University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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"Low-Complexity Multi-Dimensional Filters for Plenoptic Signal Processing"

Department of Electrical and Computer Engineering

Thursday, November 26, 2015
8:30 A.M.
Engineering and Computer Science Building
Room 468

Supervisory Committee:
Dr. Leonard T. Bruton, Department of Electrical and Computer Engineering, University of Victoria (Co-Supervisor)
Dr. Panajotis Agathoklis, Department of Electrical and Computer Engineering, UVic (Co-Supervisor)
Dr. Yang Shi, Department of Mechanical Engineering, UVic (Outside Member)

External Examiner:
Dr. Anton Kummert, Department of Electrical and Computer Engineering, University of Wuppertal

Chair of Oral Examination:
Dr. David Atkinson, Department of Geography, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Five-dimensional (5-D) light field video (LFV) (also known as plenoptic video) is a more powerful form of representing information of dynamic scenes compared to conventional three-dimensional (3-D) video. In this dissertation, the spectra of moving objects in LFVs are analyzed, and it is shown that such moving objects can be enhanced based on their depth and velocity by employing 5-D digital filters, what is defined as depth-velocity filters. In particular, the spectral region of support (ROS) of a Lambertian object moving with constant velocity and at constant depth is shown to be a skewed 3-D hyperfan in the 5-D frequency domain. Furthermore, it is shown that the spectral ROS of a Lambertian object moving at non-constant depth can be approximated as a sequence of ROSs, each of which is a skewed 3-D hyperfan, in the 5-D continuous frequency domain.

Based on the spectral analysis, a novel 5-D finite-extent impulse response (FIR) depth-velocity filter and a novel ultra-low complexity 5-D infinite-extent impulse response (IIR) depth-velocity filter are proposed for enhancing objects moving with constant velocity and at constant depth in LFVs. Furthermore, a novel ultra-low complexity 5-D IIR adaptive depth-velocity filter is proposed for enhancing objects moving at non-constant depth in LFVs. Also, an ultra-low complexity 3-D linearphase IIR velocity filter that can be incorporated to design 5-D IIR depth-velocity filters is proposed. To the best of the author's knowledge, the proposed 5-D FIR and IIR depth-velocity filters and the proposed 5-D IIR adaptive depth-velocity filter are the first such 5-D filters applied for enhancing moving objects in LFVs based on their depth and velocity.

Numerically generated LFVs and LFVs of real scenes, generated by means of a commercially available Lytro light field (LF) camera, are used to test the effectiveness of the proposed 5-D depth-velocity filters. Numerical simulation results indicate that the proposed 5-D depth-velocity filters outperform the 3-D velocity filters and the four-dimensional (4-D) depth filters in enhancing moving objects in LFVs. More importantly, the proposed 5-D depth-velocity filters are capable of exposing heavily occluded parts of a scene and of attenuating noise significantly. Considering the ultralow complexity, the proposed 5-D IIR depth-velocity filter and the proposed 5-D IIR adaptive depth-velocity filter have significant potentials to be employed in real-time applications.