Overview: The U.S. Naval Research Laboratory
Stennis Space Center

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Oceans In Action
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Marine Geosciences Research Thrusts

Dynamic Littoral and Riverine Processes

- Modeling Sediment Transport
- Prediction of Seafloor Roughness Evolution
- Prediction of Riverine Parameters
- Using AUVs to Characterize Estuary Hydrodynamics
- Seafloor Properties
- Unexploded Ordinance Remediation

4-D Geospatial Information, Science, and Technology

- Navigation Chart Modernization
- High Performance Mapping Services
- Environmental Mine Warfare Products
- Mine Warfare Mapping Products
- Geospatial Human-Computer Interaction Research
- Advanced Hybrid Computer Architecture

Seafloor, Coastal Terrain, and Terrestrial Characterization

- Terrain Trafficability
- Polarimetric SAR Applications
- Machine Learning to Predict Seafloor Properties
- Sediment Characterization to Improve Sea Mine Detection
Objective: Use a machine to find multidimensional correlations between geologic parameters from the global store of marine geologic data, and use those correlations to predict seafloor parameters in places they were not directly measured.
Machine Learning Prediction of Seafloor Properties

**K Nearest Neighbor**

**Prediction vector:** Values of predictors at each prediction location (red arrow).

**Observation vector:** Values of predictors at each observation location (green arrow).

Find the observation vector that is closest in parameter space to the prediction vector (maximize dot product)

The value of the predictand is the average of the observed values corresponding to the nearest vectors.

Inexperience is a measure of how well the predictor space is sampled by the observations. The map below indicates at each geospatial point, the relative distance (in parameter space) to the nearest neighbors. Geographic locations where we have data show up as low inexperience. Geographic locations that are geologically dissimilar to any observed point manifest as more distant in predictor space, and therefore higher inexperience.
Science of Munitions Mobility and Burial in Underwater Environments

https://www.youtube.com/watch?v=NMYV_Ov2bgw
What is the Density of Munitions?

- Interrogated 70 items in the inert/surrogate inventory at Blossom Point, MD from 5–9 Dec 2016
- Items range from inert certified UXO to simple pipe surrogates
- Weighed items using two different digital scales → MASS estimates
- Important to note that initial density estimates based on unfilled weights
- 3D laser scans and hand measurements used to build CAD models for all items → VOLUME estimates
- DENSITY = MASS / VOLUME
- Only interested in “bulk” or “overall” density
Density of Surrogate Munitions

- Preliminary results for unfilled items
- Found $s_m > 1$ for 95% of items
  - $\rho_s = 2,650 \text{ kg m}^{-3}$
- Missing details of multiple fill weights, fuzes, and other options from Army Technical Manuals
- Significant wave height
- Line colored by direction coming from

21-Apr-2013

- Wave energy by frequency band
  - < 0.1 Hz (inner)
  - 0.1-0.2 Hz (mid)
  - 0.2-0.3 Hz (outer)

- 2.25 MHz fixed platform rotary scanning sonar images
- Image recorded every 12 minutes for 33 days
- 7.5 m water depth
- Shoreline roughly parallel to right edge of sonar image
- Simple image normalization
- Three image moving window averaging (24 minutes)
Typical munitions, \( s_m > 1 \), do NOT wash up on the beach!

We hypothesize that storms generate changes in the beach profile to expose munitions.

Typical munitions, \( s_m > 1 \), will be trapped in a state of perpetual burial in stable bathymetry regions.

Exposure and mobility possible in active bathymetry regions but limited by burial processes.
Forecasting the seafloor boundary layer

Coupled Model Systems
- COAMPS+NSEA
- Delft3D WAVE-FLOW-MOR

Probabilistic Approaches
- Ripple prediction
- Sediment resuspension & settling

Atmospheric

Wave

Circulation

Seafloor

Acoustic scattering & penetration
Rapid Prototyping of Unmanned Systems

INNOVATION TIMELINE
Mainstreaming Unmanned Systems for Environmental Reconnaissance into Operations within 3 years at one-third the cost of a formalized acquisition approach

- Broad R&D Technical Expertise coupled with Strong Relations with Academia / Industry
- Emphasis on Early Engagement with Military End-user
- Pursue a Agile Spiral Development, Testing and Evaluation Cycle

1. Requirements
   - Surveyed end-user needs (size, cost, endurance, etc.)
   - Documented existing capabilities and reviewed roadmaps.
   - Leveraged R&D expertise to best define initial UXoS investment.
   May 2013

2. Capability Prototyping
   Coordinated "deep and wide" COTS/GOTS procurement with UXoS & full integration of non-system items.
   Nov 2013

3. Prototype Utility Testing
   Cycle CONOPS development, training & experimentation towards prototype solution with military, industry & academic partners.
   Dec 2013

4. Utility Refinement
   Concurrently develop exploitation tools to rapidly translate environmental data into decision supercycity.

5. Capability Acceptance Testing
   Warfighter led exercises to evaluate UXoS prototype, CONOPS and exploitation tools.
   (8 systems)
   Aug 2014 – Jan 2015

6. Operational Use by End-user
   - Forward deployment of systems
   - Alignment of final prototype with formalized acquisition approach
   (11 systems)
   Feb 2016

7. Acceptance Refinement & Delivery
   Performed formal Fleet experimentation to quantify operational readiness @ PAX2016.
   Sep 2015
Unmanned Aircraft Systems for Littoral & Riverine Geospatial Reconnaissance

Unmanned aerial systems (UAS) + video imaging can produce “Rapid” + measurable littoral data products.
Ability to test prototypes in a relevant environment with early enduser feedback will reduce total cycle time to fleet use, reduce technical risk, and reduce overall program cost.
Questions

Images courtesy U.S. Geological Survey