

"TERRASYS"

A PERSONAL INTERACTIVE 3-D

TERRAIN MODELING AND ANALYSIS SYSTEM

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ABSTRACT Processing of Digital Terrain Models (DTM) involves handling of Large quantities of data and computations. Until recently, DTM was applied only on main frames and large mini computers. The development of powerful micro computers and desktop systems changes the transportation of DTM application to personal computer environment, so to enable direct, simple, economic and wide spread use of modern digital mapping technology to the benefit of society. The transportation of DTM to a small micro computer environment, however, necessitates the development of new, efficient algorithms in order not to sacrifice quality and performance because of computer limitations.

This paper presents a new DTM system, especially developed for micro computers so that it can be applied on standard personal computers such as IBM PC XT/AT. It is a result of many years of development of both photogrammetric and mathematical algorithms representing a new approach and technology of digital terrain modeling for interactive and real-time applications. The system, called TerraSys(R), is interactive and can handle both gridded data and random data. It has a versatile terrain analysis and presentation capabilities in 2 and 3 dimensions.

1. INTRODUCTION

DTM (Digital Terrain Model) is by no means new. For the last two decades it was the subject of many research and development works in various institutions.

Because of its complexity and state of technology DTM was developed and implemented on large expensive computers. And thus, for many years, only large institutes could benefit of it, whereas the small surveying and photogrammetric office could not effort to use it.

With the appearance of the micro processor in the mid seventies, first investigation into the use of small micro processor based system for DTM was carried out by the author at Xi Information Processing Systems R&D department.

The first approach was simply to convert existing computer programmes from main frame to the micro computer environment. At the very early stages it was found that such a conversion, although could be done, will not result in a practical product. Since the main idea of providing a DTM on a micro computer was to spread its use to every photogrammetrist, it was clear that a mere conversion will result in an inefficient, slow and unfriendly system because of the then interent limitations of a micro computer, namely storage size and speed.

The aims we put forward at the end of the seventies were to develop a fully functioning DTM system, which is simple to use and have reasonable performance, on a standand micro computer such as a personal computer.

To achieve these goals there were no alternatives but to go into the development of new algorithms and a new software, exploiting modern technices.

In 1979 the author decided to go into a thorough investigation and development of a new approach adequate to the new environment and the modern computer architecture and consept. A prototype was demonstrated at the end of 1985 with a black and white display and a fully colored system a year later.

In the following pages a description is given of this newly developed DTM system - a "Personal DTM" - and its application version named "TerraSys". It is beleived that TerraSys is a breackthrough in this respect. The performance achieved on a standard desktop computer is comparable to that achieved earlier on large computers. Large areas containing thousands of data points can be handled and processed in no effort . A 3-D terrain model can be created within minutes. XYZ coordinates of an unknown point is calculated in a fraction of a second. All interactively without sacrificing anything, neither quality nor accuracy of the model.

2. GENERAL CHARACTERISTICS

Two different and complementary versions for creating DTM from given elevation points were developed. One handles points measured in random and the other handles points measured on a predefined grid. In both cases a 3-D terrain model is created. In the case fo random points the model is created using the TIN (Triangulating Irregular Network) principle whereas in the case of gridded data grid interpolation technics are used. Both versions are integrated.

Based on this newly developed Personal DTM an application system called PC-TerraSys was developed. The version which handles random points is referred to as "TerraSys TIN" and the version which handles gridded data is referred to as "TerraSys GRID".

PC-TERRASYS is a 3-D terrain modeling and application system. It has applications in Surveying, Photogrammetry, Site Planning and Civil Engineering. It runs on standard IBM PC XT/AT or compatible personal computer.

A unique feature of TerraSys is its structure. It is a modular and open-ended system with additional application modules added as required. It is a complete system. It handles multiple projects, multiple maps and multiple information layers. TerraSys is a self contained system having its own data base manager and input output (I/O) capabilities for both soft and hard copy, based on international standards. As such it is transportable and can operate on various I/O equipment.

Bearing in mind that the end user is a surveyor and a photogrammetrist, a special emphasis has been put on the ergonomics of the system to ensure simple operation. On-the-screen, user friendly menus that are simple to learn and easy to manage and operate were designed. The same menus were used for both the TIN and GRID versions. All operations are accessed through the above described menus interactively.

TerraSys accepts photogrammetric, surveying and digitized data of existing maps. It creates a 3-D terrain model and contour map at any contour interval, and provides means for 3-D terrain presentation, analysis and applications, such as: Profiles, Slopes, Cross-sections, Earthworks (Cut and Fill) etc. At present 9 modules have been developed for each version. They are described in the following paragraph.

3. TERRASYS MAIN MODULES

The nine modules developed so far for each of the two versions are as follows:

- 1) DTM Module
The DTM module creates a 3-D terrain model and contour maps from the given elevation data points. It also provides basic display and hardcopy generation.
- 2) POINT EDITOR Module
The Point Editor handles input of data given in alphanumeric form, interactively. It includes display and correction capabilities of the data points for verification and editing.
- 3) DISPLAY/DRAFTING Module
This easy menu-driven module enables display/plot management of contour maps.

- 4) **PAINTED MAPS Module**
This is a unique module which provides display of painted elevation maps for presentation.
- 5) **3D-VIEWS Module**
The 3-D module creates terrain perspectives from user-selected viewpoints, including display and hardcopy generation.
- 6) **PROFILES and SLOPES Module**
This module allows for interactive generation, displaying and plotting of terrain profiles along polygonal lines/alignment for engineering applications.
- 7) **SLOPE MAPS Module**
The slope map module provides terrain slope calculation and displaying of slope maps.
- 8) **CROSS-SECTIONS Module**
This module provides means for generation, displaying and plotting of terrain cross-sections along given alignment selected and computed interactively.
- 9) **VOLUMETRICS Module**
The volumetric module allows for interactive design and computation of site earthworks. It provides alphanumeric and graphic display of site CUT and FILL volumes.

Other modules for additional applications are being developed continuously enhancing TerraSys.

4. PERFORMANCE

To evaluate the system two types of tests were carried out, one for quality control of the DTM solution and the other for operation control of system efficiency.

The DTM solution was first tested in respect to known mathematical functions and then in respect to actual data. Surveying data measured with a regular 5" Theodolite as well as data measured with 2" Total Station were processed and checked versus manual operation.

The contour lines generated by TerraSys TIN were completely satisfactory and well within requirements.

Regarding performance, TerraSys presented a dramatic saving, measured in hundreds of percents. A few days work was reduced to a few minutes work.

Similar tests were carried out with gridded data. Special large scale photogrammetric measurements were carried out and digitized on a stereoplotter. The data then processed and compared to the manually generated contour lines. In this case control points and characteristic points were added to the regularly spaced grid (10x10m) points.

Similar tests were also carried out for small scale mapping. In all cases results were within acceptable requirements of contouring and the time saving was in a few orders of magnitudes.

Here are some examples of the system performance:

A large scale map with 470 points and 1 feet contour interval was generated, DTM and contours, in less than one minute and a small scale map with 17000 points and 10 meter contour interval in less than 5 minutes.

In all tests a standard IBM PC AT computer with the addition of a math co-processor was used.

5. SUMMARY

TerraSys brings for the first time a personal computer based professional 3-D Digital Terrain Modeling with all its benefits down to the desk of every surveyor and photogrammetrist. It makes DTM accessible and affordable.

The advantage of digital mapping and its power is well known. TerraSys contributes an additional step to the advancement and implementation of "All Digital" mapping system. The advancement and the wide spread of micro computers and personal computers is no doubt a major breakthrough. Its impact on society is well apparent. Systems as TerraSys and others, developed to operate on a microcomputer, will in a short time make "All Digital" mapping systems a common product which will enhance and increase world wide map production and improve both map quality and terrain data usage for innumerable applications.

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