How To Obtain a 1 kHz Visual Servoing Setup?

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Abstract
The research described here focusses on visual servoing [1] for production processes that take place on repetitive structures. The long term goal of the project is to create a setup capable of sampling with more than 1 kHz with a total time delay of less than 2 samples. It should track velocities up to 1 m/s with an accuracy in the order of 1-10 µm. As a starting point a black dot on a sheet of white paper is placed onto a two dimensional stage, where the goal is to control the black dot within the field of view at 1 kHz.

Ingredients
The setup as depicted in Fig. 1 consists of two stacked linear motors forming an xy-table. The input to the system is applied using an EtherCAT DAC module. A camera capable of reaching a frame rate of 200 Hz full frame (640 x 480), is mounted above the table. The data-acquisition is integrated in a Linux environment running a 2.6.24 real-time preemptive kernel [2]. The object of interest is a black dot on a sheet of white paper.

Pushing the limits
For achieving the goal mentioned earlier several important settings are discussed in this section. First of all, since a Gigabit Ethernet camera is used which supports jumbo frames, the maximum transfer unit of your network card should also support these jumbo frames. In that case you already reduce the network overhead. Furthermore, real-time priority is given to the used high resolution timers available in the preemptive kernel to decrease jitter. A region of interest (ROI) of 13 x 13 mm or equivalently of 80 x 80 pixels is used. By reading out less pixels a frame rate of 1 kHz is available. The exposure time can be set as low as 100 µs due to the use of power LEDs as illumination.

Results
The center of the black dot is detected by calculating the center of gravity and takes approximately 40 µs. The 3σ value of the measurement is 50 µm, which is still too large for the final goal. Furthermore, the position loop is closed only (!) on vision. The results of a frequency response function (FRF) measurement are given in Fig 2. Here the red line represents the measurement from input to camera coordinates. For comparison a FRF is measured from input to motor encoder, depicted in blue. Clearly different dynamics are measured in this case, caused by the place of the measurement, i.e. collocated, versus non-collocated control.

Figure 1: Visual servoing setup.

Figure 2: Measured FRFs.

References