Virtual City Tour Using GIS

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***Abstract*— This paper describes an application for a virtual city tour using Geographic Information Systems. Our project implementing GIS is used to map the geographical entities which are present in 3-D form into a digital image which is in 2-D form . After implementing the GIS we shall be able to capture, store, analyze and manage data which are spatially referenced to the Earth ,create interactive queries analyze the spatial information, edit data, maps, and present the results of all these operations. A person can get the application installed on his cell phone, he can have a complete overview of the city, and get to view each and every detail about it , he can zoom into the places , he can also use it to travel around the city and get the specific information of a particular place .**

I. INTRODUCTION

What is GIS ? This is probably the most asked question posed to those in the Geographic Information Systems (GIS) field and is probably the hardest to answer in a succinct and clear manner.

GIS is a rapidly growing technological field that incorporates graphical features with tabular data in order to assess real-world problems . What is now the GIS field began around 1960, with the discovery that maps could be programmed using simple code and then stored in a computer allowing for future modification when necessary. This was a welcome change from the era of hand cartography when maps had to be painstakingly created by hand; even small changes required the creation of a new map. The earliest version of a GIS was known as computer cartography and involved simple linework to represent land features. From that evolved the concept of overlaying different mapped features on top of each other to determine patterns and causes of spatial phenomenon.

Some other Quotes to the answer " What is GIS " ?

"*In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. Practitioners also regard the total GIS as including operating personnel and the data that go into the system.*" [1]

"*A geographic information system (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps.*" [1]

"*GIS is an integrated system of computer hardware, software, and trained personnel linking topographic, demographic, utility, facility, image and other resource data that is geographically referenced.*"

GIS has already affected most of us in some way without us even realizing it. If you've ever used an Internet mapping program to find directions, congratulations, you've personally used GIS.

GIS is a computer based information system used to digitally represent and analyze the geographic features present on the Earth's surface. The meaning to *represent digitally* is to convert analog (smooth line) into a digital form. "Every object present on the Earth can be geo-referenced", is the fundamental key of associating any database to GIS. Here, term ***'database'*** is a collection of information about things and their relationship to each other, and to ***'geo-reference'*** something means to define its existence in physical space, it refers to the location of a layer or coverage in space defined by the co-ordinate referencing system.

GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems.

Maps are a vital feature in GIS. A map represents geographic features or other spatial phenomena by graphically conveying information about locations and attributes. ***Locational information*** describes the position of particular geographic features on the Earth's surface, as well as the spatial relationship between features, such as the shortest path from a fire station to a building. ***Attribute information*** describes characteristics of the geographic features represented, such as the feature type, its name or number and quantitative information such as its area or length.

There are many GIS softwares available now-a-days , GIS softwares that are presently in use are MapInfo, ARC/Info, AutoCAD Map, etc.

II. TECHNICAL WORK PREPARATION

A. Components of a GIS System

The four main components of a GIS system are:
- Hardware
- Software
- Qualified personnel
- Data

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Hardware and software aspects :

Depending on the size, scope and goal of the program, the set up of a GIS lab can cost from just a few thousand dollars to open ended. As a minimum, a GIS lab requires new or existing computers and software. There are several GIS software packages. We present ESRI's ArcGIS software because the majority of the world utilizes it. The scope of ESRI's software ranges from free simple GIS programs, such as the ArcExplorer to professional ArcInfo. ArcView has intermediate functionality and is often sufficient for beginning GIS classes and intermediate GIS analysis. In addition, ESRI offers special extensions, such as 3D, or geospatial analyst.
The following is an overview of basic setup costs associated with a GIS lab. The prices presented here for ESRI products include the educational discount for colleges and universities and are based on ESRI information.[2]

i. Computer: about $800
ii. ArcView 9.x license: $250 each, or lab license for upto 25 computers: $1,000
iii. ArcView 9.x license: $250 each, or lab license for upto 25 computers: $1,000
iv. Or ArcInfo: $1,500 each, or $6,000 for lab license:
v. Data: mostly ZERO

Although, not necessary, one may want to consider the following expenses:
- Annual fee for updates and technical support for ArcView: $250/yr, and for
ArcInfo: $1,500/yr (prices are the same for single or lab licenses)
- ArcGIS extensions, such as 3D: $150 each, or $500 for lab license

ESRI offers substantial educational discounts, for example, for regular customers
ArcView costs $1,500 versus $250 for educational institutions. Contact ESRI for details and additional information.

Data :

A large amount of free data is in public domain and available through the federal government. Popular data are road layers and Digital Orthophoto Quads (DOQ) which are digital georeferenced aerial photographs. Some data can be very costly, for example, specific research projects may require the sampling of detailed data. However, many GIS Internet sites offer data for free download and only.[2]

GIS coordinator :

A GIS coordinator should have expert knowledge of GIS. Higher degrees are of advantage for conducting research and applying for research grants. Because of the encompassing nature of GIS a coordinator works with a variety of people. The role of a GIS coordinator could be to advise on GIS techniques and assess the feasibility of suggested GIS projects. Sometimes, clients hear about potential GIS applications and largely underestimate the labor associated with it. The scope of some projects may lie outside the limits of time, technology, and experience available to the GIS coordinator.

Maintenance:

After the initial setup, yearly maintenance costs are associated with a GIS lab. Most GIS labs are networked, so that students can work with any computer through an account on the network. Network and computer maintenance support is critical and time consuming and should be planned for. Maintenance items include:
- Automatic updates and technical support for ArcView and/or ArcInfo
- Salary for GIS coordinator, research assistants and possibly consultants
- Update of computers and other software
- Network and computer administration

A functioning GIS lab is only the beginning and much dedicated effort and expertise are necessary to actually establish and maintain a program that brings GIS into education, research and outreach.

B. Techniques used in GIS

Data creation :

Collecting geographic data is vital to creating and maintaining a GIS, because inaccurate or outdated information will not reflect true, real-world scenarios. Today's GISs are built using information derived from various types of geographic data, chiefly vector-based data. The increasing number of new data sources requires new tools that can bring into clear view today's complex world of 3-D objects, features and spatial interactions, and help build vital infrastructure for the future. However, data currency and accuracy poses challenges to all GIS professionals. How can the GIS be updated and corrected ?

- The costs and time required to prepare and collect GIS data from existing sources of information can be high. For example, geo-rectifying 500 photographs to map an entire county may take up to three months before data collection begins.
- Digitising hard-copy maps is time- and labor-intensive, and it introduces errors into the system.
- Most of the original sources of information in a GIS provide only 2-D information (the X and Y coordinates).
- Outsourcing core digital mapping and routine updates to specialty shops is expensive and time consuming.

Fortunately geographic imagery provides the ideal solution for deriving current and accurate 3-D information, and has proven to be a cost-effective tool for updating a GIS. Digital photogrammetry is an essential imaging tool for creating useful 3-D data and building a 3-D GIS. The idea of integrating digital photogrammetry and GIS has intimidated many within the GIS community. The accuracy of photogrammetry is well known, but the cost and learning curve associated with it have forced many GIS managers to select less accurate methods in their production. Many local governments have resorted to outsourcing their projects to specialty photogrammetric production shops. Fortunately, advancements in the development of geo-spatial tools are bridging this long-standing gap. It's now possible to precisely identify a geographic location in 3-D space and link that location with its information attributes through the synthesis of photogrammetry, remote sensing, GIS and 3-D visualization. This combination of geographic imaging techniques, fuelled by the precision and accuracy of photogrammetry, are the ideal tools for building the 3-D GIS of the future. [3]

Data Representation in GIS :

There are two kinds of computer graphics - Raster (composed of pixels) and vector (composed of paths). Raster images are more commonly called bitmap images. A bitmap image uses a grid of individual pixels where each pixel can be a different color or shade. Bitmaps are composed of pixels. Raster data type consists of rows and columns of cells where in each cell is stored a single value. Raster data can be images (raster images) with each pixel (or cell) containing a color value. Additional values recorded for each cell may be a discrete value, such as land use, a continuous value, such as temperature, or a null value if no data is available. While a raster cell stores a single value, it can be extended by using raster bands to represent RGB (red, green, blue) colors, colormaps (a mapping between a thematic code and RGB value), or an extended attribute table with one row for each unique cell value. The resolution of the raster data set is its cell width in ground units.

Raster data is stored in various formats; from a standard file-based structure of TIF, JPEG, etc. to binary large object (BLOB) data stored directly in a relational database management system (RDBMS) similar to other vector-based feature classes. Database storage, when properly indexed, typically allows for quicker retrieval of the raster data but can require storage of millions of significantly-sized records.

Vector graphics use mathematical relationships between points and the paths connecting them to describe an image. Vector graphics are composed of paths. In a GIS, geographical features are often expressed as vectors, by considering those features as geometrical shapes. In the popular ESRI Arc series of programs, these are explicitly called shapefiles. Different geographical features are best expressed by different types of geometry :

Points

Zero-dimensional points are used for geographical features that can best be expressed by a single grid reference; in other words, simple location. For example, the locations of wells, peak elevations, features of interest or trailheads. Points convey the least amount of information of these file types.[4]

Lines or polylines

One-dimensional lines or polylines are used for linear features such as rivers, roads, railroads, trails, and topographic lines.[4]

Polygons

Two-dimensional polygons are used for geographical features that cover a particular area of the earth's surface. Such features may include lakes, park boundaries, buildings, city boundaries, or land uses. Polygons convey the most amount of information of the file types.[4]

Each of these geometries are linked to a row in a database that describes their attributes. For example, a database that describes lakes may contain the lakes depth, water quality, pollution level. This information can be used to make a map to describe a particular attribute of the dataset. For example, lakes could be coloured depending on level of pollution. Different geometries can also be compared. For example, the GIS could be used to identify all wells (point geometry) that are within 1 mile of a lake (polygon geometry) that has a high level of pollution.

Vector features can be made to respect spatial integrity through the application of topology rules such as 'polygons must not overlap'. Vector data can also be used to represent continuously varying phenomena. Contour lines and triangulated irregular networks (TIN) are used to represent elevation or other continuously changing values. TINs record values at point locations, which are connected by lines to form an irregular mesh of triangles. The face of the triangles represent the terrain surface.

The image to the left below is representative of a bitmap and the image to the right is representative of a vector graphic. [5]

Fig 1.1 Raster Image Fig 1.2 Vector Image

Fig 1. Representation of a Raster and Vector image

Raster to vector conversion :

Data restructuring can be performed by a GIS to convert data into different formats. For example, a GIS may be used to convert a satellite image map to a vector structure by generating lines around all cells with the same classification, while determining the cell spatial relationships, such as adjacency or inclusion.

More advanced data processing can occur by using different image processing techniques . Since digital data are collected and stored in various ways, the two data sources may not be entirely compatible. So a GIS must be able to convert geographic data from one structure to another.

The following figures give a basic idea of how raster images are converted into vector images. [5]

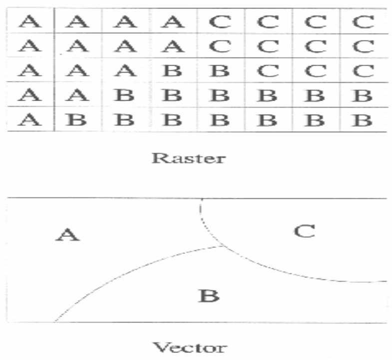

Fig.2 Conversion of Raster images to Vector images.

The figure below shows how actually real images are converted into Raster images , these Raster images can be further converted into Vector .[5]

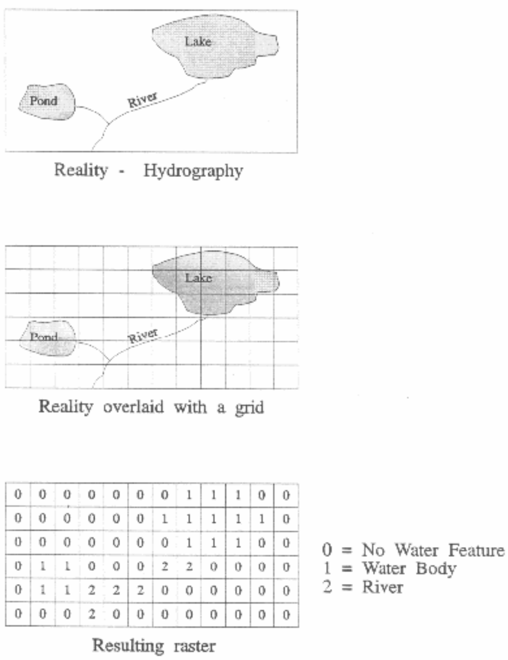

Fig.3 Conversion of real images into Raster images

C. Scope of the project

The project scope includes the following aspects:

- Locating and displaying a particular geographical Object on the map.
- Zooming and panning to a particular area on the map.
- Selection of multiple layers on the map.
- Representing attributes of different layers with different colors.
- Search of object of interest near to his current location (Proximity Analysis).
- Virtual tour of a location in City.
- Query About a particular Geographic object on selection.

D. Detailed System Design

This section consists of the architectural diagram , the product perspective , the user interface design of the project , it basically tells us how we are going to do the detailed design of the system .

The figure below gives the architectural diagram of the project.

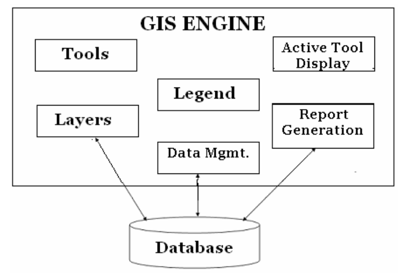

Fig. 4 Architectural Diagram

The figure below gives the detailed perspective of the project.

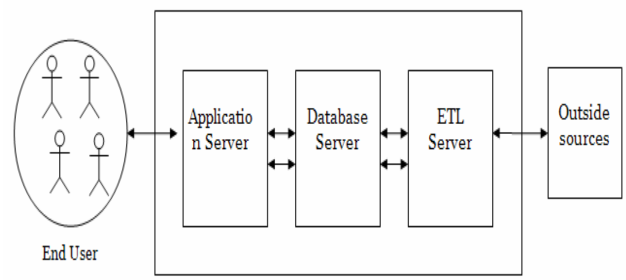

Fig. 5 Product perspective

The system consists of three main components :

- ETL (Extraction Transformation and Load) Server :
  The name says it all. The key functionality of this server will be extracting data from outside sources, transforming it to fit business needs, and ultimately loading it into the database.
- Database Server :
  This will be data warehouse of the system that will store data from ETL and application server.
- Application Server :
  This server will be the host of all End User's applications and will be the interface to the outside world. End users will execute all the tasks on this server and in turn the server will perform its functionality and will initiate necessary actions that will be required by both ETL and Database Server to fulfill the user request.

The user interface design of the project will be as follows :

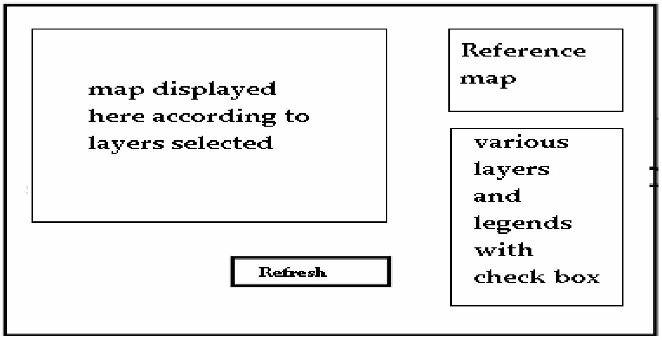

Fig 6.1 Organization of page to specify view criteria

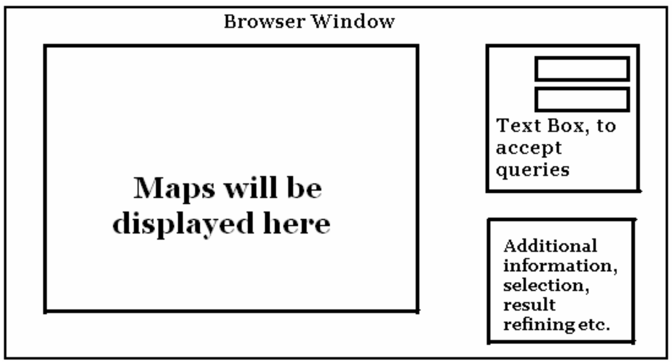

Fig 6.2 Organization of result page

E. Tools required for implementation

The following tools are required for implementation :

- Apache Web server
- Rational Solution
- MySQL Database Server
- Map server

As the first three tools are well known , we wont be explaining them , but the mapserver is discussed in detail over here as it forms the heart of the application .

The Mapserver :

MapServer is an Open Source development environment for building spatially-enabled internet applications. MapServer is not a full-featured GIS system, nor does it aspire to be. Instead, MapServer excels at rendering spatial data (maps, images, and vector data) for the web [7]. Beyond browsing GIS data, MapServer allows you create "geographic image maps", that is, maps that can direct users to content.

MapServer was originally developed by the University of Minnesota (UMN) For Net project in cooperation with NASA and the Minnesota Department of Natural Resources (MNDNR). Presently, the MapServer project is hosted by the TerraSIP project, a NASA sponsored project between the UMN and consortium of land management **interests.**[6]

Features:-

- ➢ Advanced cartographic output
  - Scale dependent feature drawing an application execution
  - Feature labeling including label collision mediation
  - Customizable, template driven output
  - TrueType fonts
  - Map element automation
  - Thematic mapping using logical-or regular expression-based classes
- ➢ Support for popular scripting and development environments like PHP, Perl, Ruby, Java, and C#
- ➢ Cross-platform support
  - Linux, Windows, Mac OS X, Solaris , etc.
- ➢ A multitude of raster and vector data formats
  - TIFF/GeoTIFF, EPPL7,
  - ESRI shapefiles, PostGIS,
  - ESRI ArcSDE, Oracle Spatial,
  - MySQL and many others via OGR
  - Open Geospatial Consortium (OGC) web specifications

MapServer creates map images from spatial information stored in digital format. It can handle both vector and raster data. MapServer can render over 20 different vector data formats, including shape files, PostGIS and ArcSDE geometries, OPeNDAP, Arc/Info coverage, and Census TIGER files.

MapServer can operate in two different modes: CGI and MapScript. In CGI mode, MapServer functions in a web server environment as a CGI script. This is easy to set up and produces a fast, straightforward application. In MapScript mode, the MapServer API is accessible from Perl, Python, or PHP. The MapScript interface allows for a flexible, feature-rich application that can still take advantage of MapServer's templating facilities.

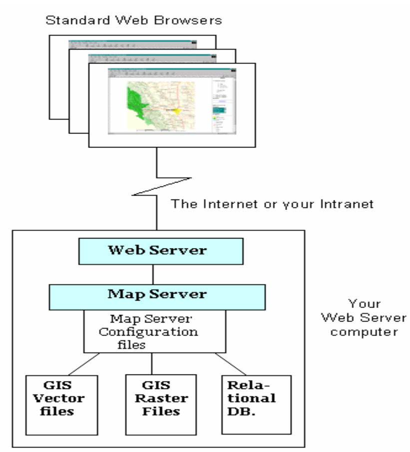

Fig.7 Map server architectural overview

Working Of a map server :

MapServer is template based. When first executed in response to a web request, it reads a configuration file (called the mapfile) that describes the layers and other components of the map. It then draws and saves the map. Next, it reads one or more HTML template files that are identified in the mapfile. Each template consists of conventional HTML markup tags and special MapServer substitution strings. These strings are used, for example, to specify the paths to the map image that MapServer has created, to identify which layers are to be rendered, and to specify zoom level and direction.

MapServer substitutes current values for these strings and then sends the data stream to the web server, which then forwards it to the browser. When a requester changes any form elements on the page (by changing zoom direction or zoom value, for example) and clicks the submit button, MapServer receives a request from the web server with these new values. Then the cycle starts again.

MapServer creates legends and scale bars (configurable in the mapfile) and generates reference maps. A reference map shows the context of the currently displayed map. For example, if the region of interest is North Dakota, the reference map would show a small map of North Dakota, with the extent of the current map outlined within it. Zooming and panning are under user control. MapServer builds maps by stacking layers on top of one another. As each is rendered, it's placed on the top of the stack. Every layer displays features selected from a single data set.

Features to be displayed can be selected by using Unix regular expressions, string comparisons, and logical expressions. Because of the similarity of data and the similarity of the styling parameters, you can think of a layer as a theme. The display of layers is under interactive control, allowing the user to select which layers are to be rendered.

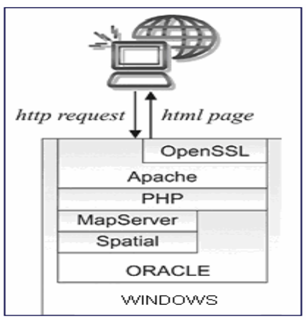

Fig .8 Working of a mapserver

While layers can't be generated on the fly, empty layers can be populated with dynamic data and manipulated via URLs. MapServer has powerful and sophisticated query capabilities, but in CGI mode it lacks the tools that allow the kind of analysis provided by a true GIS.

This overview has described some of the features of MapServer and shown why it's not a full-featured GIS: it provides no integrated DBMS tools, its analytical abilities are limited, and it has no tools for georeferencing.

Since MapServer's functions can be accessed via an API from various programming languages (such as PHP, Perl, and Python), it can serve as the foundation of a powerful spatially aware application that has many of the analytical and reporting functions of a true GIS. In addition, while there are no integrated tools for manipulating spatial data, there are third-party tool sets that perform many (although not all) of these functions.

When run as CGI in a web environment, MapServer can render maps, display attribute data, and perform rudimentary spatial queries. When accessed via the API, the application becomes significantly more powerful. In this environment, MapServer can perform the same tasks it would as CGI, but it also has access to external databases via program control, as well as more complex logic and a larger repertoire of possible behaviors. [6]

III. Conclusion

In this paper we have presented our scheme for mapping the geographical entities which are present in 3-D form into a digital image which is in 2-D form , we can capture , store, analyze and manage data which are spatially referenced to the Earth ,create interactive queries, analyze the spatial information, edit data, maps, and present the results of all these operations . Once a qualified GIS coordinator is found it is relatively easy to get a GIS program started. Data is often free, and equipment inexpensive in comparison to other labs. We believe that the various techniques presented by us will be suitable to the needs of a sophisticated user.

IV. References

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