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Possibility of GIS to Solve Space-Related Problems in the Construction Industry

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Abstract

Geographic Information System (GIS) is a computer-based technology that is widely used to address engineering challenges involving geographical data. Despite its expanding popularity, GIS has yet to fulfil its full potential in the building business. This paper presents a synopsis of recent work on spatial uses of GIS technology in the construction sector. GIS technologies have the capacity to tackle space-related construction sector challenges such as sophisticated visualisation, information integration, route planning, E-commerce, cost calculation, and so on. This study develops and discusses a GIS-based technique for dealing with time and space challenges in construction project scheduling.

Keywords: *Construction Industry Scheduling, Project Management, Construction, GIS in construction*

INTRODUCTION

GIS is a computer tool that captures, stores, quarryes, analyses, and displays geographic information. GIS, like any other information system, is a subset of information systems that consists of four components: a computer system, GIS software, a human expert, and data. Spatial and attribute data management, data presentation, data exploration, data analysis, and modelling are all examples of GIS activities. GIS synchronises geographical and non-spatial data so that both may be queried, analysed, and presented. Spatial data is connected to feature geometry, whereas attribute data

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provided in tabular form describes the qualities of individual features in a GIS layer. Each row of the table represents a feature, and each column represents a feature characteristic.

The intersection of a column and a row represents the value of a certain feature's characteristic. To represent spatial characteristics, GIS employs vector and raster data models. The vector data model constructs spatial characteristics by using points and their x and y coordinates (points, lines and areas). In the space, the characteristics are handled as separate objects.

A grid is used in the raster data model to express spatial variations of features. Each grid cell contains a value that corresponds to a spatial feature typical at that place. Raster data is ideal for representing continuous spatial characteristics.

GIS IN CONSTRUCTION INDUSTRY

GIS systems are used in many domains of civil engineering, including transportation, water resources, facility management, urban planning, construction, and E-business. This section discusses its uses in the building sector.

A. Subsurface Profile

Camp and Brown [3] proposed using GIS to create a method for producing subsurface profiles from well-log data. The well-log database was built from a succession of boreholes, and a GIS-based process was utilised to generate a 3D subsurface model. Oloufa et al. [4] emphasised the importance of site inquiry in estimating and planning new building projects, and they proposed using GIS-based approach to create a database for foundations study, design, and construction planning. Surface and subsurface characteristics impact construction methods and equipment selection, which affects project cost and schedule. As a result, Oloufa et al. employed GIS database management capacity to record descriptive soil data and correlate this data with drill sites.

B. Quantity Takeoffs and Construction Cost Estimation

Cheng and Yang proposed utilising Map/Info for quantity takeoffs and cost estimates. For quantity takeoffs, architectural drawings were separated into several levels known as data layers. The fundamental criteria in GIS-based cost estimations were area and perimeter. Thus, data layers were prepared in AutoCAD as polygons and uploaded to Map/Info as

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geometric coverage. Coverage yields geometric information about spatial properties such as coordinate, area, perimeter, and spatial connection. In contrast, the user inserts theme information such as an identity (ID) code, beam number, floor number, and so on. Recently, Bansal and Pal proposed a more broad use of GIS for cost estimate by introducing additional scripts to the GIS environment for various cost estimation activities. This was accomplished using ArcView, which makes advantage of dynamic linking between spatial and attribute data.

C. Materials Layout at Construction Site

Cheng and Yang's MaterialPlan, a GIS-based application, merges quantity takeoffs with material layout design. The system decides the size and position of the material storage space based on common sense and experience. It aids planners in quantity takeoffs as well as material layout design evaluation. MaterialPlan was created by integrating estimates with construction scheduling in a GIS context for a dynamic materials need plan. The suggested approach selects the best place to store construction supplies based on information about the quantity and locations of items needed for the project.

D. Construction Site Layout

The conventional approach to layout temporary facility (TFs) involves designing site layout using sketches, templates and 2D physical model. The developed layout is based upon the incomplete information stored in the different form. Such visual representations of TFs do not yield adequate and descriptive results. As TFs should be located close to their supporting activities to reduce the time for travel, the role of GIS may be explored for this.

Cheng and O'Connor developed an automated site layout system called ArcSite using GIS for construction TFs. ArcSite consist of a GIS integrated with DBMS was claimed a new computerized tool to identify suitable area to locate TFs. ArcSite integrate information required to find suitable location for TFs and perform series of complicated spatial operations and database queries to identify optimal site that is difficult to perform manually.

E. Real -Time Schedule Monitoring System

Cheng and Chen [8] developed an automated schedule monitoring system by using GIS to assist construction managers to control erection process for precast building construction. A case study was

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taken where structural elements were prefabricated in the manufacturing plant and transported to job site for installation. Erection of prefabricated structural components is considered a major critical activity for precast building construction. The schedule for prefabrication and transport of structural elements to job site are developed based on installation schedule.

The study suggested that the use of GIS environment improves the real time schedule monitoring system and construction process as well as improves construction efficiency. A study reported by Li et al. integrates Global Position System (GPS) and GIS technologies to reduce construction waste. GPS and GIS were integrated with construction management system in such a way that managers from the headquarters and construction sites get real time information to control cargoes coming through road to sites, so as to reduce the waste generation on sites.

F. Route-Planning

Varghese and O'Connor developed a GIS based system in which the information requied for route planning can be integrated. Study make use of two technologies: expert system and GIS to develop this tool, expert system attempt to model the human reasoning process through a set of predetermined rules while GIS provide data display capabilities. In urban areas, obstacles such as existing public utility lines, railways, canals and roads influence routes significantly. There may be a limited number of feasible crossing points; selection of a suitable route to avoid existing obstacles in a path reduces the risk of damaging the existing utilities. It also minimizes the cost required during construction. Cheng and Chang discussed the development of a GIS based system to automate the process of routing and design of an underground power supply system. The optimal paths for routing is determined using the network analysis of Arc/Info GIS package.

G. Topography Visualization

GIS is an effective tool to visualize the topographical conditions of construction site. The modeling of construction site facilitates in construction controlling and planning process. GIS-based visual simulation system (GVSS) developed by Zhong et al. is a tool that offers powerful planning, visualizing and querying capabilities as well as facilitate the detection of logical errors in a model.

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SPATIAL ASPECTS OF A CONSTRUCTION PROJECT

Commercially available scheduling tools such as Primavera and Microsoft Project fail to provide information pertaining to spatial aspects of a construction project. A methodology using GIS is developed to represent spatial aspects of construction graphically by synchronizing with construction schedule. The spatial aspects are depicted by 3D model developed in AutoCAD and using Microsoft Excel generates construction schedule. Spatial and scheduling information are linked together into a GIS environment. The GIS-based system developed in this study help in understanding the schedule along with its spatial aspects.

A. Methodology

The construction schedule that acts as a roadmap for the successful implementation of construction project is developed in Microsoft Excel and transferred to ArcGIS [14]. The spatial information of different activities defined in the construction schedule is generated in AutoCAD. The drawings are transferred into ArcGIS as layers and may be symbolized and queried. GIS allow working with drawings transferred from AutoCAD, however, to edit or modify AutoCAD drawing layer features or its associated attribute table layers need to be converted into shapefiles. The shapefiles are simple non-topological format for storing geometric location and attribute information of geographic features.

Layers transferred into ArcGIS from AutoCAD may be merged together according to the activities as defined earlier in schedule generated in Microsoft Excel. Thus, components of a drawing that belong to same activity but are located at different positions in space are joined together to construct spatial data for each activity. Linking an activity with its schedule involves in adding a field called key to schedule and its attribute table.

The field key is common between two tables (i.e. schedule and attribute table of different components) and used to establish the connection between the spatial aspect of activity and the corresponding activity in the schedule. All the entries in the field key are to be entered manually and should be unique in both schedule and attribute tables of an activity. Linking the schedule with spatial aspects of the construction activities are shown in the Fig. 1.

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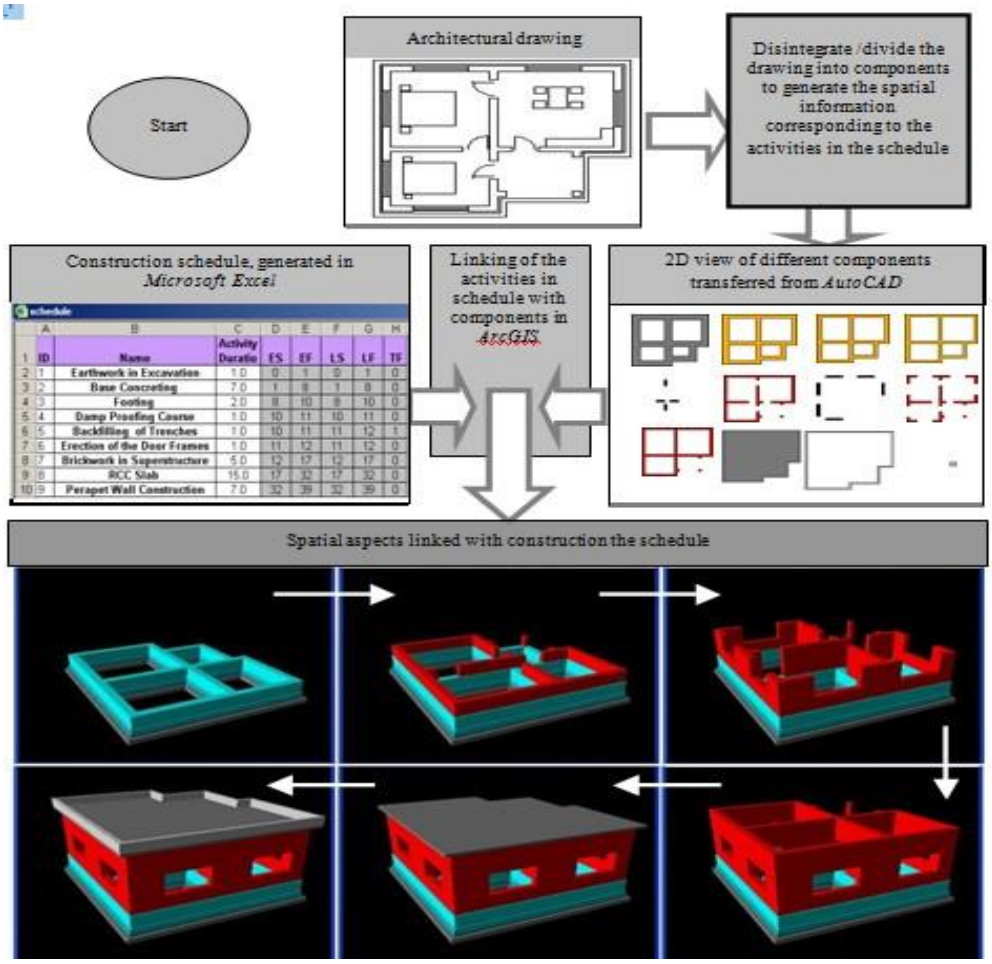


Fig. 1 Linking the schedule with spatial aspects of the construction activities

CONCLUSION

This article provides an overview of several spatial uses of GIS in the construction sector. As one of the rapidly expanding sectors used in numerous engineering projects, GIS's full potential in the construction industry has yet to be realised. By integrating geographic and attribute information in a single environment, GIS improves construction planning and design efficiency. Research in this field is sparse, as efforts to employ GIS in the construction sector have not embraced the issue of its application in actual practise.

GIS is a useful technique for integrating geographical and non-spatial building project information in a single environment. The technique provided in this study connects the construction schedule with the related geographical features to make the project sequence easier to grasp. This connection facilitates knowledge of the project and aids in the detection of potential difficulties. Non-

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spatial timetables merely communicate what is constructed 'when,' but GIS schedules communicate what is built 'when and where.'

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