Charon-Suite Module Framework

Modular Algorithms with Serializable C++ Objects

Jens-Malte Gottfried Daniel Kondermann

Heidelberg Collaboratory for Image Processing (HCI)
Interdisciplinary Center for Scientific Computing (IWR)
University of Heidelberg

IPOL 2012 Meeting on Image Processing Libraries

Outline

1. Charon-Suite
   - Serializable Objects
   - Workflows
2. Helper Tools
   - Tuchulcha
   - Template-Generator
   - Examples and Documentation
   - Precompiled Binaries
3. Application
   - Optical Flow Estimation
   - 3D Reconstruction
   - Parallel Calculations

Project Overview

What is Charon-Suite? Why was it created?

- image processing libraries difficult to maintain and extend in a research environment, steep learning curve, short life-cycle
- Charon-Suite is a framework with associated tools rather than a library

Charon-Suite

- open source framework for computer vision prototyping
- independent of any given image processing library
- simple plugin-architecture for parts of computer vision algorithms
- modules may use any language and any software package
- graphical helper tools for configuration and execution
- easy to learn, cross-platform

Used Software

Dependencies and Build Tools, License Information

framework

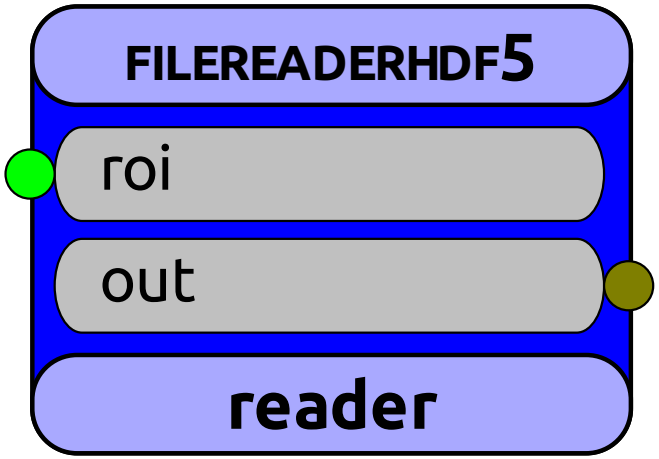
- framework written in C++
- build using cmake
- documentation with doxygen
- GUI elements using Qt4
- core and helper classes under GNU LGPLv3
- platform independent; supported: Win32/64 with MsVC, Linux/GCC, Mac/GCC

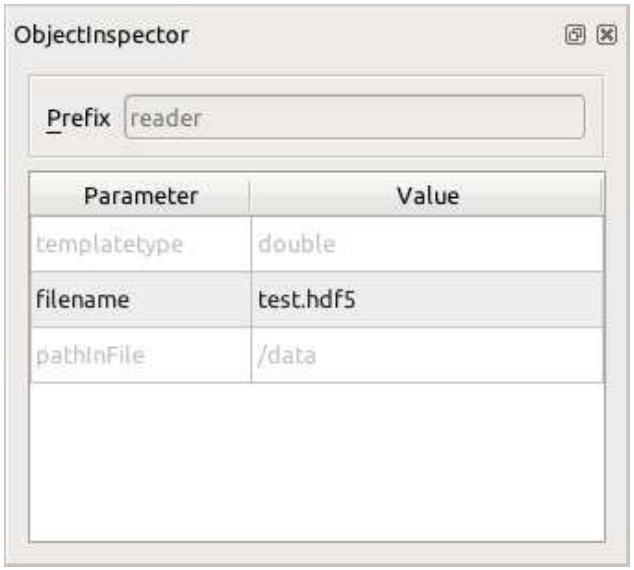
modules

- arbitrary libraries may be used: CImg, Vigra, Qt, Petsc, OpenCV and more
- wrapper modules for other languages; already available: python, matlab, scripts
- most modules also use LGPL, but other licenses possible

Charon Modules

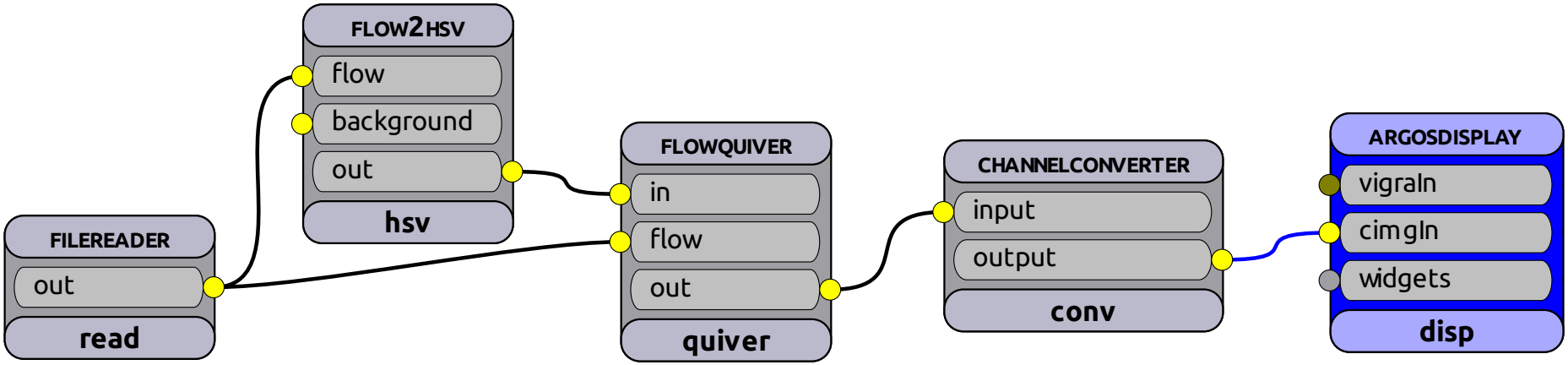
Dividing Algorithms into Parts using Serializable Objects





- algorithmic steps divided into different modules (e.g. read data, processing steps, write result)
- modules encapsulate algorithm parameters and their documentation
- load/store parameters from/to parameter files (plain text)
- white-box testing of parts and full algorithms possible
- re-usability of existing modules without introducing new bugs

Module Interaction
Data Flow/Slot Model



- slot mechanism for data exchange between modules
- full algorithm described by interaction of modules
- directed acyclic graph required
- save connections also in the plain text parameter file
- flow chart visualization
- execution by traversing the modules of this graph

Tool Overview

Simplify Usage and Development

main tools

templategenerator	set up code templates for new modules
tuchulcha	graphical workflow configuration and execution tool
paraminspector	parameter file editor, standalone object inspector

tools for scripting

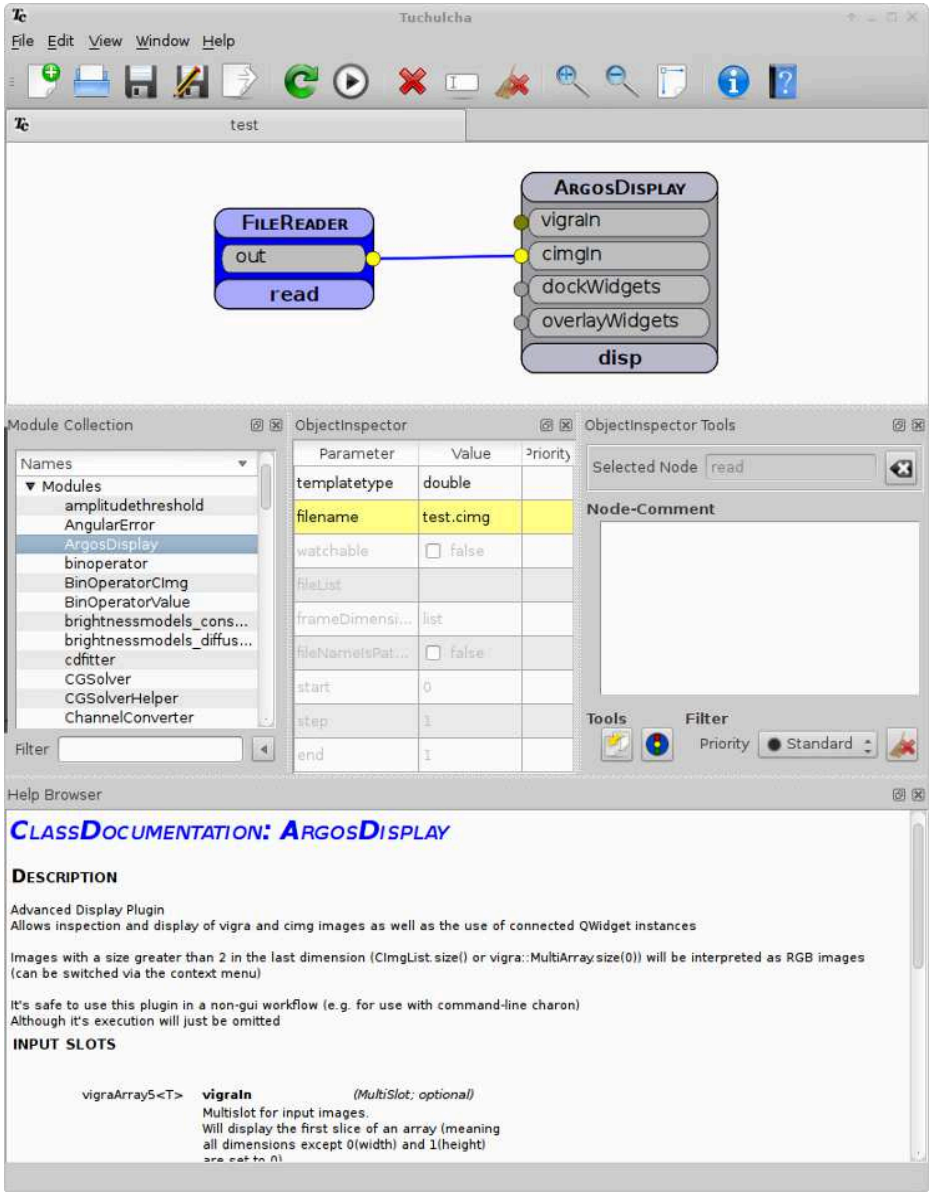
workflow-executor	command line workflow executor
charon-xml-helper	check module groups in doxygen documentation

web-based services

sourceforge	code hosting, wiki, tutorials, project web, win releases
launchpad	code hosting, ubuntu package repository, recipe-builds

Tuchulcha

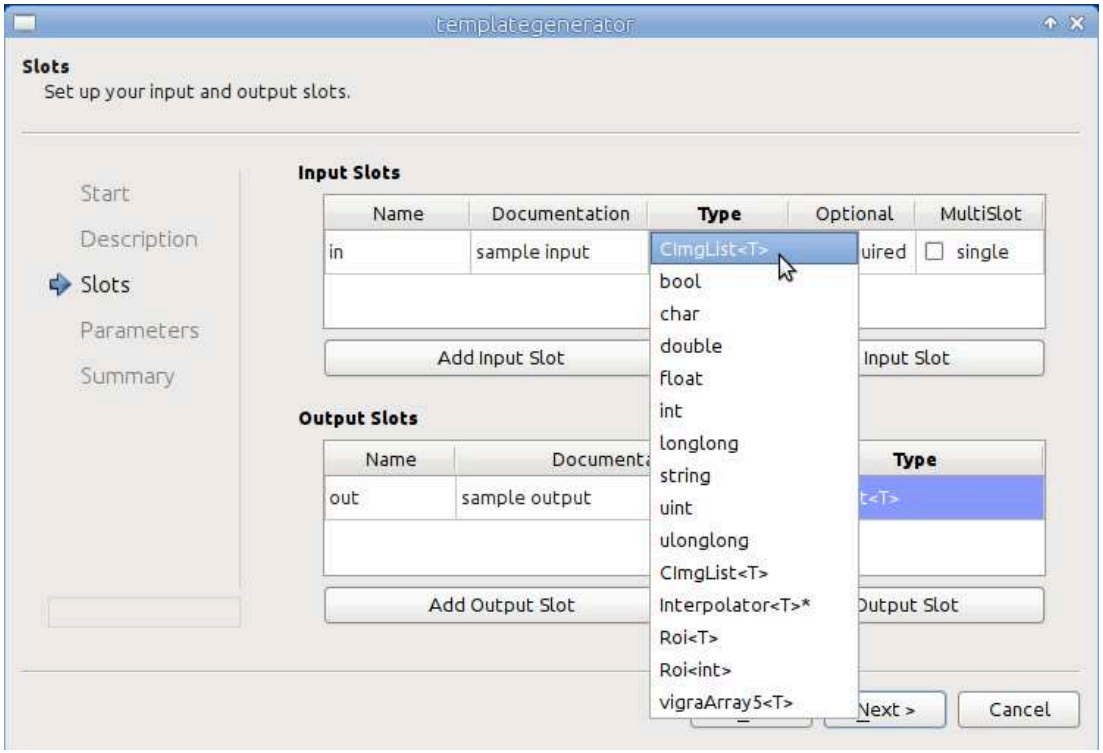
Graphical Workflow Configuration



- overview of available modules
- module documentation
- graphical workflow and connection management (like LabView or similar)
- parameter adjustment using the object inspector
- workflow execution
- qt event loop for display modules
- node/workflow comments
- parameter priorities

Template Generator

Code Templates for New Modules



- wizard simplify generating new modules
- specification of class name, input/output slots and parameters with their types and documentation
- generation of C++ files `module.h` `module.hxx` `module.cpp` and CMake `CMakeLists.txt`
- placeholder to add execution code

Examples and Documentation

Information at the Sourceforge Project Page

The project page at sourceforge is the place
to start working with the Charon-Suite framework.
There is information for beginners as well as for experienced users.

- project wiki with tutorials, build instructions
  and links to other information sources
  `http://charon-suite.sf.net`
- doxygen documentation
  `http://charon-suite.sf.net/doc/`*project*
- tool references, usage and options (manpages)
  `http://charon-suite.sf.net/doc/man`
- example workflows with detailed description and needed data
  `http://charon-suite.sf.net/doc/examples`

Testing
Test Suite and Dashboard Overview

Charon-Suite Testing

- test suite for base classes and module collections
- automated tests based on CTest
- continuous and nightly tests (using scripts)
- automated documentation, examples and manpage generation
- test result overview using CDash dashboard `http://charon-suite.sf.net/CDash/`

Precompiled Binaries

Using Charon-Suite without compiling anything

- get Charon-Suite running in a few minutes only
- download and unpack, run tuchulcha
- use example workflows with demo algorithms
- adapt these workflows to your needs

available binaries

- Win32/Win64 MsVC 2010
- Ubuntu Linux DEB Packages Repository with all dependencies
- Gentoo Linux Ebuilds (layman overlay)

`http://sf.net/apps/trac/charon-suite/wiki/InstallationGuide`

Module Collections

Overview of Existing Modules

charon-utils	data input/output, image manipulation
charon-flow	optical flow estimation and related modules
hekate	3D reconstruction and related modules
charon-petsc	parallel calculations using MPI

charon-utils: supported data formats

- cimg, pgm, bmp
- jpeg, tiff, png via external libraries
- all formats supported by ImageMagic
- hdf5 via vigra library

Charon-Flow

Various Optical Flow Estimation Algorithms

working algorithms

- Horn and Schunck (1981)
- Lukas and Kanade (1981)
- combined local/global (Bruhn et al. 2005)
- nonlinear and multiscale versions (Pyramids)
- learning flow (Sun et al. 2008)
- Charbonnier functions (Charbonnier et al. 1997) (Papenberg et al. 2006)
- Classic+NL (Sun et al. 2010)
- Range-Flow (Scene-Flow)

helpers

- CImgList based iterators (loops in workflows)
- contrastive divergence (CD) learning algorithm (Hinton 2002)
- monte carlo sampling (Metropolis et al. 1953)
- PDE solvers based on Petsc, conjugate gradients, SOR, Cuda Version (approx.), 2nd Order Newton

Hekate

Camera Calibration, Feature Detection and 3D Reconstruction

Algorithms

- 3D Reconstruction by Structure from Motion (SfM)[12]
- Feature Detection and Tracking (for example SIFT features)
- Outlier elimination of feature correspondences[23]
- Delaunay triangulation to gerenrate meshes
- Auto-calibration of cameras by image sequence
- Results can be used for camera tracking

References

1. G.Wang and J.Wu. *Guide to 3D Structure and Motion Estimation*, 2011
2. R. Hartley and A. Zisserman. *Multiple View Geometry in Computer Vision*, 2004
3. L. Xiangru and H. Zhanyi. *Rejecting Mismatches by Correspondence Function*, 2010

For more information ask Moritz Becker

Charon-Petsc
MPI-Based Workflows

features

- multi processing using `mpirun`
- wrapping parallel vector and sparse matrix classes
- export to matlab vectors
- operations like add and multiply with matrices and vectors
- parallel filtering (derivation, convolution with gaussian)
- converters from and to existing image types (VigraMultiArray)

work-in-progress

- wrapping KSP solver class
- mixing parallel and non-parallel modules

For more information ask Gerald Mwangi

Conclusion

summary

- open source framework
- modular architecture
- stable since 2009
- increasing number of available algorithms
- precompiled binaries for fast setup
- no need to reinvent the wheel
- application not restricted to computer vision

thanks to

- Daniel Kondermann (project initiator)
- Stephan Meister (charon-utils, argos)
- Michael Baron (charon-flow)
- Moritz Becker (hekate)
- Gerald Mwangi (charon-petsc)