Western Australia Section

Joint Chapter ESP:
Electron Devices Society
Solid State Circuits Society
Photonics Society

Self-adaptive Biologically Inspired Signal Processing for Salience Enhancement

A Seminar of the IEEE WA joint EDS/SSCS/IPS Chapter

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Venue: **Billings Room 3.04, 3rd floor. Electrical & Electronic Engineering Building**
University of Western Australia, Crawley

This seminar is open to the public and admission is free to all IEEE members and non-members

Biography:

Russell completed Bachelor's degrees in both Science and Biomedical Engineering at Flinders University in 2000. Following this he completed a PhD in neuroscience in 2004 at the Department of Physiology, University of Adelaide. Russell then joined the Insect Vision Laboratory at the University of Adelaide first as a Post Doctoral Researcher, then as an ARC Research Fellow (Industry). Russell completed a Graduate Certificate in Education in 2008 and took up a lecturing position in Mechanical Engineering at The University of Adelaide in 2010. Russell moved to the University of South Australia in 2011 as a Senior Lecturer and later the Program Director for the Masters of Autonomous Systems within the School of Engineering. In 2012 Russell was recognised as one of the young South Australian scientists of the year. In late 2019 Russell joined the Centre for Maritime Engineering at Flinders University as an Associate Professor of Autonomous Systems. Russell's research interests include self-adaptive biologically inspired signal processing for use in robotics and surveillance and the student transition into tertiary education.

Abstract:

There is a vast amount of visual information available and despite digital cameras being ubiquitous they can fail at the tasks they are assigned. This is because traditional cameras, and the processing behind them, are designed to capture data from the world as accurately and completely as possible. While this sounds optimal the limitations are clear when the enormous dynamic range of unconstrained environments needs to be compressed into a bandwidth suitable for storage and processing. This is exacerbated in complex environments by systems applying the same exposure time across the entire image sensor, resulting in saturation of brightly lit regions and noisy washed-out darker regions. Unlike traditional cameras biological eyes attempt to capture as much information as they can from the world, rather than trying to directly replicate it. While they do discard absolute luminance they more than make up for it by preserving, and enhancing, local contrast while minimising saturation. Biological eyes have a multi-stage adaptation process resulting in scene invariance and have unique processing steps that efficiently extract high-order information from an image, such as optic flow and the presence of small/weak-signature targets in clutter.

The multi-stage, non-linear, dynamic processing that goes on within the visual systems of animals has been modelled and applied to both visible and infrared data. The technique, called the Biologically-Inspired Vision (BIV) model, enhances small targets in visually adverse scenarios by improving pixel-wise irradiance quantisation, self-adapting to scene luminance changes and enabling fine details to be extracted persistently across day and night scenes. The BIV has been used to look at the estimation of optic flow as well as detecting small/weak-signature unmanned targets in clutter, where a doubling of detection performance and large increases in local contrast were found. The true benefit of the BIV is at long range; it reduces the false alarm rate by correctly extracting legitimate targets from environmental clutter. Furthermore, this processing is not limited to EM spectrum data with application in the audio domain also yielding increases in tracking ranges.

The key feature to the BIV is independent adaptation at each pixel within the image. This means that the information captured by each detector is maximised, irrespective of scene content. This ability to constantly adapt to the changing environment gives the best possible performance under all situations, particularly when things are poorly or variably lit. Depending on the goal of the system it is possible to: enhance imagery for human observers or object classification tasks, reduce the redundancy in the data, measure optic flow from moving objects, estimate ego-motion from a moving platform, and/or detect small targets in cluttered backgrounds. As a pre-processing filter, the BIV significantly enhances the capabilities of existing image capture systems to handoff very small targets to existing deep learning models for automated identification and classification.