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Abstract

Beach profiles change shape over many temporal scales from hourly and seasonally to geological time frames. The beach profile is also manipulated through engineering activities such as beach nourishment, erosion and accretion at jetties, and dredging. Qualitative tools are needed to understand beach profile change for engineering and scientific purposes. This study has developed a convenient interactive graphical user interface using the X Window System on a UNIX system by which a user from any discipline can view survey data on beach profiles and beach profile change, then design cross sections for beach fill projects and automatically compute basic quantities such as beach slope and cut-and-fill volumes.

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The experience of designing, coding and implementing a large program was very rewarding. The project was very productive in developing my knowledge of computer science, surveying and coastal processes. I would like to thank Dr. Patrick Michaud for his patience and help in design of BMAP-X and "eXpert" advice and help whenever I asked. I would also like to thank Dr. Nicholas Kraus for his idea for the project and numerous ideas on what BMAP-X should do. Scott Duff was instrumental in finding solutions to numerous programming problems that evaded my cranium. Don Waechter also proved more than once the errors I was seeing were in my coding and not neutrinos striking the CPU. Barry Sommerfeld provided numerous insights to problems found in designing beach profile software.
I. Background and Rationale

Personnel at the Conrad Blucher Institute for Surveying and Science (CBI) at Texas A&M University-Corpus Christi are involved in several beach monitoring and restoration projects along the Texas coast. These projects involve surveying of several beach profiles at each site to determine the shape and condition of the beach. Typically, a profile is surveyed from the foredune or beach-fronting road to some distance offshore corresponding to a depth between 8 ft and 30 ft, depending on whether the project site is on a bay or along the open Gulf coast. The profile data are used to:

1) compare to historical data to determine erosional and accretional rates,
2) design new beach shapes,
3) determine the amount of fill needed to restore a beach,
4) determine post-fill volumes of sand moved, and
5) monitor post-fill erosion/accretion rates.

The personnel at CBI have designed and constructed a beach survey sled to measure beach profiles in water depths as great as 32 ft (see Figure 1). This new survey instrument enables these researchers to survey profiles to approximately one mile offshore of the Texas Gulf coast with an accuracy of 0.01 ft horizontally and 0.01 ft vertically (Grosskopf and Kraus 1994). The resulting profiles are compared to historical profile survey data or are used to determine the shape and volume of profile shapes proposed for beach restoration projects.

Figure 1. Blucher Institute Beach Survey Sled.
CBI staff and students need a tool that enables convenient reduction and analysis of profile survey data. Also, the same tool can help in the design of beach restoration projects by determining cut and fill volumes and calculating equilibrium shapes. This tool enables the user to generate beach profiles from three different sources:

1) data collector from a total station,
2) data in International Survey Reduction Package (ISRP) format (Birkemeier, 1984), free format (FRE), and x-y pair format, and
3) graphically via mouse.

The user can also determine cut and fill volumes between any two profiles by either defining an area with a mouse or by specifying a contour range.

To address the aforementioned need, this project has developed an integrated and interactive suite of analysis and visualization programs called Beach Morphology Analysis Package for X Window Systems (BMAP-X). The architecture of BMAP-X is flexible and general, and numerous capabilities are expected to be added in the future.
II. Narrative

Idealized beach profile survey data consist of distance-elevation pairs of points, with the origin of the horizontal distance located somewhere on shore and the elevation typically referenced to a water datum such as mean water level. Beach profile data are thus two-dimensional and can be plotted on a Cartesian Coordinate system with the x axis (abscissa) denoting distance offshore and the y axis (ordinate) denoting elevation. Such two-dimensional data are readily amenable to graphical display and manipulation.

The following is a summary of how the BMAP-X works. To start BMAP-X, the user clicks on an icon bearing the name of the program. A Program Control Window similar to Figure 2 is displayed:

![Program Control Window](image)

Figure 2. The Program Control Window.

The Program Control Window contains a **Menu Section** which offers the user choices of main functions of the program, a **Drawing Area** or canvas for displaying and editing beach profiles, a **Text Input Area** for the user to reply to prompts from the program, a **Message Area** which instructs the user as to what type of event the program is expecting, a **Tools Area** which displays pertinent tools available in response to the latest command, and a **Selection Box** for selecting or changing the active profile.
A. Menu Section

After BMAP-X is started, the user chooses one of the following items from the menu bar:

1) File  
2) View  
3) Generate  
4) Report  
5) Units  
6) Convert  
7) Reduction  
8) Timeview  
9) Legend  
10) Generalize

Each of the menu bar items has multiple choices from which the user can select. The options available for each menu item are described below.

File Menu Option

The File menu option has the following ten options available to the user: New, Open, Close, Close All, Combine, Save, Save As, Save Project, Print, and Quit. The following is a description of usage for each menu item:

New- This button is selected when the user wants to construct a new profile. The user can enter coordinates by typing in the text input window, graphically using the mouse to point to vertex locations on the drawing area, or combinations of both.

Open- This button is used to load an existing profile and display it graphically on the drawing area. After pressing the Open button, the user selects which file to view by either double clicking with the mouse on the selected file or highlighting it and selecting the "OK" button.

Close- This button closes the top-most or most recently opened profile. The action produced by pressing this button is to close the active or topmost layer and activate the next layer down in the stack.

Close All- This closes all the profiles that are open. The action produced by pressing this button is to reset the number of layers open to zero and clear the screen.

Combine- This button is used to combine separate layers (e.g., from sled and hand held surveys after comparing the overlapping regions). When this option is selected all the layers currently in the Drawing Area are combined into one new layer. The individual layers are deleted and BMAP-X displays the single combined profile.
Save- This button saves the active layer or layer being edited. If the layer has not been named, the user is prompted to enter a new layer name.

Save As- This button saves the active layer or layer being edited as a new file. The user is prompted to either enter a file name to save the profile in or save the file as the original file name.

Save Project- This button saves all layers to a single file. This feature can be used to group related profiles in a single file for easy access at a later date.

Print- This button enables the user to produce a hard-copy output on a PostScript printer.

Quit- This button enables the user to quit BMAP-X. The user is first prompted to save any modified profiles, then the program ends after destroying its window.

View Menu Option

The View menu option enables the user to manipulate the extents of the drawing area and has the following options:

1) Redraw
2) Zoom Previous
3) Zoom Layer Extents
4) Zoom All Layers

Redraw- This option redraws the screen and is useful when viewing animation sequences.

Zoom Previous- This option enables the user to enlarge any area by either pointing to a subarea on the screen or by entering the coordinates of a bounding rectangle in the text input window.

Zoom Layer Extents- This option lets the user "zoom out" to the extent of the top-most layer.

Zoom All Layers- This option lets the user "zoom out" to the extent of all the layers currently open.

Generate Menu Option

The Generate option enables the user to generate a profile using an external program. For this project, only the $x^{2/3}$ (Bruun 1954, Dean 1977, 1991) equilibrium profile method is included.
Report Menu Option

The Report menu option lets the user print Cut-Fill and Area reports. When the user selects one of the report buttons, a report is printed at the user's default printer showing the results of the last Cut-Fill or Area operation.

Units Menu Option

The Units menu option lets the user specify the units to be used for reports.

Convert Menu Option

The Convert menu option lets the user convert beach profiles stored in ISRP format to FRE format.

Reduction Menu Option

The Reduction menu option lets the user reduce raw field data from a Cadastral Electronic Field Book (CEFB) Observation file (.OBS) and convert it into FRE format for use by BMAP-X.

Time-View Menu Option

The Time-View menu option lets the user view a group of profiles measured at a single location as an animation sequence. The user can view the formation and movement of bars and troughs and use all the tools available for the drawing area except cut-fill.

Legend Menu Option

The Legend menu option lets the user turn the legend off or on. The legend can sometimes prevent the user from viewing profiles clearly, especially when multiple profiles are displayed.

Generalize Menu Option

The Generalize menu option lets the user create an interpolated profile from a existing profile. This lets the user create a profile with specific horizontal intervals which can be used with a program that requires evenly spaced data.

B. Drawing Area

The drawing area or canvas is used to display profiles, elevation and distance offshore grid-lines, and the water level. The drawing area can display multiple profiles at the same time.
C. Text Input Area

The text input area can be used in place of a mouse for coordinate input. After coordinates are entered and the return key is pressed, the input is treated the same as a mouse click at the entered coordinates.

D. Message Area

The message area displays all messages for the user including prompt-expected input format and the next-expected action by the user.

E. Tools Area

The Program Control window also contains a toolbox area with the following tool buttons:

1) ADD
2) DELETE
3) MOVE
4) PAN
5) ZOOM
6) AREA
7) CUT-FILL
8) DISTANCE

These tools change the mode of the drawing area. The mode of the drawing area determines what action is to be taken when the user enters mouse events in the drawing area. These buttons also control the mode for the text input window in the same manner.

**ADD**- This button lets the user add points to the active layer by changing the drawing area mode to ADD. All subsequent mouse-up events within the drawing area window cause a vertex to be added to the current layer.

**DELETE**- This button lets the user delete points from the current layer by changing the mode of the drawing area. A mouse down event describes the upper left corner of a selection box and the mouse up event is the lower right corner. All points within the selection box are removed from the current layer.

**VE**- This button lets the user to move selected vertices. The user is prompted to enter a cement amount in the text entry window or use the mouse to describe a displacement (move mouse to the drawing area, press mouse button down, drag mouse the desired in the x and y directions, then release mouse button).
**PAN**- This button lets the user move the extents of the drawing area. When this button is activated the drawing area mode is changed to PAN. The next mouse down event inside of the drawing area determines the starting point of the pan vector and the next up event becomes the ending point of the pan vector. The extents of the drawing area are changed by the pan vector and the drawing area is redrawn.

**ZOOM**- This button lets the user to zoom to any subregion of the drawing area. When the ZOOM button is activated, the drawing area mode is changed to ZOOM. When in the ZOOM mode BMAP-X interprets the next mouse down/up events in the drawing area as the new display extents, then redraws the drawing area with the new extents.

**AREA**- This button lets the user to calculate the area within the selection box and under the profile line. When the AREA button is activated the drawing area mode is changed to AREA and the next mouse down/up events are interpreted as defining the corners of the selection box.

**CUT-FILL**- This button changes the mode of the drawing area to CUT-FILL and the next mouse up/down events in the drawing area are interpreted as the corners of the selection box.

**DISTANCE**- This button lets the user determine the horizontal, vertical, and slope distance between two points in the DrawingArea. When the DISTANCE button is activated the drawing area mode is changed to DISTANCE and the next mouse down/up events are interpreted as the end points of a distance vector.

**F. Selection Box**

The Selection Box displays a list of the profiles currently displayed in the DrawingArea. Only the profile at the top of the list is active (editable). When a profile is active the user can ADD, DELETE, and MOVE points in that profile. The Selection Box lets the user select the profile to make active. The user selects a profile by double clicking on the profile name in the selection box. If the profile selected is not active, the profile's position is exchanged with the current active profile and placed at the top of the list.
III. Project Environment

A. Equipment

Equipment includes a Hewlett Packard 9000 Model 755 RISC-based computer using the HP-UX V.9.01 operating system. The current system at the Conrad Blucher Institute uses a 20-inch Sony Trinitron monitor, Hewlett Packard Laserjet 4M PostScript printer, and a mouse for pointing.

B. Program Languages and Data Sources Used

Most of the coding was written in the C language using X Window development tools and the HP ANSI C compiler. Many of the procedures and functions used are standard tools provided in the Motif Toolkit. Some programs are written as Unix shell scripts.

C. Interfaces With Other Systems

BMAP-X reads files compatible with the Interactive Survey Reduction Program (ISRP) and the Beach Morphology Analysis Package (BMAP) (Sommerfeld, Mason, Kraus and Larson, 1994).