FEATURED RESEARCH: NAVEL RESEARCH LABORATORY

NRL's Automatic Change Detection and Classification (ACDC) and Autonomous Navigation Systems

Maura Lohrenz, Marlin Gendron, Brian Bourgeois

NRL Code 7440, Stennis Space Center, MS

The Geospatial Processing Applications and Analysis (GeoPAL) team at the Naval Research Laboratory (NRL Code 7440.1) recently completed development of autonomous, real-time computer-aided detection (CAD), computer-aided classification (CAC) and clustering algorithms to detect, identify, and cluster seafloor objects in side-scan sonar imagery. These algorithms have been successfully tested and transitioned to the Naval Oceanographic Office (NAVOCEANO) and are being used operationally to perform environmental characterization in preparation for mine-hunting exercises and operations. The algorithms eventually will be transitioned within a cohesive Automated Change Detection and Classification (ACDC) system for the NAVOCEANO bottom-mapping program. Future ACDC functions will include identifying contacts of interest detected in side-scan and other imagery, classifying and cataloging these contacts, and performing change detection by comparing the classified contacts with contacts detected in previous surveys (and stored in an historical database).

Our team's objective is for these algorithms to perform at least as well as - and more consistently than - manual detection, classification, and identification methods, while operating autonomously and in real-time. Other CAD algorithms have traditionally relied on image-processing techniques that require the manual definition of various parameters, such as intensity thresholds and contact sizes. In an attempt to minimize false detections and miss rates, the CAD operator needed to "tweak" these parameters as conditions in the data changed. Unfortunately, relatively minor differences in some parameters can produce radically different detection results. This lack of robustness and repeatability, as well as the need for manual intervention, has made it difficult to develop truly autonomous CAD and CAC programs. Our goal is to create algorithms that can "reason," can make intelligent decisions, have a memory, and can learn from past performance - especially past mistakes (false detections, for example) - to continuously improve. In support of this goal, the CAD and CAC algorithms we are developing as part of the ACDC system for NAVOCEANO utilize a self-modifying database, providing the algorithm with a virtual memory of past performance, which helps predict future performance to make crucial decisions.

We are now implementing intelligent wavelet networks that match both individual features (detected in current and historical surveys) and multiple features over an entire area of interest (i.e., pattern matching), resulting in an autonomous change detection capability. As part of the pattern-matching component of ACDC, we have developed a unique geospatial-clustering algorithm to cluster similar objects within an area into bounded polygons and calculate a "clutter density" for each clustered region.

The NRL Positioning, Navigation and Timing (PNT) team (Code 7440.5) specializes in underwater positioning and autonomous navigation. Current research includes Inertial Navigation System (INS) drift reduction using enhanced gravitational deflection of vertical information and the development of acoustic approaches to enable an Unmanned Underwater Vehicle (UUV) to independently sense the relative position of its neighbor vessels in a larger task force. We are focusing on a biomimetic approach using two hydrophones as 'ears' and on approaches using range and Doppler information that will be available with emerging acoustic modem systems. In collaboration with the NRL GeoPAL team, we are applying the change detection component of ACDC to compare the positions of previously- and newly-detected features for improved UUV position estimates (minimizing INS drift errors) in real-time.

Unlike most other work in this area, where it is assumed a priori that UUVs know their own position and the position of neighboring vessels, our techniques do not require extensive off-board communication/navigation infrastructure; instead, we are pursuing vessel-relative approaches to positioning and navigation. For autonomous navigation, we are developing neural network controllers grown using genetic algorithms, which are more adept at handling the poor sensor data quality typically seen underwater. Additionally, we are developing methods for these controllers to learn in-situ and adapt to changing situations that affect sensor performance. We have successfully demonstrated the ability of land robots to follow each other at close range using this controller with the dual ear sensors and are proceeding to conduct similar tests in water.

Although our autonomous navigation and ACDC systems were originally developed for underwater sensors, the techniques and algorithms could be used for many other applications, including autonomous vehicle alert and warning systems, control of multiple Unmanned Air Vehicles (UAV), CAD/CAC/change detection and clustering of objects in radar and other imagery, and other augmented cognition projects.

For more information on these projects and recent publications, refer to our websites: http://mmc.nrlssc.navy.mil and http://www7440.nrlssc.navy.mil/positioning/index.html