Paper Reference Number: PN-131

GIS based planning for finding optimal gas pipeline route in IITR campus

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GIS provides a large number and a variety of analytical functions that are capable of replacing manual and traditional methods of route planning. It is a powerful tool to integrate thematic layers in an automated environment to compute possible shortest route with associated costs which eventually can reduce the cost and time of project execution and hence the operating expenses.

Planning for the optimum route requires an extensive evaluation process to identify the best possible path. This path must comply with the requirements of the user in terms of safety and cost. With the fast development environment in gas industry, and with the increase in consumption of these products, the need for an optimum route becomes more important as this can reduce a huge operational cost.

In this case study we are considering IIT Roorkee campus for gas pipeline planning. This study incorporates the georeferencing of the scanned image, digitization of vector layers, database development and route network analysis to find out the best possible route for laying pipeline in the campus area.

1. Introduction

GIS is a science and technology which combines different data from various sources for route design processes through spatial analysis. The present study was initiated to demonstrate the use

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of various data from different sources and geospatial information system (GIS) analysis for developing a path way for gas pipeline in IIT Roorkee campus. Pipelines are the most efficient, cost effective and environment friendly means of gas transport. Careful and intelligent planning of the pipeline route can save on cost, time and other several expenses to ensure longer operational life. Proper planning and management are considered essential means of guiding and accelerating the development.

The purpose of the establishment of the gas pipeline is to strengthen the operation and management of gas network and affiliated facilities in IITR campus, to solve traditional backward mode of artificial management and to promote the informationization construction process through systematic construction and application.

1.1 Data collection and processing
Data is the life of GIS, and the function of GIS is nothing if there is no data input. The data of the gas pipeline GIS include the basic geographical data, the measurement data, attribute data, pipeline metadata. For the drawing function of gas network and facilities, the GIS offers external importing tools for a variety of graphical data, providing flexible, convenient, and powerful functions for graph editing and processing; The pipeline attribute information can easily be input and managed through strong editing and operating functions to attribute data, absolutely ensuring that pipeline and facilities are corresponding to the related attribute information. The quality of all pipeline data must be detected before entering database, including the logical consistency and integrity of gas network data and labeled data. Data that not satisfy the requirements are sent back to modify, ensuring the correct data enter into the database. Seamless combination of graphics ensures that map accuracy meets requirements and the output is of high quality.

1.2 Data organization and storage
Gas pipeline is having spatial data and attribute data. Spatial data refers to the location of geographical entities and relationship amongst them, which includes geographic data, measurement data of pipeline. Attribute data includes form data, documents data, multimedia data and so on. The relations between spatial data and corresponding attribute data are linked through the keyword ID.
Data is stored in layer so as to be convenient for update, maintenance and management. When layered, geometric characteristic symbols (such as points, lines, surfaces) and special type should be considered in a comprehensive way, so that data of each layer having the same geometric characteristic symbols and the same attributes compositions.. According to surface elements, basic geographic data can be divided into residential buildings, public buildings, sport complex, general utilities, and educational departments.

1.3 Pipeline
The pipelines shall be designed in a manner that ensures adequate public safety under all conditions likely to be encountered and to withstand all installation, testing and operating conditions/loads. All necessary calculations shall be carried out to verify structural integrity and stability of the pipeline for combined effect of pressure, temperature, soil-pipe interaction, external loads and other environmental parameters as applicable. Such calculations

- Buoyancy control and stability analysis for pipeline section to be installed.
- Pipeline expansion/contraction and its effect on station piping.
- Evaluation of potential for earthquake occurrence along pipeline route and carrying out requisite seismic analysis to ensure safety and integrity of the pipeline system.

The pipelines shall be normally designed for an assumed economic design life of 30 years. The pipelines are designed for the following operating temperature 1imits:

- above ground: 65°C maximum and –28°C minimum
- below ground: 60"C maximum and –28°C minimum

1.4 Clearance between pipelines/mains and other ground structures

A clearance of at least 150 mm shall be provided between a buried pipeline and other underground structure not used in conjunction with the pipeline. Wherever such-clearance cannot be provided, adequate precautions to protect the pipeline by means of casing, bridging, or insulating material shall be ensured.

In laying parallel pipelines in the same trench, the minimum clear distance between the pipelines shall be 500 mm.

The 'location of a new underground pipeline, when running parallel to an existing underground pipeline shall beat a minimum clear distance of 5 m. Wherever such clearances cannot be provided, adequate precautions to protect the pipelines by means of casing or insulating material shall be ensured.

2. Approach and methodology

The basic approach for gas pipeline route network analysis in IIT Roorkee campus was to get the campus area map, georeferencing of the map and after that digitization is completed for the area. Various features were drawn with the help of drawing tool such as campus buildings, departments, residential areas, road network. Several layers are defined. Attributes are assigned to each feature in the map which collected by field inspection and manually. These data includes the information about all the features drawn on the map such as the for the hostels, information about its physical area, perimeter, warden name, office telephone no., mess manger, no. of storey, girls/boys hostel. The geodatabase table can be edited furthermore and new information can be added or removed. The idea behind the geodatabase is to provide a uniform approach to reducing the complex behavior of the real world to a set of set of tables in a database with extended and customizable behavior In this case study the map which is used is made in year 1998, since then many new constructions have been developed in campus area. For accurate planning of gas pipeline we need to have information about those features. These features can be included with the help of google earth and ET geo wizard software. With the help of google earth new features can be digitized online and added through ET geo wizard.

For example Rajiv Gandhi bhawan, new Kasturba and Radhakrishnan bhawan were initially not present in the map area. So these new constructions are imported through Google earth into the map. Because the map is georeferenced so these got the accurate positions on the map.

All the layers are merged into one, so the criteria regarding the gas pipeline can be considered. In this case study we have developed three different layers of the pipeline, first one is the main pipeline which has the highest width and second which is the sub part of the main line, has somewhat low width, third pipeline has the lowest width to supply the gas in remote and inaccessible areas of the campus. While planning the gas pipeline route all the criteria has to be considered very carefully

Figure 1 Digitization of campus hostels

Figure 2 Digitization of campus residential area

2.1 Route selection

Route selection shall take into account the design, construction, operation and maintenance of the pipeline taking the following into consideration:

- Safety of public and personnel working on or near the pipeline;
- Protection of environment, other properties and
- Facilities; including electrical interferences; Third party activities;
- Geotechnical and hydrological conditions;
- Requirements of construction
- Future explorations and developmental plans;
- Existence of archeological/historical monuments, parks

2.2 Developing a geodatabase

Geodatabase is an object oriented model. Every table becomes a class with properties methods and events. Each time a user add a feature to the geodatabase table then certain behavior is executed through the use of subtypes, domains and relationships or via custom codes written as class extension (using arc objects). The idea behind the geodatabase is to provide a uniform approach to reducing the complex behavior of the real world to a set of set of tables in a database with extended and customizable behavior. One of the biggest benefits of the geodatabase is that it unifies a common location and in a common formats all geographic relevant data which is accessed by a common set of tools. The idea behind the geodatabase is to provide a uniform approach to reducing the complex behavior of the real world to a set of set of tables in a database with extended and customizable behavior. One of the biggest benefits of the geodatabase is that it unifies a common location and in a common formats all geographic relevant data which is accessed by a common set of tools. Geodatabase allows an organization to physically store the geometry of the feature(point, line, polygon) and the attribute that describe that feature inside a relational database management system as a single row in a table. The geodatabase also models the relation between the tables and each feature in geodatabase model.

SHAPE*	Name_of_building	Area	Circumference	SHAPE_Length	SHAPE_Area	Chief_Warden	Office_Chief	Mess_Manager	No_of_Se	Bhawan_Secretary	Mess_Secretary	No_Of_Bl	Boys_or_Gals_
Polygon	A N Khosla Bhawan	1430.7048	259.6236	259.623585	1430.704814	NA	0	<Null>	<Null>	Vishwaswaroop Saha	Nitin Bhargava	1	Married
Polygon	Jawahar bhawan	2195.8296	464.23959	464.239597	2195.829592	N P Padhy	275587	<Null>	880	Vishwaswaroop Saha	Nitin Bhargava	6	Boys
Polygon	Bound.Sarojini Bhawan	3539.7444	362.67014	362.670143	3539.744409	Shashi	275863	<Null>	<Null>	Chetani	Bhavjot Kaur	<Null>	Gals
Polygon	Living.Sarojini Bhawan	1451.9167	248.85559	248.855592	1451.916796	Shashi	275863	<Null>	<Null>	Chetani	Bhavjot Kaur	<Null>	Gals
Polygon	Cautley Bhawan	2260.925	577.85132	577.851309	2260.924944	R P saini	275857	<Null>	657	<Null>	<Null>	<Null>	Boys
Polygon	Ganga Bhawan	2027.2957	460.54111	460.541122	2027.295659	A K Singh	275858	<Null>	650	Vineet Chak	Arjun Maurya	4	Boys
Polygon	Rajendra Bhawan	736.6853	167.05429	167.054294	736.68532	R P Maheshwari	275861	<Null>	601	Shubham Bansal	Kapil Sayal	4	Boys
Polygon	Azad Bhawan In	1306.1583	160.9649	160.964905	1306.158292	M L Kansal	275856	<Null>	<Null>	Shakti Vansi	Zubair Parihar	5	Boys
Polygon	Azad Bhawan Out	4129.8452	474.64764	474.647658	4129.845283	M L Kansal	275856	<Null>	<Null>	<Null>	<Null>	0	Boys
Polygon	Azad Bhawan 2	920.95026	250.4904	250.490397	920.950275	M L Kansal	275856	<Null>	<Null>	Shakti Vansi	Zubair Parihar	0	Boys
Polygon	Khosla International House	3168.9961	566.77667	566.776655	3168.996115	U P Singh	275329	<Null>	<Null>	Vishwaswaroop Saha	Nitin Bhargava	<Null>	International Studen
Polygon	Govind Bhawan	3926.4119	864.00238	864.002408	3926.411796	G S Agarwal	275859	<Null>	<Null>	Amit Kumar	Mohd Shahrukh	4	Boys
Polygon	GP Hostel 1	576.25122	141.35736	141.357364	576.251195	NA	274344	<Null>	<Null>	<Null>	<Null>	<Null>	Married
Polygon	Azad Wing(Mrd Hostel)	906.54077	243.79187	243.791877	906.540772	M L Kansal	275856	<Null>	<Null>	Shakti Vansi	Zubair Parihar	<Null>	Married
Polygon	GP Hostel II	520.35406	143.91812	143.918129	520.354091	NA	274344	<Null>	<Null>	<Null>	<Null>	<Null>	Married
Polygon	Ravindra Bhawan	516.16119	130.56358	130.563577	516.161214	N K Samadhiya	275467	<Null>	432	Pankaj Agarwal	Abhishek Narayan	<Null>	Boys
Polygon	Ravindra Bhawan	536.85901	115.8978	115.897802	536.859033	N K Samadhiya	275467	<Null>	432	Pankaj Agarwal	Abhishek Narayan	3	Boys
Polygon	Ravindra Bhawan	390.18713	85.330933	85.330931	390.187147	N K Samadhiya	275467	<Null>	432	Pankaj Agarwal	Abhishek Narayan	0	Boys
Polygon	Ravindra Bhawan	435.49457	122.99763	122.99763	435.494569	N K Samadhiya	275467	<Null>	432	Pankaj Agarwal	Abhishek Narayan	0	Boys
Polygon	Ravindra Bhawan	426.74765	111.39718	111.397175	426.747636	N K Samadhiya	275467	<Null>	432	Pankaj Agarwal	Abhishek Narayan	0	Boys
Polygon	Ravindra Bhawan	524.05212	130.11009	130.11009	524.052147	N K Samadhiya	275467	<Null>	432	Pankaj Agarwal	Abhishek Narayan	0	Boys
Polygon	Jawahar Bhawan	623.79602	120.41103	120.411027	623.795998	N P Padhy	275587	<Null>	880	Vishwaswaroop Saha	Nitin Bhargava	0	Boys
Polygon	Jawahar Bhawan	1491.246	285.80746	285.807469	1491.245963	N P Padhy	275587	<Null>	880	Vishwaswaroop Saha	Nitin Bhargava	0	Boys

Fig 3

3. Result

The image shown below is the final image which shows the route networking for laying the pipeline in IIT Roorkee campus area. The red one is the main pipeline through which the gas is supplying. Furthermore branches are connected to this main pipe line. Line with sky blue color is the secondary line through which all the tertiary lines are connected so that supply can be possible to the houses and bungalow.
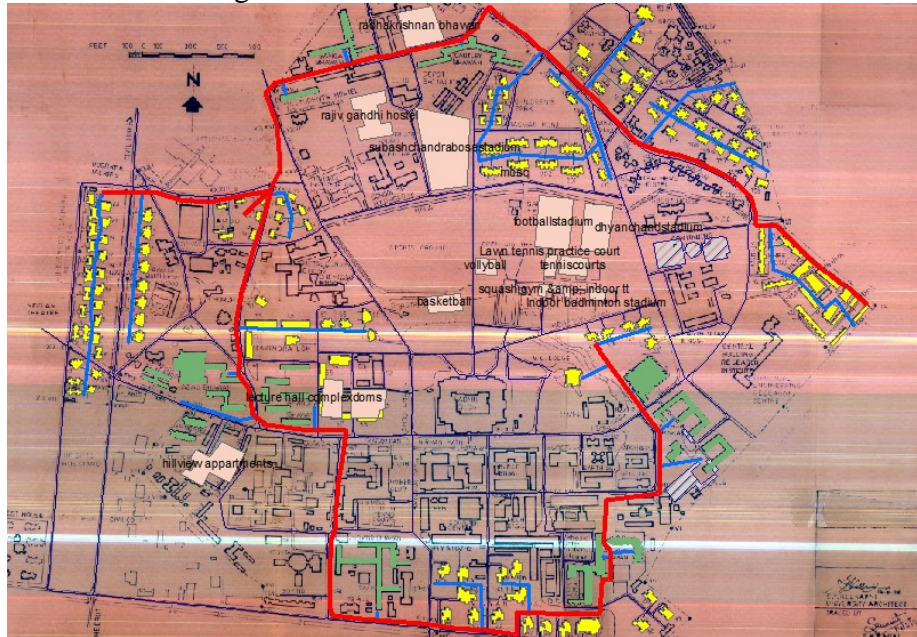

Figure 3 Optimal pipeline route in IITR campus

These lines are laid out considering all the criteria which are earlier mentioned like Safety of public and personnel working on or near the pipeline; Protection of environment, other properties and Facilities; including electrical interferences; third party activities etc.

4. Conclusion

GIS has been proved very important tool for the planning of gas pipeline in the campus area. It has not only increased the efficiency but also the economy of the distribution of the gas system. In this campus gas pipeline GIS, the geographical distribution and characteristics of the gas pipeline network and equipment are fully reflected, the inquiry and management of geographical environment information, pipeline information and their attributes are realized. Once the pipeline is designed, further many applications of the GIS can be developed

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<div align="center">**Brief Biography**</div>

Education

      Master of Technology at **Indian Institute of Technology, Roorkee**.

      From 2010 to current; Geomatics Engineering.

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