ARCHIVING, ANNOTATING AND ACCESSING VIDEO AS DATA

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ABSTRACT: Since 1989, the Monterey Bay Aquarium Research Institute (MBARI) in California, USA has recorded video of remotely-operated vehicle (ROV) dives into the deep sea. Currently over 14,000 digital videotapes of dives in Monterey Bay and other regions of the Pacific have been archived and managed as a centralized institutional resource. To provide for efficient navigation through this rich data source, MBARI is developing a software and hardware system, the Video Annotation and Reference System (VARS). VARS facilitates the creation, storage, and retrieval of annotations that describe the biology, geology, and other aspects of images on the video. The system references a knowledge database of over 3,500 biological, geological and technical terms allowing for speed and consistency when annotating. VARS also provides efficient access to the 900,000 annotation records and related ancillary data through its query component. One can pose a question, constrain the query to a particular organism or concept, depth and location, and quickly move the query results to a spreadsheet or geographic information system. When VARS development and testing is complete, MBARI intends to disseminate the system for research use. Sharing such software tools, data and standardizing video metadata has the potential to extend the use and value of scientific video.

INTRODUCTION

Marthe Melguen's presentation "French Voyages of Exploration and Science in the Age of Enlightenment" reminded me how oceanographic tools and data have changed over the span of my career. My first research experience was a three-year Smithsonian expedition to the Caribbean on a motor-sailboat that we, the project team, built outside Washington D.C. My primary research tools at that time were SCUBA tanks, a microtome, and a microscope. Our data and specimens included calcareous rocks shipped back to the museum and serial sections of coralline algae, as well as aerial photographs taken from a small rented plane with the door removed. We projected those photographic slides to draw (by hand) maps of the reefs we were studying. SCUBA and snorkeling forays allowed us to identify species of corals and macroalgae and to provide ground truth for the patterns of their distribution seen in the photographs.

NEW TOOLS AND TECHNIQUES

In contrast, our current research tools at the Monterey Bay Aquarium Research Institute (MBARI) are much more sophisticated and require greater technical skills to develop and maintain. A satellite receiving system collects remotely sensed images of primary productivity and sea surface height and temperature from orbiting NASA satellites. Engineers continue development of autonomous underwater vehicle (AUV) systems, including one with sub-bottom profiler, side scan sonar and multibeam sonar for generating detailed bathymetric maps of the seafloor. Moorings collect data from dozens of instruments and automatically relay them to shore. Other research platforms at MBARI include ships and two remotely-operated vehicles (ROVs) with high-resolution cameras and chemical sensors (Newman and Robison 1994).

High bandwidth data, including those high-quality video images, can be challenging to analyze and archive for use in ocean science. Since 1988, when the MBARI purchased its initial remotely operated vehicle (ROV) *Ventana*, we have maintained visual records of exploration of Monterey Bay. Initially, a Sony DXC 3000 broadcast-quality video camera was installed on *Ventana*. Video and other data transferred through optical fibers in the umbilical back to the ship where analog video recorders provided a high-resolution record of each dive. Back in the lab, after the dive, technicians reviewed the videotapes and generated text files describing the animals and habitats (Barry and Baxter 1993) or quantifying marine snow (Davis and Pilskaln 1993) seen on tape. A software program linked those text files to files of ancillary physical data (latitude, longitude, conductivity, temperature, pressure) collected by the ROV (Gritton and Baxter 1993). The video tapes and data files are archived as an institutional resource, rather than as proprietary data for the principal investigator of the dive.

The addition of a new ROV *Tiburon,* which MBARI engineers designed and built, presented the prospect of doubling the number of dives and videotapes. It was clear the institute needed a faster and more accurate system for video annotation.

An MBARI-funded internal project to develop a more useful annotation system was launched. Video technicians who do the annotation and software engineers comprise the project team. Science users of the ROV video were interviewed to determine their priorities for the system to be developed. We developed specifications for a system that would:

- minimize keystrokes
- display terms specific to a given research discipline
- provide quick access to details of descriptions
- summarize a dive with image snapshots
- be based on a hierarchical taxonomic list
- have multiple aliases to reduce annotation errors
- allow multiple interpreters of any given observation
- have annotation interface, video deck control and video display on one monitor.

To provide access to the images and data, the project team developed the Video Annotation and Reference System (VARS), a set of three software applications (with knowledge base, annotation and query components). The knowledge base, an encyclopedia of over 3,500 biological, geological and technical terms, is the foundation of the system. The knowledge base can be viewed in alphabetical or hierarchical order. New organisms or objects can be added as they are discovered or as fauna in new regions of study are encountered.

The annotation software references that knowledge base, providing consistent spelling and information about objects seen on the video. Columns at the top of the annotation graphical user interface (GUI) show timecode, observations, and associations with video image to the right (Figure 1). Physical data relating to the selected row is accessible via tabs above the video image . The lower section of the graphical user interface has quick buttons for special functions such as noting a sample taken, the population number, or that the video image is a close-up. Controls for the video tape deck are conveniently located right and center on the screen. The horizontal list of species at the bottom of the GUI functions as additional quick buttons for common animals. The list can changed easily be for a given habitat (shallow midwater, deep midwater, cold seep, deep benthic) or for an individual user's preferences. Annotation can be done in real time on the ship or later in the laboratory. The system also supports frame capture of still images off the video stream to outline the highlights of each dive. The software can be used for everything from simple annotations to outlining the general fauna in an area, to very detailed documentation of each organism, geological feature, and other habitat characters.

The query component has a separate graphical user interface (Figure 2) that allows users to extract data from the database to show the distribution of species or other objects from the database and identify the location of video sequences. Results of the query are displayed in a spreadsheet with links to framegrab images and physical data collected concurrent with the video. Complex queries can be made by constraining temporal, spatial, or physical parameters (for example, season, location, or depth) from a menu on the GUI.

Software Architecture

The software components were written in the Java programming language to run on multiple platforms and maintain compatibility between shipboard and office environments. This should maximize utility of the software for future external users who adopt the system because they can add the appropriate species, geological features and equipment seen in their own regions. Castor, an open-source, data-binding framework for Java, is used in the annotation and knowledge base components to perform object-to-relational mapping. Data used in the MBARI Video Annotation and Reference System (VARS) are stored in Microsoft SQL Server databases.

We expect to disseminate the full software system royalty-free to the research community to help meet the challenges inherent in archiving video data. For more information or to express interest in testing the program, please contact conn@mbari.org.

References

Barry, J.P. and Baxter, C. 1993. Survey design considerations for deep-sea benthic communities using ROVs. *Marine Technology Society Journal* 26: 20–26.

Davis, D.L. and Pilskaln, C. H. 1993. Measurements with underwater video: Camera field width calibration and structured light. *Marine Technology Society Journal* 26: 13–19.

Gritton, B.R. and Baxter, C.H. 1993. Video database systems in the marine sciences. *Marine Technology Society Journal* 26: 59–72.

Newman, J.B. and Robison, B. H. 1994. Development of a dedicated ROV for ocean science. *Marine Technology Society Journal* 26: 46-53.

Figure 1. Upper section of graphical user interface for the video annotation component shows columns with video time-code, observations (the larvacean, *Bathochordaeus*), associations (describing the animal) and the video image. Lower section of the GUI has annotation quick buttons, timecode and video deck controls.

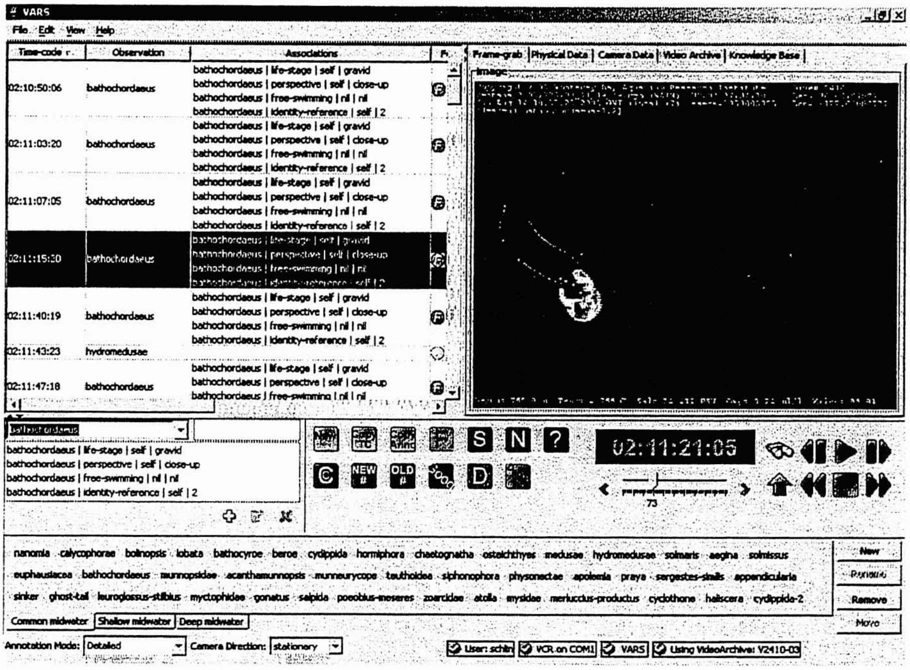

Figure 2. Graphical user interface for query component of the video annotation and reference system allows queries to be constrained by observations or species of interest, their behavior, the date, scientist and/or location.