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The Zandman-Slaner Graduate School of Engineering

Real Time Methods for Restoration, Enhancement and Analysis of Videos with Applications in Intelligent Transportation Systems

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THESIS SUBMITTED TO THE SENATE OF TEL-AVIV UNIVERSITY

in partial fulfillment of the requirements for the degree of

"DOCTOR OF PHILOSOPHY"

Under The Supervision of Prof. Leonid P. Yaroslavsky – The Iby and Aladar Fleischman Faculty of Engineering, Tel-Aviv University

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June 2008

Abstract

Image and video enhancement is a core enabling technology in many fields. Nonetheless, several important questions such as multiframe restoration, enhancement and analysis of video streams, acquired in time-varying and unknown system and environmental conditions, remain unsolved. While many methods have been proposed throughout the years for solving multiframe restoration problems, well-established restoration methods exist for situations in which all sources of blur and degradation are known or easily predicted. When some of the parameters are unknown, however, the problem becomes much more difficult. The presented research addresses the following challenges: (i) efficient and robust motion estimation techniques; (ii) Real time methods for video stabilization and super-resolution in instable, due to camera and environmental noise, videos; and (iii) Motion-based scene analysis and reasoning.

At first motion estimation techniques are evaluated through a novel comparison framework. Based on the evaluation of these methods, an improvement, through numerical exact derivation, is suggested for the optical-flow class of motion estimation techniques.

Evaluation of the motion field and its statistical analysis allows a reliable segmentation of video frames into stable and moving components and subsequently stabilizing images, without harming real moving objects, and improving frames resolution. Along with the development of real-time methods for image stabilization and super-resolution, the potential and limitations of utilizing the motion field of instable sequences for super-resolution are sought. An important part in the process of resolution enhancement is signal reconstruction from sparse data accumulated from the set of randomly displaced image frames. The method used is improved by the theory of discrete signal reconstruction from sparse data.

Finally, based on the earlier stages, the accurate motion analysis along with image stabilization and resolution enhancement methods are utilized for providing means for reasoning the scene observed. This, for example, allows detection of irregularity of the motion in the scene. In traffic application, this corresponds to congestion or accidents.

The results presented are of both theoretical and practical interest and offer new efficient tools for substantial improvement of infrastructure of vision-based systems in general and of intelligent transportation systems in particular.

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