Underwater Particle Holography and Grid Middleware

Henry Nebrensky (Brunel University)
Objectives of HoloMar

- Develop, construct & evaluate a fully-functioning prototype underwater holographic camera
  - Holographically record large volumes of the upper water column containing marine plankton & seston

- Design, develop & construct a fully-functioning hologram replay facility
  - Replay holograms in the real image mode for high resolution inspection & measurement

- Record, analyse & interpret holograms using specially developed image processing algorithms
  - Identification of species, size, relative location & distribution of marine organisms without operator intervention
HoloCam launch from the R.V. Calanus
Data extraction & image processing

Steps:
• Global adjustment of hologram for brightest and sharpest image
  – orientation of plate holder and angle of reference beam
• Scan videocamera through depth; capture successive images
• Digital processing for image enhancement
  – cleaning and background removal
  – object tracking
  – best focus
  – image enhancement
  – segmentation
• Species identification
  – based on neural networks recognition

Results:
• Size measurement & relative position
• Measurement of local concentration and distribution by category
HoloScan replay facility
Denizens of Loch Etive

Calanus finmarchicus from holograms at 70 m; 2 mm long and located several tens of centimetres from the exit window.
Distribution of “targets” around copepods

Interactions Between Meso- and Micro-Plankton: Deductions From Fine Scale Distributions in Three Dimensions Obtained Using In Situ Holography.


EOS Transactions, American Geophysical Union. Vol 83 No 4. 22 January 2002. p 84
In-line Holograms of Flocs

1 mm

1 mm

0.5 mm

1 mm
The Holographic Data Problem

At high magnification (a 1 mm by 0.7 mm view), one plate can generate 30 Terabytes of raw data.

- Need to extract / visualise information, not data
- How does one characterise the 3-d, projected real image?
  - e.g. brightness and contrast: how to find the brightest and darkest voxels in that 30 Tb?
  - Real image properties both fixed in plate and depend on replay laser and viewing camera
Instead of using photographic film, it is possible to capture the hologram directly on to the CCD, and then reconstruct numerically within a computer. This avoids the need to handle glass plates within the holocamera, and eliminates chemical development.

Numerical reconstruction is computationally heavy - multiple FFTs.

Marc Fournier-Carrié, a Socrates student, has implemented reconstruction software for single image planes from in-line holograms for his lab project.

The system is written in C++ on Linux.
Use of R-GMA in BOSS

- Grid monitoring infrastructure
- Based on GGF GMA
- Discrete consumers and producers
- Registry acts as matchmaker

More on R-GMA see e.g. “RGMA: today and tomorrow” at http://documents.cern.ch/AGE/current/fullAgenda.php?ida=a022043
BOSS

RefDB

CMS

BOSS DB

Workload Management System

Replica Manager

Job output filtering
Runtime monitoring

UI IMPALA/BOSS

JDL

CE / GK

CMS software

WN

CE

CMS software

SE

Push data or info

Pull info

data registration

input data location

parameters
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Use of R-GMA in BOSS

- R-GMA smoothes “firewall” issues
- Consumer can watch many producers; producers can feed multiple consumers.
- Provides uniform access to range of monitoring data (WP7 network, etc.)
- Doesn’t depend on other EDG components

- Scalability not proven
  - GK a bottleneck?
  - Need separate CMS-specific R-GMA infrastructure?
- Starting large-scale testing now - “J”

Coming soon (“J+27”):
- Registry replication
- On-fly schema definition
- Security – HTTPS
Further Work

• Effects of humidity on holographic emulsions
• Digital holography: recording of holograms
  – Sensors / Optics / Integration
  – BITLab holography facility
• Digital holography: numerical reconstruction
  – Use of DC and Grid for number crunching
  – Tracking the images associated with a given hologram
• Visualisation
  – BITLab

• Scalability of BOSS2RGMA – testing “now”
• R-GMA as a transport layer for application meta-data

• Open-source release of HoloBatch code
The End