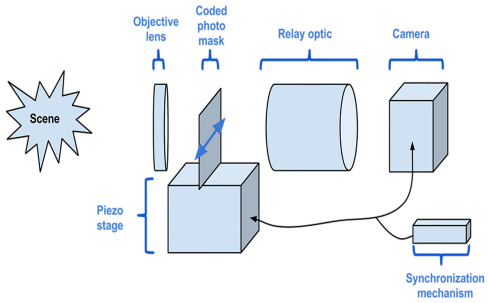
Thomas Niederberger

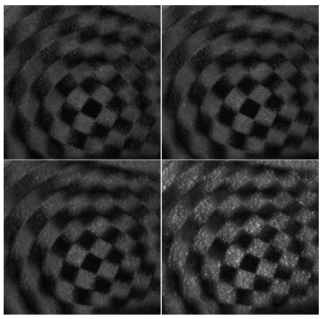
Graduate Candidate	Thomas Niederberger
Examiner	Prof. Dr. Guido Schuster
Co-Examiner	Prof. Dr. Aggelos Katsaggelos, Northwestern University, Evanston/Chicago, IL
Subject Area	Sensor, Actuator and Communication Systems
Project Partner	Northwestern University, Evanston/Chicago, IL

Building a High Speed Video Camera using Compressive Sensing

An approach using Compressive Sensing and a Coded Aperture



Design of the experimental setup showing the major components. The movement of the stage and the camera are synchronized.

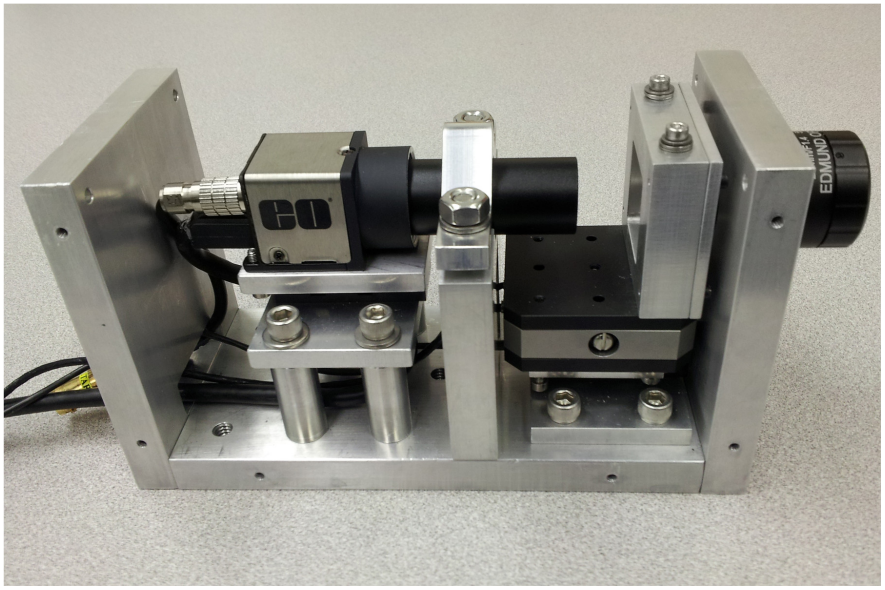


Reconstruction results of a spinning wheel. Outer wheel areas move faster, contain more motion blur and are more difficult to reconstruct.

Introduction: Compressive sensing has sparked a lot of interest in the signal processing community in recent years, because it allows to sample a signal at a much slower rate than the well-known Shannon-Nyquist rate and reconstruct the signal later with high quality. A research group at Duke University developed a hardware prototype of a high-speed video camera that makes use of compressive sensing. The idea is to take video footage with 30 frames per second and then increase the rate to more than 300 frames per second. In order to realize this, a binary coded aperture is moved by a piezo positioning system in front of the sensor and methods from compressive sensing are used to reconstruct a high-speed video sequence.

Objective: The principal research goal is to build a high-speed camera using the same approach as the group at Duke University and increase the spatial resolution. The hardware components must be evaluated and an experimental setup designed. Finally, different reconstruction approaches shall be studied and discussed.

Result: We built a camera prototype with a spatial resolution more than 10 times higher than before and established an experimental measurement setup. Results show that the optical reproduction quality of the system is satisfactory and that from a single image more than 16 frames can be reconstructed. Even though the camera has some shortcomings in terms of precision of the physical movement we could show that the coded aperture approach can be expanded for use with a high-resolution sensor. We showed experimental evidence that the reconstruction quality is limited by the structure of the sensing process. In the thesis we indicate ways how this could be changed in order to improve reconstruction quality. Preliminary results obtained with simulations show the potential of these approaches.



Fully assembled video camera prototype