REAL-TIME FULL-FIELD VIBROMETRY USING A SMART-PIXEL LOCK-IN CAMERA

Florian Dötzer[1], Fridtjof Seufert[1], Stefan Sinzinger[1]

[1] TU Ilmenau, Department of Mechanical Engineering, Optical Engineering Group, Germany
florian.doetzer@tu-ilmenau.de

Full-field vibrometry techniques such as frequency shifted or phase modulated interferometry already offer considerably short acquisition times compared to scanning methods such as Laser-Doppler-Vibrometry when high spatial resolution is required. However, when measurements with picometer-sensitivity are to be performed, this can only be achieved by recording a large number of frames with a subsequent narrowband (lock-in) filtering during digital postprocessing. Due to the limited frame rate of regular CMOS camera sensors, the acquisition time then can be several seconds to minutes and the computationally intensive evaluation of the large image stack further adds to the measurement time.

Both problems are addressed by the use of a smart-pixel camera that implements an electric lock-in circuit in every pixel before AD-conversion [1]. It supports the demodulation of frequencies even beyond 100 kHz which means that the same number of oscillation periods can be acquired significantly faster compared to a regular camera. As illustrated in figure 1, the filtering is applied in the analogue domain and only a single frame is produced in the end, which can be instantly further processed compared to a whole stack of images that must first be processed and filtered digitally. This should enable such interferometric setups to perform even highly sensitive measurements in real-time (i.e. several measurements per second).

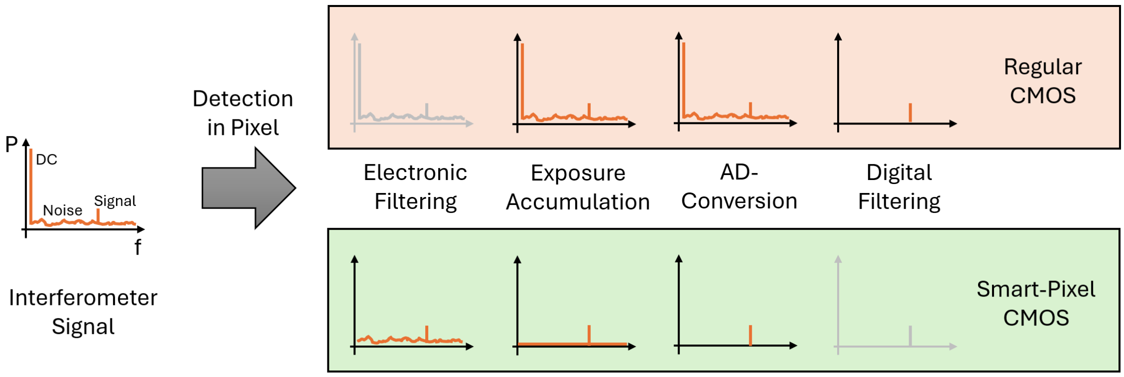

Fig. 1. Simplified signal filtering pipeline for lock-in detection with a smart-pixel camera compared to a regular one.

Additionally, there is also a second possible advantage regarding measurement noise. As the typical signal to be measured in such an interferometer is an extremely weak modulation in front of a much stronger DC background, the measurement can be assumed to be shot noise limited. In this case only a larger number of accumulated photons, i.e. a larger full well capacity (FWC) can increase the signal to noise ratio (SNR) for a conventional detector. The smart-pixel detector however filters out the DC component such that only the modulated part is accumulated in the potential well. Hence, the entire FWC and AD-converter bit depth is available for the modulated part only. This promises to provide a performance similar to a conventional detector with excessively large FWC and bit depth which should provide measurement results with superior SNR.

In this submission, we will present first measurements using the smart-pixel camera inside an established interferometric full-field vibrometry setup. We compare the results to the ones obtained with a conventional camera detector and discuss advantages and limitations.

---

[1] Heliotis AG, "C4 – Heliotis AG," Heliotis AG. https://www.heliotis.com/c4/