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Large-scale 3D Particle Tracking with Dynamic Vision Sensors

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Motivation

Visualization of flows in wind tunnel testing can provide better insights into the problem at hand. The complexity, cost and responsiveness of the visualization method is of crucial importance for practical use. In this work we aim to develop a cost-effective and fast visualization method based on tracking helium-filled soap bubbles in real time with a set of novel cameras

Dynamic Vision Sensor (DVS)

The DVS was developed at the Institute of Neuroinformatics, University of Zürich[1]. It can be considered as a special type of "smart" camera since follows an event-driven approach. Each pixel independently registers any change of relative intensity and generates an event, composed of the pixel identification, the time instant of the change and its sign. The result is a continuous stream of events that is to a computer for further analysis.

The high temporal resolution of 1μs allows to capture very fast processes, this can otherwise only be achieved by high speed cameras. The advantage with the DVS is the inherent reduction of data, since only the changes in the scenery are recorded, allowing to achieve fast data transmission and post-processing on standard hardware. At the moment the main limitation is the low resolution of 128x128 pixels.

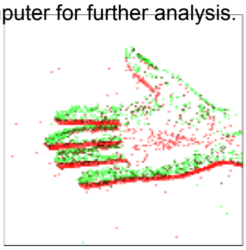

Figure 1 Moving hand as detected in a 2ms time window. Displayed events are increases and decreases of local intensity.

Helium Filled Soap Bubbles

Helium filled soap bubbles are used as neutrally buoyant tracers with low inertia and good visibility.

A new type of bubble generator was developed for better control of the bubble size and generation rate [2]. Bubble formation is initiated in a microfluidic T-junction, bringing together the soap solution and helium to form a gas-liquid slug flow. The bubble weight and size are defined by the volume of each phase. A micro-valve controls the precise amount of soap solution and the ejection timing.

Figure 2 Left: Elements of the bubble generator. Right: Time lapse of bubble formation at the nozzle.

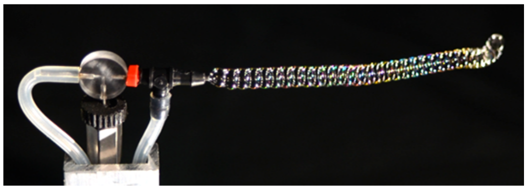

Figure 3 Example of mono-disperse bubble generation (here: fused bubble chain before flow-induced separation).

Measurement

For a 3D reconstruction of the particle tracks at least 2 cameras at different viewpoints are required. In the present system a third camera is used to increase the probability of detection and to minimize the appearance of ghost particles, where by chance the images of two different particles on two cameras might appear to stem from a non-existing "true" particle.

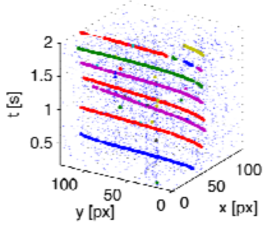

Figure 4 Tracks identified in a single DVS camera view. The small blue dots depict all registered events, the color-coded tracks are the result of Kalman filtering.

A Kalman filter is used to track the bubbles in each camera. Subsequent matching of candidate tracks between then cameras is then employed to reconstruct the 3D path-lines. The result is the bubble position as a function of time, from which the local velocity can be derived as well.

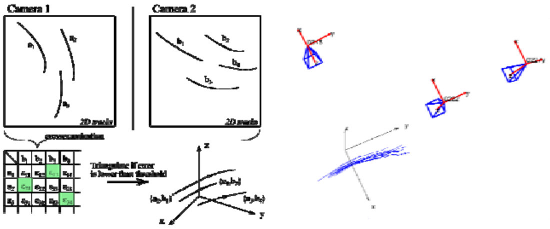

Figure 5 Left: Pair-wise correlation between tracks, if the tracks match, they are triangulated. Right: Example of reconstruction in 3D with position of cameras.

References

[1] Lichtsteiner, P., Posch, C., Delbruck, T. & Member, S. *Temporal Contrast Vision Sensor*. Work 43 (2), 566–576, 2008.

[2] Borter G., *Erzeugung von neutraldichte Seifenblasen aus einer Zweiphasenströmung in Mikrokanälen*, MSc. Thesis ETH Zürich, 2013.