

Balancing Pencils using Spike-Based Vision Sensors

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<http://www.ini.uzh.ch/~conradt/PencilBalancer>

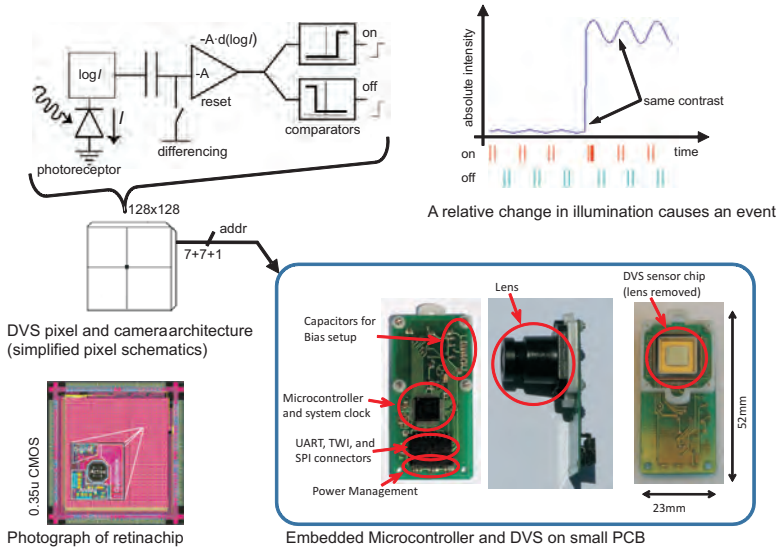


Technische Universität München



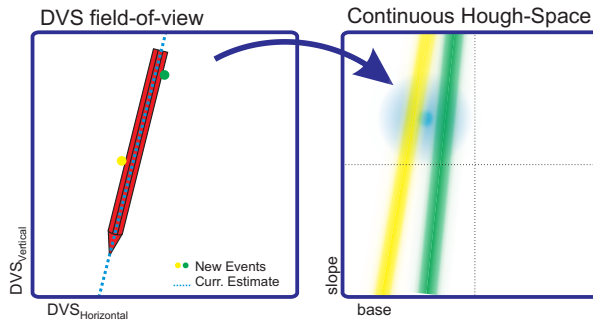
Embedded Dynamic Vision Sensor

Retina Output Cells respond to relative intensity change (contrast)



2D Line Tracking Algorithm

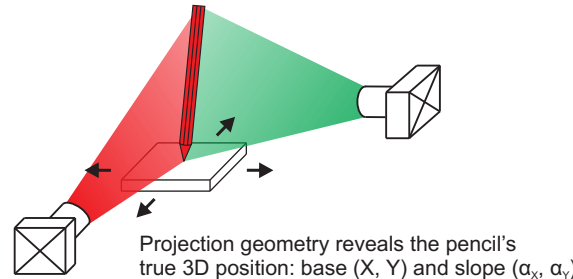
Continuous Hough Transform for each of 2 DVSs individually



Each incoming event (yellow and green) updates the current estimate for the pencil's base and slope, shown as blue line (left in visual space) and blue Gaussian (right in Hough-Space)

3D Pencil Tracking

Combining 2 independent estimates into a 3D-position



Balancing Controller

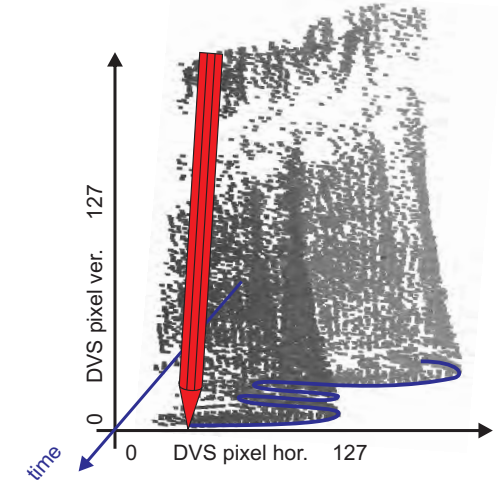
Standard PD control at 500Hz update rate

$$X_{des} = g_P X + g_a \alpha_x + g_D \dot{X}$$

$$Y_{des} = g_P Y + g_a \alpha_y + g_D \dot{Y}$$

g_P, g_a, g_D : gains
 X, Y : positions
 α_x, α_y : tiltangles

Balancing Performance



Space-time plot of 54k events (dots) reported from one DVS sensor during balancing in a time window of 240ms. The pencil's base over time and the last tracked position are shown in blue and red.

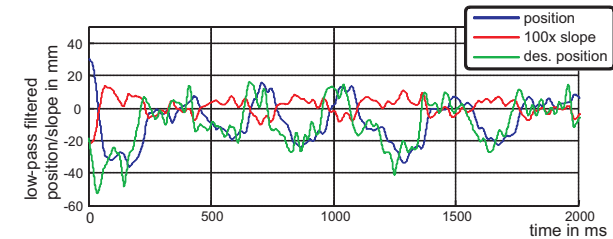
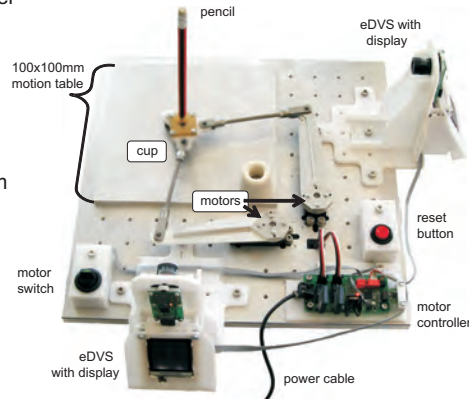
Balancer Hardware

Standalone Embedded Balancer

2 orthogonally mounted eDVS

2D actuated table
 - range of motion ~100x100mm
 - actuated by 2 high-speed brushless Servo Motors

On-board low-level position control (Microcontroller)



Upper diagram:
 Recorded traces of position, slope, and desired position (data low-pass filtered: 3rd order Butterworth, -3dB 30Hz)

Right diagram:
 Position histogram in top-down view on table

