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Subject Area	Sensor, Actuator and Communication Systems
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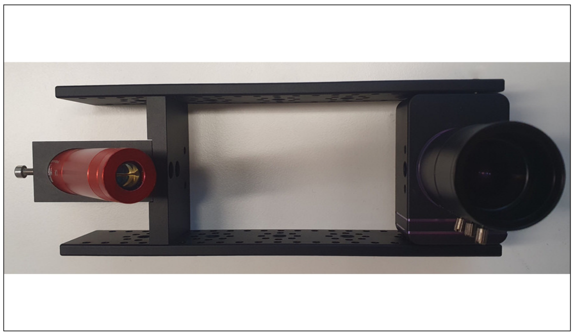
Neuromorphic Vision Based 3D Laser Mapping and Robot Control



The developed laser triangulation sensor
Own presentment

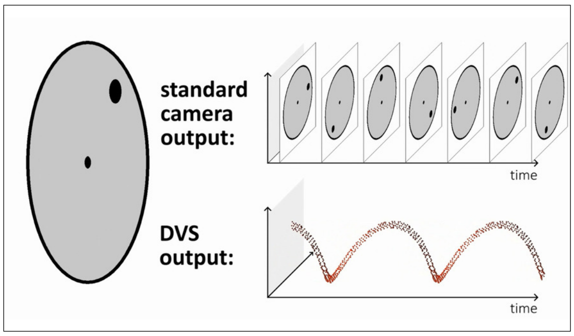
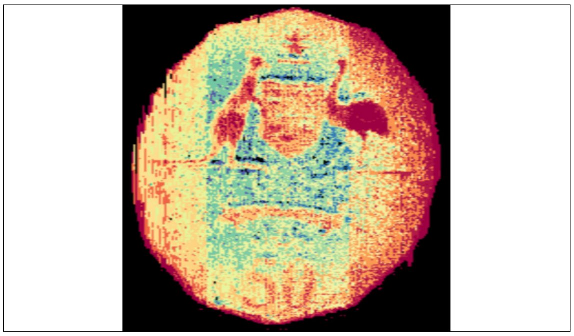


Illustration of the working principle of Dynamic Vision Sensors (DVS)
Davide Scaramuzza. Tutorial on Event-Based Cameras.



3D rendering of an Australian fifty cent coin featuring the Commonwealth Coat of Arms.
Own presentment

Introduction: Laser triangulation based depth sensors are commonly used in industrial applications for quality inspection in assembly lines, as well as for robot guidance in manufacturing processes.
Nowadays, such systems are typically designed with traditional image sensors, which provide low dynamic range and high data redundancy.
Due to the limited dynamic range, the sensors are often unable to accurately capture the scenery if the illumination varies significantly. In order to overcome this problem with conventional sensors, applying a high-power laser is often required.
Moreover, the high data redundancy typically results in the necessity for application specific integrated circuits to be used in order to perform well at high sampling rates. However, despite containing such circuitry, the sensors are often incapable of delivering the sampling rates that they are advertised with, unless a reduced region of interest is configured.

Approach: To overcome these issues, this thesis implements a laser triangulation system based on a neuromorphic vision sensor in combination with an off-the-shelf embedded computer with a 5kHz sampling rate for the full sensor range.
The design and behaviour of neuromorphic vision sensors (also known as dynamic vision sensors or silicon retinae) are inspired by the mammalian retina. Whereas traditional vision sensors create stroboscopic images at fixed time intervals, these sensors generate events upon changes in the measured scenery. Due to the sparsity and asynchrony of the data, these sensors are well suited for low latency and high speed applications. As each of the pixels in the sensor array operates independently, neuromorphic vision sensors offer a significantly higher dynamic range than traditional vision sensors.

Result: The system developed in this thesis takes advantage of the superior dynamic range of these sensors, as well as the high-resolution temporal information in the event stream and the sparsity thereof, in order to extract the laser line from the visual data. Based on the extracted laser line, a mapping into three dimensional physical space was designed for a reconstruction of the scenery.
In addition, a calibration of the required parameters was implemented, as well as two applications of the triangulation sensor in combination with a linear axis. The first application is a linear axis controller based on the visual information, whereas the second implements the creation of a three dimensional map of scanned scenery.
The resulting sensor generates profiles at 5kHz with an accuracy of less than 1mm, in addition to which the control loop has shown end-to-end latencies of less than 10ms.