

DEMEDITOR: A TOOL FOR EDITING DEMS

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ABSTRACT

A system to visualize and edit digital elevation models based on interferometric synthetic aperture radar data is presented. The visualization and exploration of digital elevation models has been basically done through the use of two-dimensional interfaces. As virtual reality interfaces have proven to offer a high degree of presentation realism and several interaction facilities, they are an appropriate way to visualize and interact with objects such as terrain models. The realistic presentation of the height component of such kind of object is fundamental for its comprehension. Digital elevation models frequently present elevation errors due to problems occurred during imaging process or raw data processing. Several methods have been developed to correct these errors, but a total elimination is not much probably. The visual interpretation of the data, the use of analyse tools to assess this interpretation, and the manual editing of error areas in the digital elevation model compose the error reduction procedure presented by this work. The system offers both a two and three-dimensional interface to visualize and interact with the digital elevation models, and allows the selection of error areas in the terrain in order to remove them. The removed areas can later be interpolated and smoothed.

Keywords: virtual reality, remote sensing, digital elevation models, DEMs visualization and error editing.

1. INTRODUCTION

This paper presents a virtual reality (VR) based system to edit digital elevation models (DEMs). The user can visualize and analyse the synthetic aperture radar (SAR) data, identify elevation errors in the terrain and correct them according to its needs.

Section Digital Elevation Models describes the main features related to the terrain models. In section DEMs and VR the advantages of using VR interfaces to visualize and explore DEMs are described. Section The DEMEditor describes the system proposed by this paper to edit DEMs.

2. DIGITAL ELEVATION MODELS

DEMs can be obtained from many remote sensing systems, as interferometric synthetic aperture radar (InSAR) data [Wimme00]. High resolution DEMs are used in different applications, and become very relevant to provide information about areas where there are no detailed, precise and updated topographic maps.

A regular DEM can be conveniently stored as a real matrix, where the value in position (x, y) describes the measured or estimated height z of the terrain in the corresponding coordinates.

Systems to visualize and manipulate DEMs normally are based on two-dimensional (2D) interfaces. These interfaces allow the user to analyse the terrain, but do not offer a realistic and intuitive presentation of the data, once they appear flat.

Another aspect related to DEMs is the fact that they commonly pursue errors. These errors appear as height errors in the terrain. For example, the DEM presents a high slope in an area that should be totally flat, or a mountain appears lower than it is in the real world. Such errors can occur in consequence of the imaging process, or/and during the process of the raw data, collected by the radar, to generate the DEM.

Several methods and algorithms have been developed to reduce these errors in DEMs, in order to acquire high precise models. Nevertheless, experience has shown that finally a visual interpretation of the data can help considerably to

identify errors, being the process very subjective. Identified errors are later removed, normally through the use of IDL (Interactive Data Language). The correction process becomes very complex and exhaustive for the user, once there do not exist specialized tools developed for editing errors in DEMs, as far the authors know.

3. DEMS AND VR

Successful visualization and interaction with DEMs requires fulfilling the user's expectations about the data and the information through a convenient interface.

VR is a technology that allows the development of three-dimensional (3D) interfaces [Ames97]. 3D interfaces, because its similarity with the real world, present information in a very realistic way.

VR interfaces also offer high interaction with the virtual environment. This interaction can be done through the use of special touch sensors to manipulate objects in the scene, or navigating through the environment. A free navigation allows the user to explore the scene without help, according to its desire, and a viewpoint-based navigation guides the user through the environment taking him/her to pre-defined places of interest.

As mentioned in section Digital Elevation Models, visual interpretation is a powerful method to analyse and correct DEMs. The use of 3D VR interfaces allows the realistic presentation of the terrain, so that the user can visually grasp more easily the information represented in the environment. Once visualizing the DEM as a 3D surface, the user can navigate around it, approximating to view features in more detail, or selecting an overview viewpoint that gives him/her a complete view of the terrain, in order to explore the entire DEM and analyse it. Through this exploration, errors can be visually identified and removed.

4. THE DEMEDITOR

The DEMEditor is a prototype for a VR DEM editor that intends to permit SAR data end users to analyse and edit DEMs.

A set of requirements were collected and structured, in order to define a user-friendly interface and to develop a system that allows the correction of errors in the data. Moreover, through the use of the prototype another user requirements could be collected and defined for the continuation of the implementation of the system.

The system was implemented in IDL

version 5.3, a language developed by Research Systems Inc. IDL is large used by SAR data users because it pursues a set of ready to use functions for data analysis and visualization.

The DEMEditor is a tool for visualization and analyse of DEMs, and a tool for editing errors remained in DEMs after the entire processing of the data. The 2D window based interface, as well as the tools for analysing and validating the data are based on the interface of the ENVI software developed by Research Systems, Inc. ENVI is a well known visualization and analyse tool and SAR data end users are familiarized with its interface, what is the main reason that the DEMEditor interface adopts some patterns from its interface. The 3D interface for visualization and interaction with the data, as well as the editing functionalities were developed based on previous experiences with VR interfaces.

The DEMEditor is composed by three main components: visualization, analyse and editing component.

The visualization and analyse components are responsible for providing a set of functionalities that allow the user to explore the data and make analyses to verify the integrity of the data. Visualization can be done in two and three dimensions. The 2D interface offers three windows to visualize the DEM: scroll, display and zoom window. The scroll window presents the entire DEM in an adequate scale factor in order to allow the user to have an overview of the whole terrain, the display window presents the area selected on the scroll window (inside a green box) in an 1:1 scale, and the zoom window presents the area selected on the display window (inside a green box) reduced initially by factor 2. The selection boxes on the scroll and display windows allow the user to explore different areas of the terrain by moving them to the desired place in the window.

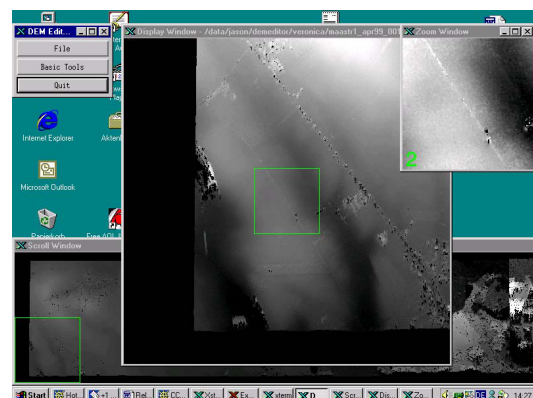


Fig. 1: The main interface of the DEMEditor.

Through the zoom window the user can

explore the data in a very precise way by increasing the zoom factor and making analyses of individual pixels in the image. Fig. 1 shows the initial interface of the editor. A menu, on the upper left side of the figure, offers default options. The scroll window showed in the lower part of the figure, the display window that is located in the upper middle part, and the zoom window, on the upper right side of the figure show a particular view of the DEM.

The 2D interface provides some tools to analyse the data. These tools can be selected through a menu on the display window.

Passing the cursor over any of the windows, its x, y coordinates in the file will be showed, as well as its brightness value (Fig. 2).

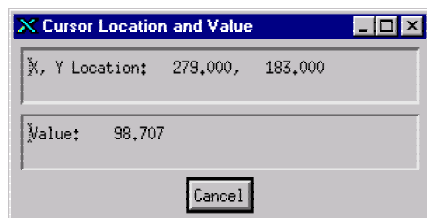


Fig. 2: Tool for verification of position and value of pixels.

Analyse the profile of a set of points allows the user to validate the correctness of the elevations of the digitally generated DEM. This is done by measuring the height of a set of points in the terrain, and comparing these elevation values with the elevations of the same points in the digital DEM. The profile tool of the editor works defining a line through the selection of points in any of the windows, and cutting the line with the right mouse button. A window presenting the elevation values from the selected points is showed. It is also possible to delete profile lines, as well as move them through the image in order to see the variation of the profile. Fig. 3 shows a profile line and its corresponding profile window.

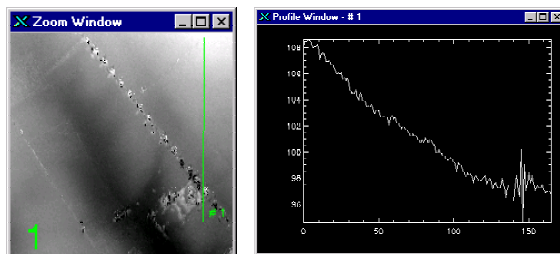


Fig. 3: The zoom window's profile line with the associated profile window.

In order to improve the appearance of the image to assist in visual interpretation and analysis,

a histogram is offered by the editor. By default, the editor verifies the best contrast values for the image when the file is opened or reloaded by the application, but the user according to its needs can modify this value.

The DEMEditor uses a linear stretch, identifying lower and upper bounds from the histogram, in this case the minimum and maximum brightness values in the image, and moving the lines in the histogram to stretch this range to fill the full range. Fig. 4 shows the image appearance if the brightness values are stretched from values between 0 and 255. Once most of the brightness values of this image occur between the values 86,2978 and 111,859, stretching the image to this largest range decreases its contrast, taken the visual interpretation more difficult. This can be observed comparing Fig. 3 (left) and Fig. 4 (left), which present the same image stretched to different contrast values. The histogram window can be seen in Fig. 4 (right).

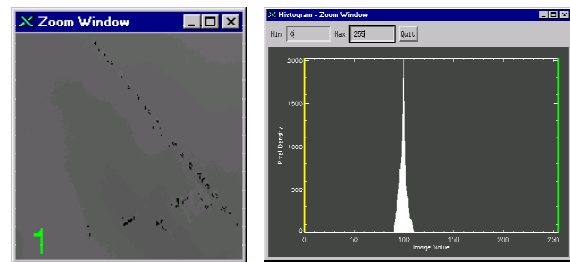


Fig. 4: The image contrast stretched to the range of 0 to 255 brightness values.

The 3D interface for visualizing the DEM is limited to the image area presented in the zoom window. The 3D visualization option offers some resources to explore visually the terrain, such as the possibility of mapping the amplitude picture related to the terrain area over the surface, enhancing the realism of the presented data. It is also possible to apply a colour table to the surface, so that a specific colour corresponds to a specific height value. Through this function the data become more comprehensive as when represented in grey scale.

One of the more relevant features of a VR interface is its navigation and interaction functionality. In order to allow a more efficient exploration of the data, the editor offers a set of viewpoints that the user can select to navigate around the terrain, and also a distance controller that allows the user to come closer to the terrain. Fig. 5 shows the 3D visualization interface with its presentation (left) and navigation (right) options. In the upper part of the window the DEM is presented as a 3D surface, mapped with its corresponding amplitude picture. According to the colours, elevation changes in the terrain can be observed,

ranging from low elevations represented through blue colours to high elevations represented by yellow colours.

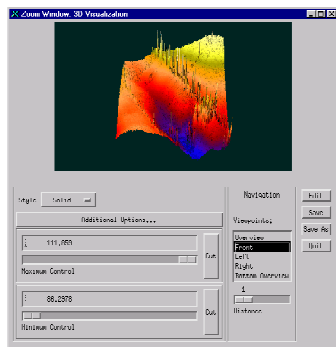


Fig. 5: 3D visualization interface.

The main function of the DEMEditor is to allow the user to modify the DEMs. Errors that could not be corrected during the data processing could be visually identified with the assess of analyse tools, and later should be removed. Initially the user is able to select an area of the image what not corresponds to the correct elevation values. The values selected could then be removed, interpolated, or both. Editing can be done in the 2D and 3D interface. If the user edits the 3D interface, he/she can choose to make modifications over the entire surface, or a region of interest may be selected for modification. Fig. 6c shows the editing menu. The functions Interpolate, Median, Moment and Mean are options to interpolate and smooth the terrain, as well as obtain statistical information about the data.

In the 2D interface the editing process can be done selecting the option “Region of Interest” in the display window’s menu. Moving the left mouse button around the region to be edited, a red polygon will be created surrounding the values to be modified. By releasing the mouse button, the editing menu is shown and the user can cut and interpolate the region. Fig. 6a and b illustrate this process.

An update option (see Fig. 6c) is available in both editing menus to make possible for the user

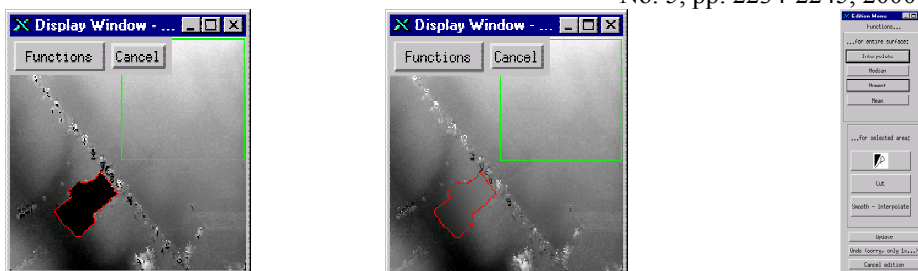


Fig. 6: The editing task: a) a region of interest is selected and cut; b) the hole is interpolated; c) the editing menu.

to actualise the modifications made in all windows, and so permanently keep an overview of how the terrain looks like.

5. CONCLUSIONS AND FUTURE WORK

The system described in this paper is used to visualize, analyse and edit DEMs. The DEMEditor presents the terrain data through a 2D interface, as well as 3D one. Analyse tools offered by the system allow the user to enhance the images, in order to facilitate the visualization. The user can also make comparisons between the data to assess the interpretation process. The possibility of edit the DEM, after the identification of errors in the model, represents a new method to correct elevation data in DEMs. The DEMEditor permits to remove data from a specified area and interpolate and smooth this area. The navigation through viewpoints facilitates the exploration of the terrain, once the user can move around the surface and visualize the data.

Next the definition and modelling of specialized icons for editing DEMs will be done, in order to create an intuitive, user friendly, VR based interface for correction of errors in DEMs. Several experiments will be made with SAR data end users, in order to validate and improve the user interface.

6. ACKNOWLEDGEMENTS

The authors are grateful to CNPq, DAAD and Aero-Sensing Radarsysteme GmbH that partially founded this research.

7. REFERENCES

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