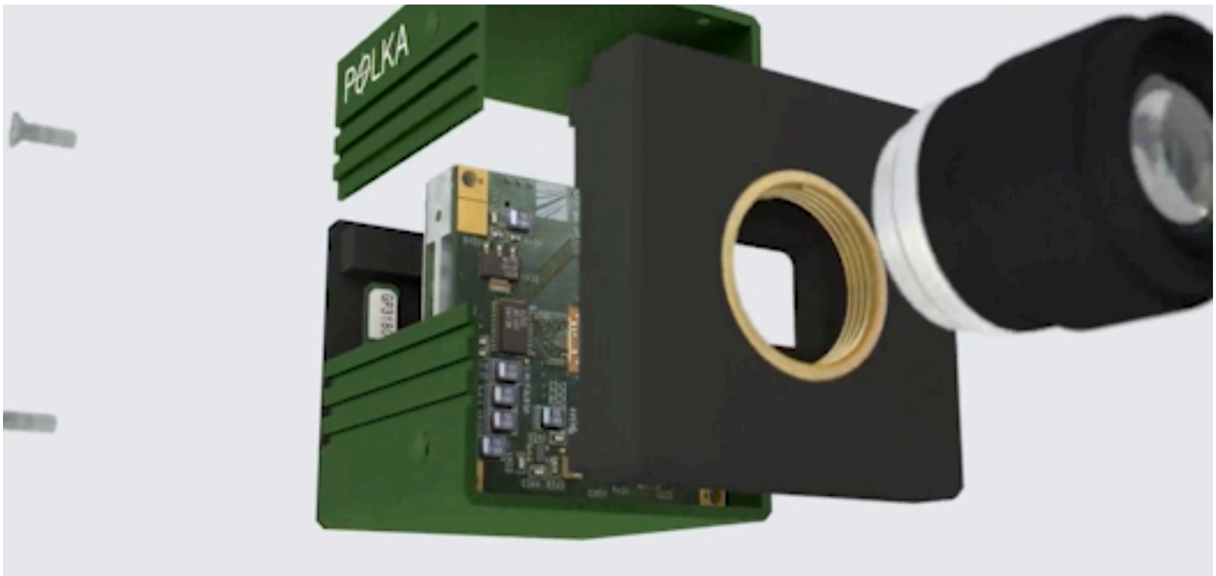
Fraunhofer IIS Use Case
Polarization Image Processing System

2017/01/12



- 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

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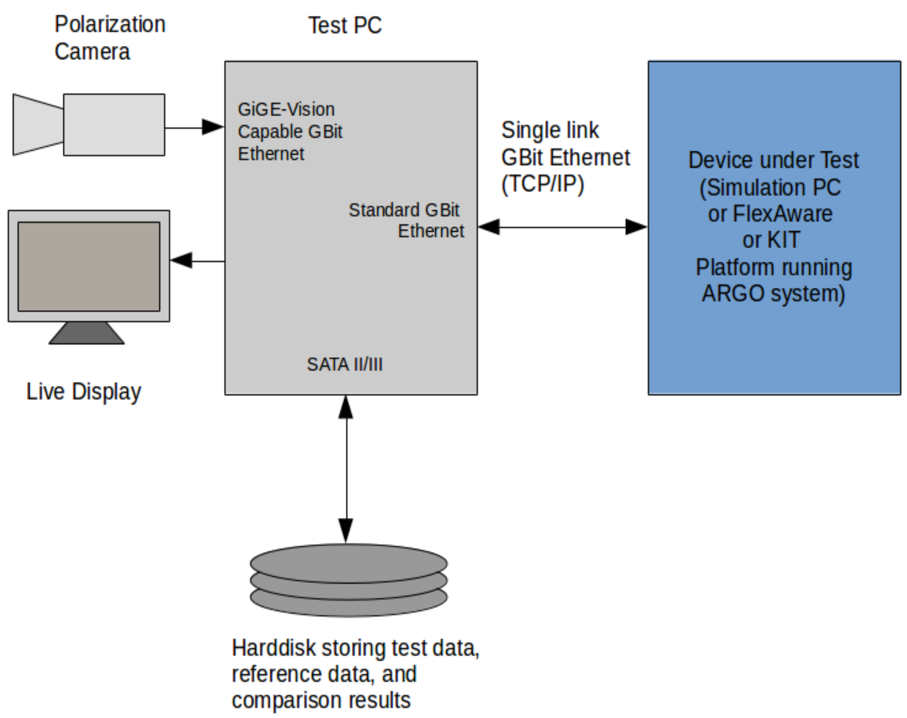
Challenges

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)

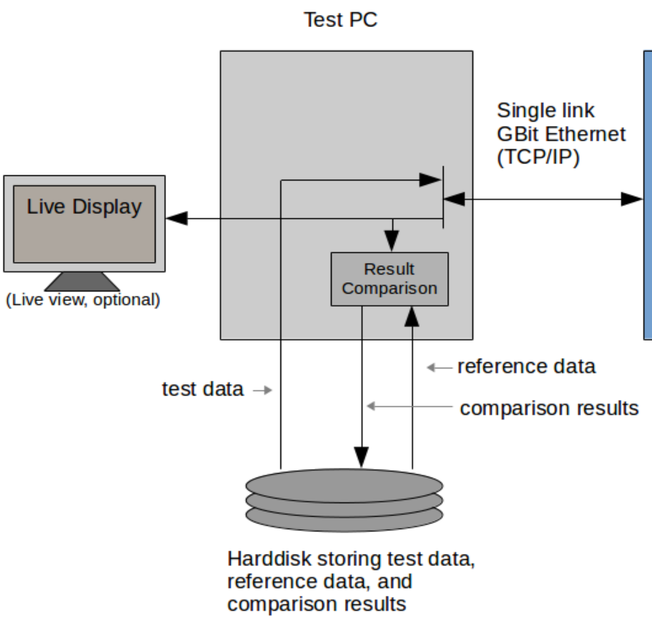
Phase 2: Model in the Loop test

- 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

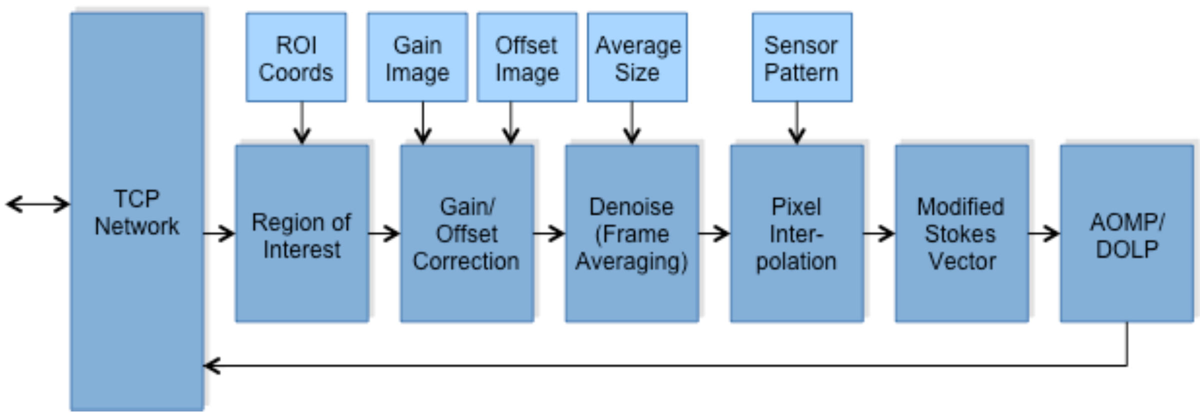
Phase 3: Hardware in the loop test: (by end of testcase 1)

- 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.



Details of the Scilab PIPS Model

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



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)

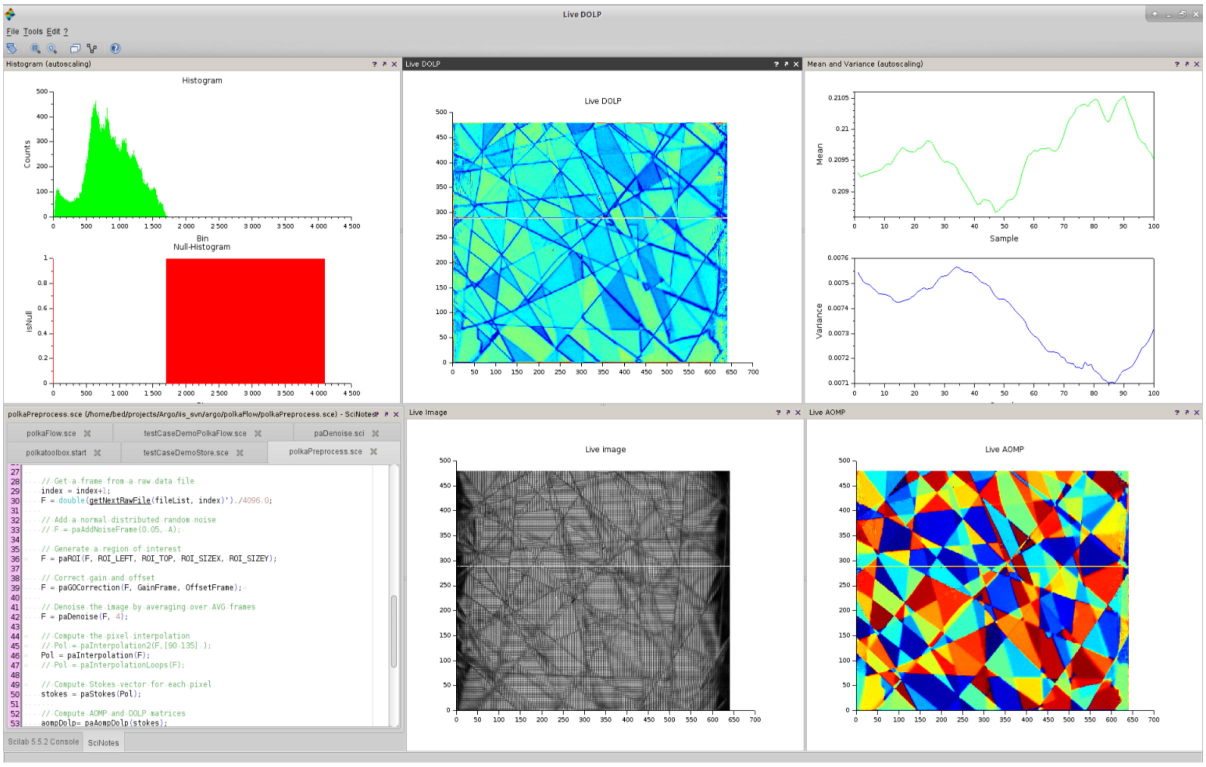
- Temperature compensation
- Application specific processing, e.g. ATN (*apperent temper number*)
- Enhanced denoising (↔ unweightened frame averaging)
- Edge-aware pixel interpolation (↔ simple neighbour averaging)

Results

What is the benefit we expect from ARGO?

- Drastically reduced time-to-market
- Reduced number of iterations in software development caused by errornous C-Conversion of simulation code
- Higher performance of resulting implemenation 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 platfom



More infos

https://www.iis.fraunhofer.de/en/ff/bsy/tech/kameratechnik/polarisationskamera.html
http://scilab.io/use-cases/real-time-embedded-systems-require-higher-performance/