Novel polarization image sensor and camera system developed at Fraunhofer IIS

- Polarization: physical property of light (like wavelength and intensity), but not perceivable to humans
- Used in industrial applications like quality monitoring in glass or carbon fibre production
- Medical applications are currently in research
- Currently, PC software for image processing is available; image analysis is highly application dependent and customer specific
- Software development in the traditional way: Matlab simulation, conversion to C/C++, optimization for target architecture, debugging, profiling...
- ARGO workflow will drastically reduce time-to-market (factor of 3...5 expected)
- In the future, parts of the algorithm will be implemented on embedded systems (inside the camera)

**Keywords:**
Worst case execution time, embedded system, safety critical, model based design

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688131*
**Challenges**

Polarization image processing system is used as test case in the ARGO project
- Testcase increment 1 contains most common processing steps (common to almost all applications)
- Testcase 2 will contain computation intensive enhancements and application specific processing steps. More challenging w.r.t. WCET constraints

**Solution**

- Model in the Loop: Simulation PC
- Hardware in the Loop: ARGO platform

**Phase 1: Infrastructure buildup and test:**
- Implement Scilab model and infrastructure software, hardware setup
- Record short sequences of raw data (= test data) from the polarization camera (~2000 frames per sequence, ~50sec)
- Process test data in the Scilab PIPS model, each resulting in a AOMP and DOLP sequence (= reference data)

**Phase 2: Model in the Loop test**
- Transmit previously recorded test data sequences via Ethernet framewise to a simulation PC (also running the PIPS model) and receive processed frames
- Compare results from simulation PC to reference data. They must be exactly identical.
• No WCET constraints applicable in this phase

**Phase 3:** Hardware in the loop test: (by end of testcase 1)

- Transmit test data sequences via Ethernet framewise to the ARGO target hardware (running the compiled and WCET-optimized PIPS model) and receive processed frames.
- Use increasing frame rates for stressing the target system.
- Results from the target should be identical to reference data except for round-off effects caused by arithmetic precision on the target.

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**Details of the Scilab PIPS Model**

It covers the most common steps used in almost every polarization imaging application.

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**Outlook for Testcase Increment 2**

- Polynomial based pixel linearization for higher precision (Note: camera must be seen as a measuring instrument rather than a visual image source)
• Temperature compensation
• Application specific processing, e.g. ATN (*apparent temper number*)
• Enhanced denoising (↔ unweighted frame averaging)
• Edge-aware pixel interpolation (↔ simple neighbour averaging)

**Results**

**What is the benefit we expect from ARGO?**

• Drastically reduced time-to-market
• Reduced number of iterations in software development caused by erroneous C-Conversion of simulation code
• Higher performance of resulting implementation due to automatic parallelization and WCET awareness → More application areas
• Much easier migration to other target platforms, i.e. embedded devices

Example: Model in the Loop using Raspberry Pi as simulation platform

**More infos**
