TUTORIAL 6
CUBE

TITLE: Seeing inside the cube: improved sonar imaging with techniques from computer graphics and vision

INSTRUCTOR: Eddy Loke

ABSTRACT
Volumetric seabed and subbottom data can be obtained by ``zigzagging" vessels mounted with bottom-penetrating sonar systems. The size of sonar datasets typically ranges up to several GBs per seabed, and this will further grow due to increasing demands on sampling rate and trace size. Traditionally, the analysis of a seabed is done by the inspection of a large number of 2D pingplots, showing the obtained underwater acoustic signals one after another, neglecting the true spatial nature of the data. When the area of interest is too big, or the required accuracy is too high, visual inspection becomes infeasible and the 3D coherency has to be increased, demanding the design for and application of efficient and automated 3D visualization techniques from computer vision and computer graphics, which feature a fast and unsupervised, but interactive, processing of a vast amount of data. In this tutorial, various visualization techniques will be introduced and their application will be illustrated in various real sonar imaging case studies --- highlighting semi-buried shipwrecks and pipelines in the sea bottom using colored computer-graphic displays.
Although sonar operators are still used to interpret 2D pingplots, i.e. real-time on-screen and offline printed ones, modern visualization systems add extra analysis tools:
(1) ``Random" ship trajectories and the resulting 2D pingplots make a precise 3D interpretation difficult. By exploiting the 3D nature of the data, we can provide accurate 3D images of the subbottom. Standard viewers allow inspecting structures from any angle and at any magnification. Using off-the-shelf hard- and software, this interactive manipulation can be done in real-time. If necessary, 3D views can be compared against 2D plots.
(2) The simultaneous use of traditional 2D plots, including newly created ones on the basis of 3D interpolated data, and 3D interactive viewing, preferably on one or on two neighboring screens, allows constructing a precise impression of 3D structures. As a matter of fact, fast and interactive 3D viewing allows to easily selecting a certain region of interest, which can then be analyzed in 2D using existing or interpolated plots. In other words, sonar operators will have all the possibilities and tools to ``learn to manage" 3D technology.
The tutorial can be attended by anyone interested in computer vision and computer graphics as well as by sonar imaging specialists.

Outline

-Introduction
- volume visualization
  - volume visualization pipelines
  - multiresolution approaches
- sonar subbottom surveys
  - bottom-penetrating sonar data
  - preprocessing
  - registration

-Interpolation of irregular sonar data sets
- introduction
- volume interpolation
- directional ping interpolation
- matching
- results & specific application

-3D data segmentation
- introduction
- octree representations
- boundary refinement
- results & specific application

-Geometry extraction
- introduction
- discrete surface models
- object surfacing
- results & specific application

-Sonar sea bottom surveys: case studies
- the ISACS project
- the EXOCET/D project
- pipeline visualization

BIOGRAPHY

Eddy Loke received the MSc degree in Computer Science Engineering from Delft University of Technology in 1994, and, in 1995, the MA degree in Psychology from the University of Leiden, both in The Netherlands. During the last eight years, he has been working as a researcher at the Vision Laboratory of the University of Algarve in Faro, Portugal, in various EU-funded projects (Integrated System for Analysis and Characterization of the Seafloor---ISACS---and EXtreme ecosystem studies in the deep OCEan: Technological Developments---EXOCET/D), in the fields of image and 3D data processing, scientific visualization, computer graphics and pattern recognition. He authored about 30 papers. In 1999, 2000 and 2001, he entered the student poster competitions of the OCEANS, MTS/IEEE conferences in Seattle, Providence and Honolulu on his work in the visualization of sparse girded sonar data sets and, in 2000, he was awarded 3rd prize. He is about to receive the PhD degree from Delft University of Technology. He has been a reviewer for various IAPR conferences, IEEE Computer Graphics and Applications, and Int. J. of Pattern Recognition and Artificial Intelligence.