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MergeBathy (2015)

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ABSTRACT

Developed in C++, MergeBathy (2015) is cross-platform and multi-threaded software suite for constructing digital bathymetric models. It provides the user with a set of modeling tools to construct custom bathymetric surfaces, including splines-in-tension routines for interpolation output or as an intermediate resampling step when merging multiple bathymetry data sets. Notable to MergeBathy is its user-friendly and flexible processing options made possible from its integrated bathymetric process framework.
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Code metadata

Current Code version	*5.0.3*
Permanent link to code / repository used of this code version	https://github.com/ElsevierSoftwareX/SOFTX-D-17-00007
Legal Code License	*CC0*
Code Versioning system used	*GitHub*
Software Code Language used	*C, C++*
Compilation requirements, Operating environments & dependencies	*Windows 7 and Windows 10 x86, x64, CentOS 6 and 7 (Linux) x86, x64, Visual Studio 2010 for Windows*
If available Link to developer documentation / manual	https://github.com/Sammie-Jo/MergeBathy_Repos-mergeBathy_DOCS
Support email for questions	Samantha.zambo@gmail.com

Software metadata

Current software version	*5.0.3*
Permanent link to executables of this version	https://github.com/Sammie-Jo/MergeBathy_Repos-mergeBathy_CPP
Legal Software License	*CC0*
Computing platform / Operating System	*Windows 7 and Windows 10 x86, x64, CentOS 7 (Linux) x86, x64*
Installation requirements & dependencies	*None.*
If available Link to user manual — if formally published include a reference to the publication in the reference list	https://github.com/Sammie-Jo/MergeBathy_Repos-mergeBathy_DOCS
Support email for questions	Samantha.zambo@gmail.com

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1. Introduction

A Digital Bathymetric Model (DBM) is an estimate of the shape of the seafloor created from bathymetric soundings (measurements). Utilized for safety of navigation of ships and underwater vessels, geophysics research, bounding of ocean or acoustic models, and the study of marine life ecosystems [1], DBMs have significant economic importance. Measurements stem from a wide variety of sensors including space-borne gravity, airborne laser, ship and underwater vehicle sonar, and Lidar [2]. Due to the high collection cost, high-resolution data is scarce over most of the world's ocean. The measurements used to create a DBM for a specific area of interest therefore come from a variety of different technologies with different vertical/horizontal resolution, accuracy, etc. Input data with multiple resolutions pose a significant challenge for the computation of an output DBM. MergeBathy (2015) is an integrated software suite for processing bathymetric data of varying resolution for the creation of a DBM [3] that utilizes the latest academic advances in processing techniques. MergeBathy stream-lines the steps of taking cleaned bathymetric sonar data and producing final DBM products.

2. Problems and background

As presented in the publication from the General Bathymetric Charts of the Oceans, *The IHO-IOC GEBCO Cook Book*, bathymetric modelers need flexible tools to process potentially large amounts of bathymetry data for the creation of DBMs. Current modeling tools for DBM construction involve individual algorithms, toolkits or GIS software. MergeBathy is the accumulation of efforts to provide an integrated approach that is between toolbox software and GIS system software in terms of architecture complexity.

This new software tool incorporates splines-in-tension algorithms from the Generic Mapping Toolbox [4] and MB-System [5] for sparse data set interpolation or resampling. Dense data set algorithms include localized regression or LOESS by Cleveland (1979) or the Kalman filter algorithms to generate a DBM. Since these dense data algorithms produce a smoothed surface, higher details can be restored by adding ordinary kriging of the residuals as published in Calder (2006) Reference [6](to restore finer details lost from over-smoothing), and utilizes CUBE's Uncertainty pRopagated Variance Equation (CURVE) [7] (to attribute uncertainty). Smoothing locally allows for a user-specified, scale-controlled surface reconstruction of sparse data that is capable of modeling complex surfaces [8] and kriging the residuals [9] honors data points in the reconstructed surface when desired by the modeler. In general, MergeBathy has a defined process flow that alleviates some of the burden from the user in constructing DBM.

3. Software functionalities

We present MergeBathy's high-level process flow diagram in Fig. 1. The merging of multiple input data sets into a single input data set for further computations is part of MergeBathy preprocessing (data fusion) functionality. To merge these data sets, MergeBathy must first apply any metadata to the individual files (not shown), transform and rotate coordinates, create an output grid, remove offsets between data sets, and optionally pre-spline to account for data sets of different resolutions.

Once the software computes a single unified data set, MergeBathy begins its trend surface analysis functionalities seen in the final two sections, which generate the final surface. Here, MergeBathy regresses to compute the trend surface, smooths the detrended surface to highlight desired features, optionally kriges the residual to restore finer details, restores the residual and trend surface, and estimates uncertainty. A Monte Carlo estimator is also available for computation uncertainties for input data.

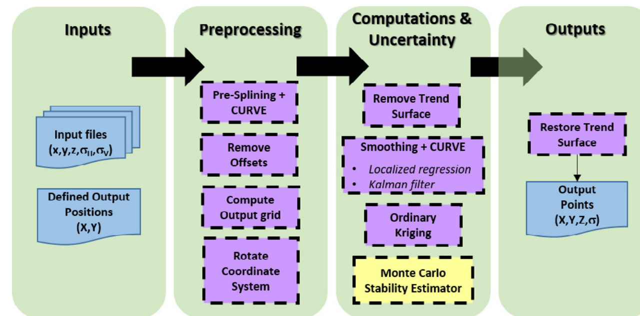

Fig. 1. High-level MergeBathy flow for processing bathymetric data.

4. Implementation

Multi-threaded and cross-platform in design, MergeBathy is available to Windows x86, x64,[1] Linux x86, and Linux x64 from a C and C++ codebase. MergeBathy utilizes several third-party libraries including GMT Reference 4, MB-System [5], Bathymetric Attributed Grid (BAG)[2,3] files [10].

5. Illustrative examples

Example 1: Computational grids

This case study compares the effects of choosing a regular computational grid on which to output. Fig. 2 shows bathymetric surfaces generated with (a) Duck, NC data onto a defined computational grid (b) 50 by 50 m with a 50 by 50 m smoothing Hann window and then with a finer regular computational grid (c) 10 by 10 m with a 10 by 10 m smoothing Hann window. Notice the increase in "jaggedness" to the contours in (b) compared to (c). The "jaggedness" we will try to smooth away in the next example.

Example 2: Non-uniform smoothing scales

This case study compares the effects of choosing smoothing scales. This case study extends the previous case study in Example 1: Computational Grids. Fig. 3 shows bathymetric surfaces generated with Duck, NC data onto a regular 10 by 10 m computational grid (a) with a 20 by 20 m smoothing Hann window and then with a larger smoothing scale in the along-shore direction with a (b) 20 by 100 m smoothing Hann window. Note that with very short smoothing scales as in (a), there is a significant amount of texture to the contour lines. In (b), the plot shows gentler alongshore contours given by the 100 m Y smoothing scale, yet the cross-shore profile is still very similar to that shown in (a) because the cross-shore smoothing scale is the same in both merges. Thus, the "jaggedness" of the contours in (a) smooths to an overall, better representation that is more natural in (b). The larger smoothing scale in the along-shore direction allows for a smoother transition across-shore. The "jaggedness" seen in (a) has been successfully smoothed by this window (b).

1 We suggest a 64-bit processor for large input data sets.

2 Non-proprietary file format developed by Open Navigation Surface Working Group (ONSWG); version 1.0.0 [10].

3 Utilizes additional third-party libraries not listed.

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