

High-resolution seafloor DEM of World War II wreck site by combining multibeam bathymetry and SfM photogrammetry

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The high-resolution digital elevation model (DEM) generation using Structure-from-motion (SfM) photogrammetry is challenging for underwater objects and geomorphology because global positioning systems-based mapping techniques cannot be applied to the seafloor. We eliminate this problem by incorporating precise control points obtained from high-resolution multibeam echosounding bathymetry to generate 3D models using SfM photogrammetry.

A World War II wreck USS Emmons, a 106-m US Navy Benson-class destroyer minesweeper sank in ~40 m of water off Okinawa Island, Japan, is used as a case study for this project. The Sonic 2022 was used for multibeam bathymetry which has a variable ultrasonic frequency of 200 to 400 kHz, 256 ultrasonic beams and selectable swath coverage of 10 to 160 degrees. An ultrasonic frequency of 400 kHz is selected for this study. An ultra-high-resolution DEM with a grid size of ~5 cm was generated for a 120 m ×30 m area covering the entire wreck site using geographical coordination using 1,716 images of the wreck obtained during scuba expeditions.

The USS Emmons stalled from damages incurred during an attack by Japanese *kamikaze* planes on April 6, 1945. The ship was abandoned and intentionally sunk. The wreckage of the *kamikaze* planes is also scattered on the seafloor. More than 70 years after the end of the Second World War, documentation of the war through material evidence beyond first-person accounts is increasing in significance. The model provides a primary record of the current state of the wreck, and allows for the establishment of various measures for its conservation.

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