Ph.D. in Information Technology
Thesis Defenses

January 17th, 2022
at 9:30
Room Alpha and online by Teams

Paolo FRIGERIO – XXXIV Cycle

High-Accuracy Control of MEMS Micromirrors

Supervisor: Prof. **Giacomo Langfelder**

Abstract:

Microscanners based on the MEMS (Micro-Electromechanical System) technology have experienced an ever increasing demand since the fabrication of the first simple prototype in 1980. The demand for such devices comes from a wide range of different fields: from Augmented Reality (AR), Virtual Reality (VR) and picoprojectors systems for the entertainment industry, to systems for imaging, spectroscopy and medical instrumentation, as far as LiDAR applications. The world of picoprojection, in particular, nowadays requires higher and higher resolutions. This thesis discusses the implementation of positioning control systems for micromirrors based on piezoelectric actuation and piezoresistive sensing, which represents the most recent technology adopted in the field. Such technology offers many advantages, while posing new challenges that are analysed and solved in the thesis. The implementation of control systems for both the horizontal and the vertical image scan is discussed: the developed systems demonstrate a control accuracy within the diffraction limited spot-size, frequency stability of the horizontal scan within 1 ppm and linearity of the vertical trace within 1 %, whilst managing undesired resonant mode coupling to the piezoresistive (PZR) position sensor embedded on the device. Concurrently, the discussion also tackles characterization of the lead zirconate titanate (PZT) thin-films used for driving the scanners. The material is characterized both for actuation and sensing, in terms of transduction efficiency, polarization hysteresis and temperature dependence, with the goal of a future transition from a piezoresistive to a piezoelectric approach to sensing of the scanner position.

Leonardo GAFFURI PAGANI – XXXIV Cycle

About MEMS IMUs Stability and Reliability

Supervisor: Prof. **Giacomo Langfelder**

Abstract:

MEMS inertial sensors, after decades of evolution, are now eyeing at navigation applications in many different fields. This would enable a novel breakthrough for the technology, traditionally boasting low costs, small footprints and low power consumption. Main goal of this research project is to investigate instability sources in MEMS inertial sensors and, possibly, solutions for their mitigation. The work methodology is based on finite elements, analytical and behavioral models development, and their experimental crosscheck via innovative test structures, inertial sensors and systems design. Specifically, the first part focuses on the analysis of gyroscopes medium-term instability due to drive-sense relative phase drifts caused by temperature variations. Both a low-noise characterization setup and an accurate model are developed. Moreover, a novel compensation technique to improve zero-rate-output drifts in temperature is devised. The second part pivots on structural damage modeling and prediction, and how a newly developed system approach prevents this from happening in a novel time-switched frequency-modulated accelerometer device. The presented system demonstrates excellent recovery time and vibrations rejection performances, with a factor 20 improvement with respect to the previous embodiment.

PhD Committee

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