Visualizing the Human Body with ITK and VTK
Tutorial Proposal for Vis2002

Duration

Full day

Target Audience

Attendees are expected to be familiar with basic principles of image processing and computer graphics. The course is intended for developers, researches and users interested in applications involving medical image processing, analysis and visualization.

Level

Intermediate

Abstract

This tutorial introduces the Open Source Image Segmentation and Registration Toolkit (**ITK**) developed with the support of the National Library of Medicine. **ITK**'s design principles, including data representation and algorithms, will be described. Guidelines for working with visualization packages such as OpenGL and **VTK** and with GUI packages such as **FLTK** and **Qt** will be presented. Cases studies will be presented to illustrate the potential of the toolkit for building applications involving medical image processing and visualization.

Description

ITK is an open-source software toolkit for performing registration and segmentation. Segmentation is the process of identifying and classifying data found in a digitally sampled representation. Typically the sampled representation is an image acquired from such medical instrumentation as CT or MRI scanners. Registration is the task of aligning or developing correspondences between data. For example, in the medical environment, a CT scan may be aligned with a MRI scan in order to combine the information contained in both. Registration and Segmentation are fundamental aspects of any medical image application and when properly combined with visualization they support the core functionality of practical applications.

ITK was developed with the support of the National Library of Medicine of the National Institutes of Health with the aim of facilitating the use of the data made available by the **Visible Human Project**. The toolkit was designed to also support general medical image applications and to serve as a resource for reducing costs and development time both in academic and commercial projects. (More detailed information about the toolkit is available at: `http://www.itk.org`).

ITK is implemented in C++ and is cross-platform. **ITK**'s C++ implementation style is referred to as *generic programming* (i.e., using templated code). Such C++ templating means that the code is highly efficient, and that many software problems are discovered at compile-time, rather than at run-time during program execution.

Because **ITK** is an open-source project, developers from around the world can use, debug, maintain, and extend the software. **ITK** uses a model of software development referred to as *Extreme Programming*. Extreme Programming collapses the usual software creation methodology into a simultaneous and iterative process of design-implement-test-release. The key features of Extreme Programming are communication and testing. Communication among the members of the **ITK** community is what helps manage the rapid evolution of the software. Testing is what keeps the software stable. In **ITK**, an extensive testing process (using Dart) is in place that measures the quality on a daily basis. The **ITK** Testing Dashboard is posted continuously reflecting the quality of the software.

This tutorial lead users through the process of downloading and installing the toolkit. It introduces the basic concepts of software engineering behind the architectural organization of the toolkit and discuss how these principles are applied to image processing and analysis. **ITK** algorithms take advantage of the *generic programming* approach in order to get the best balance between performance, maintainability and generality in the code. This tutorial highlights the difference between conventional programming styles, that impose unnecessary restrictions on algorithmic design, and generic programming techniques, that offer advantages in performance and component modularization. Course attendees will also learn how to use **ITK** in conjunction with the popular open-source toolkits **VTK**, **Qt** and **FLTK**.

Schedule

First Session

Introduction

Speaker: Terry Yoo, NLM/NIH — Time: 30 min

- Description of **ITK** origins.
- The Visible Human Project.
- **ITK** motivations and goals.
- Open Source license conditions.
- Future funding opportunities.

Downloading and Installing the Toolkit

Speaker: Luis Ibanez, Kitware — Time: 30 min

- Tarballs / CVS access / Web pages / Mailing lists.
- How to use **CMake** to configure **ITK**.
- ITK structure and additional libraries.
- How to run and modify an example.
- How to start a new project.
- How to combine **ITK** and **VTK**.

ITK Architecture

Speaker: Luis Ibanez, Kitware — Time: 110 min

- Data pipeline approach.
- Generic programming and C++ Templates.
- How to connect **ITK** and **VTK** pipelines.
- How to interact with a GUI: **FLTK** & **Qt**.
- Segmentation Architecture.
- Registration Architecture.

Second Session

Segmentation based on Watersheds

Speaker: Josh Cates / Ross Whitaker, University of Utah Time: 90 min

- Overview of the Watershed algorithm.
- Implementation of the algorithm in **ITK**.
- How to effectively prepare data for segmentation.
- Description of **ITK** watershed filters .
- Demonstration of segementation of specific anatomical structrures
- Experiences with visualization tools based on **ITK**, **Tcl/Tk** and **VTK**.

Visualization for Computer Assisted Surgery

Speaker: Stephen Aylward, UNC-Chapel Hill Time: 90 min

- Diagnosis of Retinopathy of Prematurity
- Liver Transplant Planning
- Statistical Pattern Recognition

Practical examples using ITK and VTK

Speaker: Bill Lorensen, GE Time: 90 min

- Practical Examples Using ITK and VTK
- Registration of medical volumes using ITK.
  - Longitudinal MRI studies
  - CT to CT lung studies
  - PET to CT for animal studies.
- Using ITK with other software packages, in particular VTK and vxl (the Computer Vision Library).
- Wrapping ITK functionality into other software libraries, specifically VTK

Speakers

Stephen R. Aylward

Stephen R. Aylward is an assistant professor in the Department of Radiology and an adjunct assistant professor in the Department of Computer Science at the University of North Carolina at Chapel Hill. He received a B.S. in 1988 from Purdue University, an M.S. in 1989 from the Georgia Institute of Technology, and a Ph.D. in 1997 from UNC-Chapel Hill. He previously served as the technical leader of the McDonnell Douglas Neural Network Laboratory. Dr. Aylward is Director of the Computer-Aided Diagnosis and Display Laboratory in the Department of Radiology at UNC (the CADDLab - http://caddlab.rad.unc.edu). The CADDLab's researchers are dedicated to conducting applied image-processing research regarding the 3D planning, delivery, and evaluation of surgical and interventional radiology tasks. His current work focuses on segmenting, registering, and visualizing vasculature for minimally invasive vascular interventional and partial-organ transplant procedures. Dr. Aylward also serves as a consultant to the Surgical Navigation Technologies division of Medtronic and to R2 Technologies.

Josh Cates

Josh Cates is a member of the research staff of the Scientific Computing and Imaging Institute at the University of Utah's School of Computer Science. He received his B.S. degree in Biology in 1995 and M.S. in Computer Science in 1999 from the University of Tennessee. His interests include software engineering and problems in computer vision, including image processing (differential geometry and p.d.e-based methods), image segmentation, and computed tomography.

Luis Ibanez

Luis Ibáñez is a Research Engineer at Kitware, Inc. He received a B.Sc. in Physics in 1989 and a M.Sc. in Optics in 1994 from the Universidad Industrial de Santander (Bucaramanga, Colombia). He received a D.E.A in 1995 and a Ph.D. in 2000 from the Universite de Rennes I (Rennes, France). During his Ph.D. Luis Ibáñez was member of the Laboratory of Medical Information Processing (LATIM) at the Ecole Nationale Superieure des Telecommunications de Bretagne (Brest, France). From 1999 to 2001 he was Research Assistant Professor in the Division of Neurosurgery at the Univesity of North Carolina at Chapel Hill. His current interests include: medical image processing and analysis, image registration, shape description, morphogenesis modeling and application of genomics paradigms to computation.

Bill Lorensen

Bill Lorensen is a Graphics Engineer in the Electronic Systems Laboratory at GE's Corporate Research and Development Center in Schenectady, NY. He has over 35 years of experience in computer graphics and software engineering. Bill is currently working on algorithms for 3D medical graphics and scientific visualization. He is a co-developer of marching cubes and dividing cubes, two popular isosurface extraction algorithms. His other interests include computer animation, color graphics systems for data presentation, and object-oriented software tools. Bill is the author or co-author of over 60 technical articles on topics ranging from finite element pre/postprocessing, 3D medical imaging, computer animation and object-oriented design. He is a co-author of "Object-Oriented Modeling and Design" published by Prentice Hall, 1991. He is also co-author with Will Schroeder and Ken Martin of the book "The Visualization Toolkit: An Object-Oriented Approach to 3D Graphics" published by Prentice Hall in November 1997. He gives frequent tutorials at the annual SIGGRAPH and IEEE Visualization conferences. Bill holds twenty six US Patents on medical and visualization algorithms. In 1991, he was named a Coolidge Fellow, the highest scientific honor at GE's Corporate R&D. Prior to joining GE in 1978, he was a Mathematician at the US Army Benet Weapons Laboratory where he worked on computer graphics software for structural analysis. He has a BS in Mathematics and an MS in Computer Science from Rensselaer Polytechnic Institute.

Ross Whitaker

Dr. Whitaker received his B.S. degree in Electrical Engineering and Computer Science from Princeton University in 1986. He received his Ph.D. in Computer Science from the University of North Carolina, Chapel Hill in 1993. From 1994-1996 he worked at the European Computer-Industry Research Centre in Munich Germany as a research scientist in the User Interaction and Visualization Group. From 1996-2000 he was an Assistant Professor in the Department of Electrical Engineering at the University of Tennessee. Since then he has been at the University of Utah where he is Assistant Professor in the College of Computing and a faculty member of the Institute for Scientific Computing and Imaging. He teaches image processing, computer vision, and pattern recognition. His research interests include: computer vision, image processing, medical imaging, and computer graphics/visualization.

Terry Yoo

Terry S. Yoo is a Computer Scientist in the Office of High Performance Computing and Communications, National Library of Medicine, NIH, where he explores the processing and visualizing of 3D medical data, interactive 3D graphics, and computational geometry. Previously as a professor of Radiology, he managed a research program in Interventional MRI with the University of Mississippi. Terry holds an A.B. in Biology from Harvard, and a M.S. and Ph.D. in Computer Science from UNC Chapel Hill. He has been a speaker and organizer of successful courses on medical visualization and 3D image processing (SIGGRAPH 1993, 1994, 1998, 2001 Vis 2000, 2001).

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