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Automated generation of geo-referenced mosaics from video collected by deep submergence vehicles: an example from Rosebud vent (Galapagos Rift)

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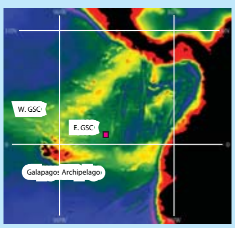
1 Objectives

Many advances in understanding biological processes at the deep seafloor are facilitated by direct observation. Mosaics of seafloor imagery have significant advantages over still photographs and video because they are able to capture large areas while retaining sufficient resolution to identify small-scale features. During a typical submersible or ROV dive, hours of video are recorded. Our objective is to develop user-friendly software to mosaic this video, allowing researchers to create "photographic dive tracks".

Our software is tailored for the incorporation of video mosaics into GIS quickly following a dive. "Photographic dive tracks" can be used for dive planning during a cruise and can be used for "legacy" video of past cruises for time-series comparisons.



Study site

Here, we present initial results of our project to automate the creation of geo-referenced seafloor mosaics from video and navigation data. During a cruise to the Galapagos Rift in May 2005, we utilized our software with data from the submersible Alvin to mosaic the seafloor at Rosebud Vent.

Fig. 1. Study site (■) for images and data on this poster (Eastern Galapagos Spreading Center, 1° N, 86° W)

2 Methods

Mosaicking basics

Mosaicking involves the co-registration of frames with overlapping features (determining the transformation relating pixels of two images). The main assumption for mosaic construction is that the imaged surface is flat, which is often violated in the rough topography of mid-ocean ridges. Distortions lead to an accumulation of co-registration error over a sequence of images.

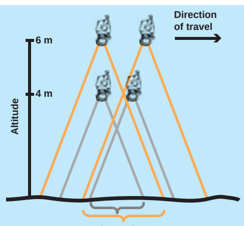


Fig. 2. Minimum overlap for automated processing

Assuming camera normal to seafloor and lens angle 40°, the field of view in direction of travel is approx. 3/4 x altitude. At 4m altitude, moving 1/2kt (approx. 25 cm/s), need 1 frame every 4 sec. At 6m altitude, need 1 frame every 6 sec.

Registration and geo-referencing procedure

The following protocol assumes that video frames are time-tagged and that navigation data are recorded frequently (e.g. LBL positions renavigated with Doppler navigation).

(1) Use vehicle navigation data (position and altitude) to determine segments of overlapping frames from an entire dive.

To lower the accumulated co-registration error and work with a manageable image size, our software divides video transects into ~15-m segments for mosaicking.

(2) Extract frames directly from DVCAM tapes.

(3) Process frames, co-register, and verify with navigation.

We co-register images utilizing a 4-parameter rigid affine model. This model captures rotation, translation, and scaling. Our mosaicking technique involves the featureless Fourier domain method in conjunction with artificial intelligence (Support Vector Machine) for transformation quality assessment, allowing an automated co-registration process.

(4) Construct geo-referenced mosaic (world file and/or GeoTIFF).

Fig. 3. Stages in automated processing

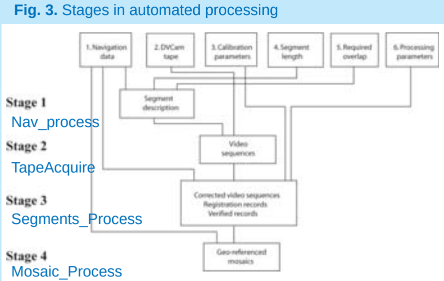
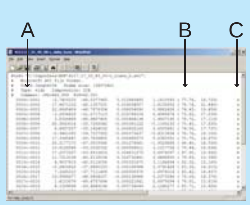


Fig. 4. Output of co-registration, indicating (A) frame numbers, (B) overlap %, and (C) satisfactory matches.

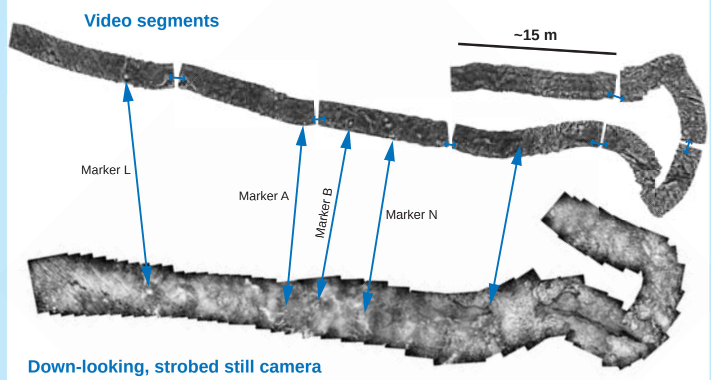


3 Results

For validation of the automated processing, we compared video mosaic segments to manually-constructed still camera mosaics.

Automated video mosaic vs. manual still mosaic

Fig. 5. Transect mosaics with contrast-enhanced frames. 10-min sequence from Alvin Dive 4117. Arrows indicate matching features. The seven video segments will overlay when placed into GIS. The initial frame of each segment is tied to vehicle position and heading.



Still camera mosaic constructed manually due to low overlap.

Mosaic placement into GIS

GIS may be used to display the mosaics and associated metadata. Transect mosaics may be displayed in association with vehicle track lines.

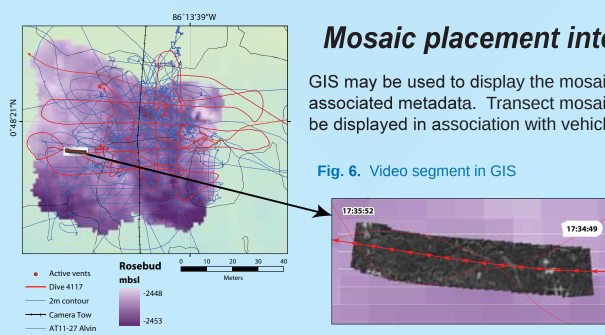


Fig. 6. Video segment in GIS

4 Conclusions and future goals

We are now poised to use our software to generate geo-referenced mosaics of the seafloor at Rosebud from "legacy video", to quantify the temporal changes in vent community distribution. On our next cruise, in Oct. 2006, we will test our software during Alvin dives at the East Pacific Rise.

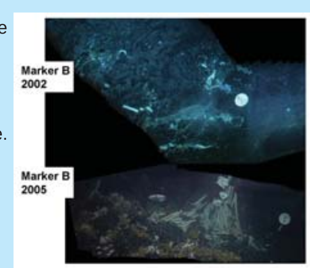


Fig. 7. Video mosaics for Marker B site at Rosebud in 2002 (top) and 2005 (bottom).

Suggestions for users

Mosaicking during a dive involves a compromise between altitude, speed, camera positioning, and lighting. Overall, the best mosaicking is likely to derive from a dedicated camera/lighting system. Video mosaicking as described here allows for maximum use of existing video cameras on Alvin.

Acknowledgments

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