some common processing backbone leveraging license plate recognition technology and robust feature point tracking amongst other techniques. The two approaches are well developed.

Chapter 6 conducts an experimental validation of both contributions using a new dataset acquired for this purpose by the candidate. The evaluation is thorough and includes comparisons against all the existing approaches that were reviewed in Chapter 4. One shortcoming of the evaluation is that the absence of a common benchmark dataset preventing a direct comparison of all methods on the same dataset. This limitation is mitigated well by comparing instead across datasets and discussing their different characteristics. I found the evaluation to be comprehensive and very well conducted. It provides a clear analysis of the advance made over the state of the art, supported by quantitative analyses on a large dataset. The proposed approach is the first stereo camera speed measurement system that meets the OIML requirements which is a significant achievement that has potential to impact the industry.

Chapter 7 and 8 conclude the thesis by discussing possible applications and avenues for future and summarising the achievements.

In summary, the thesis of Pavel Najman makes two important and timely contributions to the field through the introduction of novel approaches for vehicle speed measurement and long-distance calibration. Both contributions have been thoroughly evaluated to demonstrate the advance made over the state of the art and validate the formulated hypothesis. The research has resulted in two high quality journal papers (one listed as undergoing minor revision which I believe has now been accepted, another one listed as under review). These two publications complement the existing portfolio of publications by the candidate which indicate his research erudition and aptitude for high quality research.

For the aforementioned reasons, I firmly believe that the doctoral thesis meets the requirements of the proceedings leading to the PhD title conferment and I therefore recommend that the candidate should be awarded the PhD degree.

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