A FUZZY DECISION SUPPORT SYSTEM FOR MATERIALS ROUTE IN CONSTRUCTION SITE

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Abstract

To plan and visualise routes of materials movement in complex construction site is an important consideration in construction project management. The unique complexity of routing materials is burdens on planner and site manager. To address this issue, an study was taken to develop a PC based software tool, named Virtual Construction Material Router (VCMR) that produce sequences of materials routing scenarios based on site layout, available route, activity schedules, and location of temporary accommodation. The core of this system is a GIS-fuzzy based decision-support system, which extends planners experience and assists them make informed decisions to the complexities of time-activities compressed site materials management. This system is to ensure them to select and visualise the most suitable route for materials movement.

Introduction

Reliable predication of materials routing is critical to the success of construction site management. Optimum forecasting for materials movement is an important consideration in the development of an effective project execution planning. This study deals with the implications of materials routing within a complex construction site.
Bell and Stukhart (1986) suggested that material management functions include "material requirement planning and material take off, vendor evaluation and selection, purchasing, expenditure, shipping, material receiving, warehousing and inventory, and material distribution." They emphasise that material management system is concerned with the planning and controlling all necessary effects to ensure that the right quality and quantity of materials and installed equipment are appropriately specified in timely manner, are obtained at reasonable cost, and are available when needed. Construction material management is seemingly divided into a number of issues; which include routing and material scheduling. Material scheduling has received a great deal of attention in construction management research, while material routing in a construction site has, so far, been neglected.

Materials management and movement in site

Great deal of work has been done on material management in scheduling and location. However few research studies have specifically dealt with material routing in construction sites. Muehlhausen (1991) reported that material management as practised in the construction industry, which includes the planning, executing, and controlling of all activities influencing the flow of material to and through job-site, has received a little attention in the application of new technologies. The prevailing tools for planning access are based on models, templates and drawings, which do not facilitate the generation of possible scenarios (Varghese and O'Connor, 1995).
Hazem and Bell (1995) suggested that material management systems should be integrated with computer systems that are used for design and scheduling. They proposed an Object Oriented Methodology (OOM) data structure for a materials-management system. McCullouch and Gunn (1993) developed a computer-based material management system. This research claimed that this computer system requires only 26-37% of a field supervisor's time, which can save a great deal of his time and reduce paper work in material management on construction projects.
Olusegun, Jacob and Dennis (1998) provided a framework for the development of strategies for improving planning practices. This research links between construction planning and situational factors in the environments within which construction planning is undertaken.

Materials logistic in construction site
Modern logistic is described as the process of strategically managing the movement or storage of materials, parts and finished, inventory from supplier, through the firm and on to the its destinations (Christopter, 1985). The efficient movement of materials is to increase and meet site demands is often emphasised in the decision making process. McCord and Leu (1995) reported materials routing problem is key point in material logistic where the objectives is to minimise risk and cost form a mutli-attribute utility theory perspective. They explained the assumptions made when posing the cost risk problems as a bi-criterion shortest path problem. It also pointed out the numerical sensitivity analysis carried out on the preference parameter and the shape of the risk disuitility function using the road network. It concludes that their model finds several different routes as opposed to one optimal route, under mild uncertainty

assumptions for the model parameters. Although the model is unable to choose a single rout, it does succeed in generating a relatively small number of no inferiors paths for representation to the decision makers without soliciting preference information from them.

The most extensive applied work in the materials logistic has been conducted by advanced computer application group of IIASA in Laxenburg, Austria, Weigkricht and Fedra (1995) mention information and decision support for hazardous materials logistic problems developed at IIASA. This system integrate large database, optimisation techniques, geographic information system as well as effective user interface and computer graphic. This system also will improve decision-making and support quick and effective generation and evaluation of different alternations.
Mirchandani (1995) consider a neglected aspect of the general materials management problem: the location of inspection stations. Their study gave a set of hazardous materials truck flows in a network. The research is to locate a fixed number of inspection stations with limited inspection capacities to minimise the number of uninspected trucks in the network. It developed several heuristics and report preliminary computational result by using computer based decision-making system.

Another research (Boffey and Karkazis, 1995) has demonstrated by using a non-linear program to select routes for hazardous material deliver in order to minimise risk. They applied non-linear program to find a shortest path for material. The research is to conclude a condition, which if satisfied, ensures that the linear version of the model finds the same route as the non-linear model. In case the condition is not satisfied, they outline a strategy, based on shortest paths to find the optimal solution to non-linear model.

Wyman and kuby (1995) point out that optimisation techniques can be used to quantify the potential saving from new technology which could in turn to be used to promote the new technology. It may be possible to find solutions that are superior to traditional solution for material logistic. Use of location model is to assess decision-makers. This model can be used to restructure the spatial information system dealing material problem in construction site.
Decision support system in materials management and routing

Materials management is defined as the management system for planning and controlling all necessary efforts to ensure that right quality and quantity of materials and installed are obtained at reasonable cost and are available when needed (Bell and Stukhart, 1986). Computer based decision support system played an important role in material materials management in maximising the construction productivity and reducing materials surplus and time of construction work (Bell and Stukhart, 1987).

Material management decision support system development efforts have been focused on integrating the materials related functions of quantity takeoff, requisition, purchasing, expediting, transportation, and field materials control and warehousing (Hazem and Lansford, 1996). Meanwhile, integrating decision support system in materials management has less attention in materials movement in construction site. Specifically, it is in selection of routes for materials movement.
Fuzzy logic is a scientific revolution that has been waiting to happen for decades and its central tenets will dramatically change the relationship human being have with the real world. In recent year, it has been used for DSS and combined the advanced Information Technology in decision processing. Fuzzy logic systems attempt to model the human reasoning process through a fuzzy set. The reasoning process of fuzzy set has been captured through fuzzy logic system in many areas of construction industry such as building design selection (Peak, 1992), resource allocation (Chang et al. 1990), CAD design control (Campo, 1995).

Feng and Xu (1999) have developed an integrated system in which knowledge based decision system; artificial neural network and fuzzy system are used for urban development. On the other hand Hanna and Lotfallah used a fuzzy logic approach to select the suitable crane type in construction projects. This system uses fuzzy logic techniques to aid contractors to optimise the selection of crane types.

Fuzzy approach has dominated research in computerised construction management. Yu and Skibniewski developed (1999) a multi-criterion decision model for quantitative constructability analysis, which is based on a neuro-fuzzy knowledge. They suggest that with this system, the constructability can be quantified, measured and improved. It also incorporates construction manager's subjective preference information. They have used neuro-fuzzy network-based approach in providing a mechanism to trace back factors causing unsatisfactory construction performance and the necessary feedback to construction engineers for technology innovation (Yu and Skibniewski, 1999).

The construction industry has attempted to apply these modern information technologies to such as its project management and cost control. Using the fuzzy logic to select suitable design approaches was developed at the University of Nebraskz NE (Peak, etc. 1992). It suggested that a multicriterion decision-making methodology could be applied for selecting the best design/build proposal under uncertainty which relate the high technical factors and low construction cost. Jeljeli and Russell (1995) suggested that use of decision analysis approach is to cope with

uncertainty in construction industry. The approach has implemented a model to analyse the uncertainty in decision making for construction clear up in sites. In the context of construction project management, site managers is tend to identify a few key determining factors or more widely certain factors to control project budget by using neural network technique to decision making processing (Chua, Kog, Loh and Jaselskis, 1997). WorkPlan (Choo, Tommelein, Ballard and Zabelle, 1998) has been created to systematically develop a week work plan with using a database program. It considers possible factors and uncertain reasoning to choose the best scheduling to construction work. It uses database program during the decision-making processing.

Papadias, Karacapilidis and Arkoumanis (1998) developed a system for processing fuzzy spatial queries 'a configuration similarity approach'. This system uses related queries to retrieve all images in the database that match the some input configuration, which is expressed by a set of binary direction (e.g. north), topology (overlap, inside) or distance constraints.

Other researchers (Wu and Hadipriono, 1992) has presented a new method to estimate the duration of construction project activities called duration decision support system by using the fuzzy modus technique to evaluate the impact of different factors on activities duration. It uses linguistic values of these factors to represent in fuzzy set models, and allows a scheduler to partially match evidence with rules and select the suitable duration of construction project. Despite these developments, little research has specifically been designed to deal with materials routing in construction sites. This study is to develop a tool to help site managers and planners in selecting the most suitable route for materials movement in a complex construction site. It builds on construction schedule and events sequence research. Existing software will be used to analyse the time critical aspects of task schedules. However, it accounts for the implications of task execution on space on site, which in turn may affect other tasks. This issue is important for materials routing as it recognises the dynamic nature of construction activities and their impact on the movement of resources between various locations on a construction site.

Virtual Construction Materials Router

The Virtual Construction Material Router (VCMR) proposes a novel approach to materials routing. It integrates advanced DSS techniques to determine the best route between various locations on complex construction sites. It is specifically designed to achieve the following objectives:

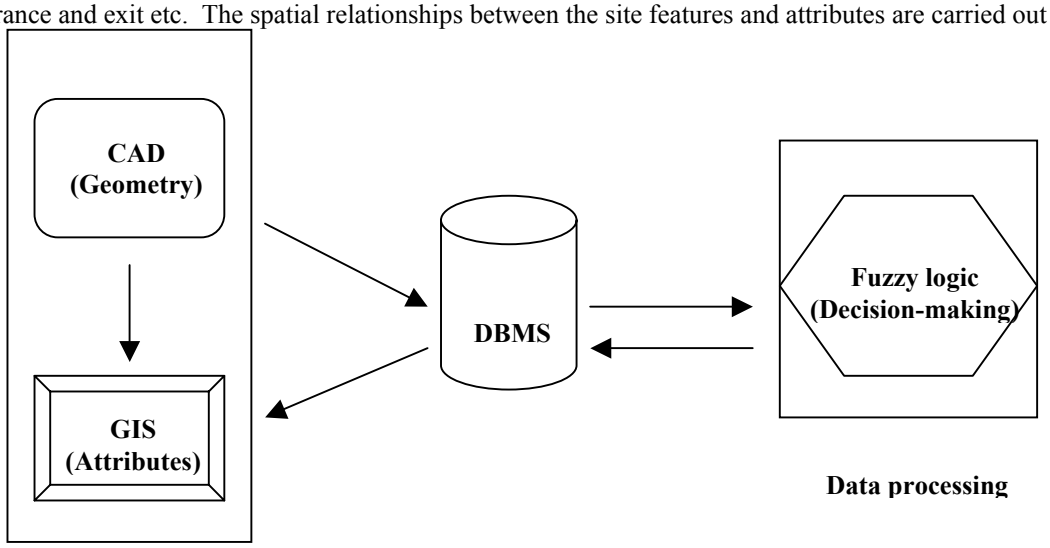
Generate various scenarios for material routing;
Allow rehearsal of various scenarios as construction progresses;
Produce a critical path analysis in the planning of construction materials routing; and
Select the most suitable route for materials movement.

System architecture

Based on the above activities, structure of VCMR was constructed as show in figure 1.

Figure 1 Structure of VCMR

The geometry of the site layout is created in a CAD package (i.e. AutoCAD). Site information includes the location of new buildings, access in the site, temporary and permanent facilities, impediments, storage areas, compound area, entrance and exit etc. The spatial relationships between the site features and attributes are carried out using a



Geographical Information System (i.e. AutoMAP). As displayed in figure 2, the site layout and spatial attributes includes possible routes between different locations of the site.

The geometry and its spatial attributes are subsequently stored in a database management system (i.e. Ms Access) in a text format. As work on site progresses, thematic data relating to site spatial attributes can be revised and updated through a user interface, as shown in figure 3. This information is updated and then stored in the DMBS.

This information is stored in a DBMS ready for visualisation and presentation. It is possible to execute the query function in AutoCAD MAP. The selected nodes could be linked and

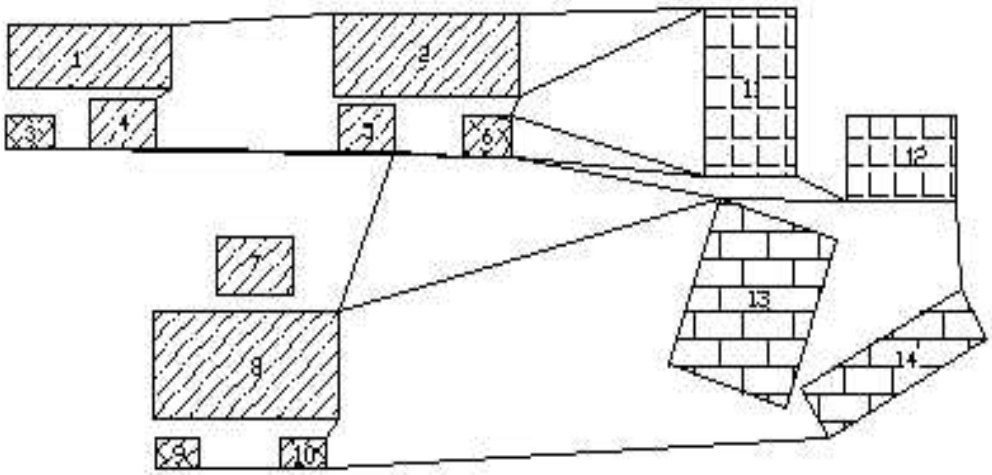


Figure 2 A completed site layout

redisplayed in AutoCAD Map. This graphical representation will enable site managers and planner to identify possible conflicts of material movement and activities. It also allows the rehearsal of various scenarios.

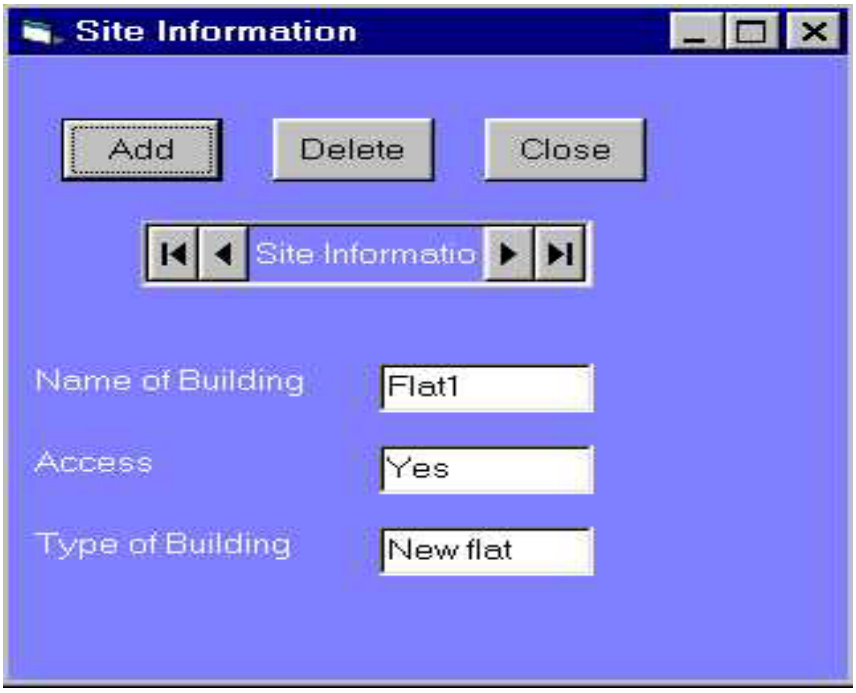


Figure 3 DBMS in VCMR

Results

A prototype of VCMR intelligent routing selection system has been developed. The routes are produced by the decision-making system (figure 4), which use a rules based fuzzy logic ystem to process the input criteria of routing. User defined criteria are selected or entered through a VRMC interface to supply the analytical queries. This includes destination of materials, types of materials, date and time, and materials storage locations (figure 5).
Figure 6 and Figure 7 show a visualisation created by the VCMR for criteria-set output in a complex construction sites.

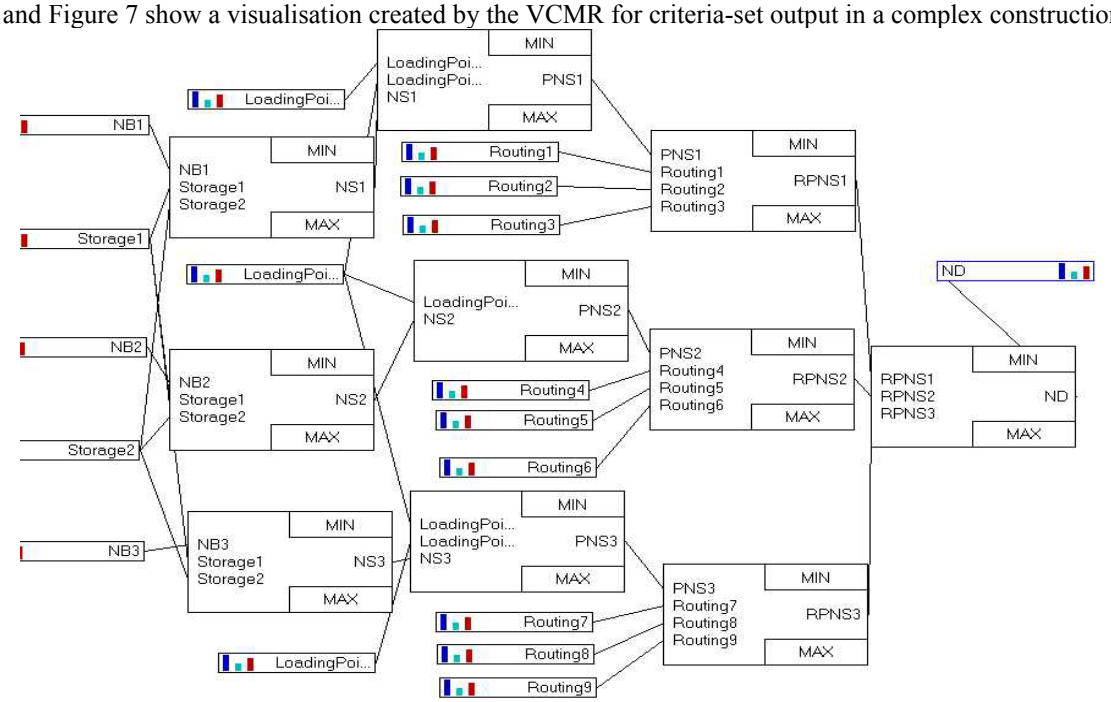


Figure 4 Fuzzy logic decision-making system in VCMR

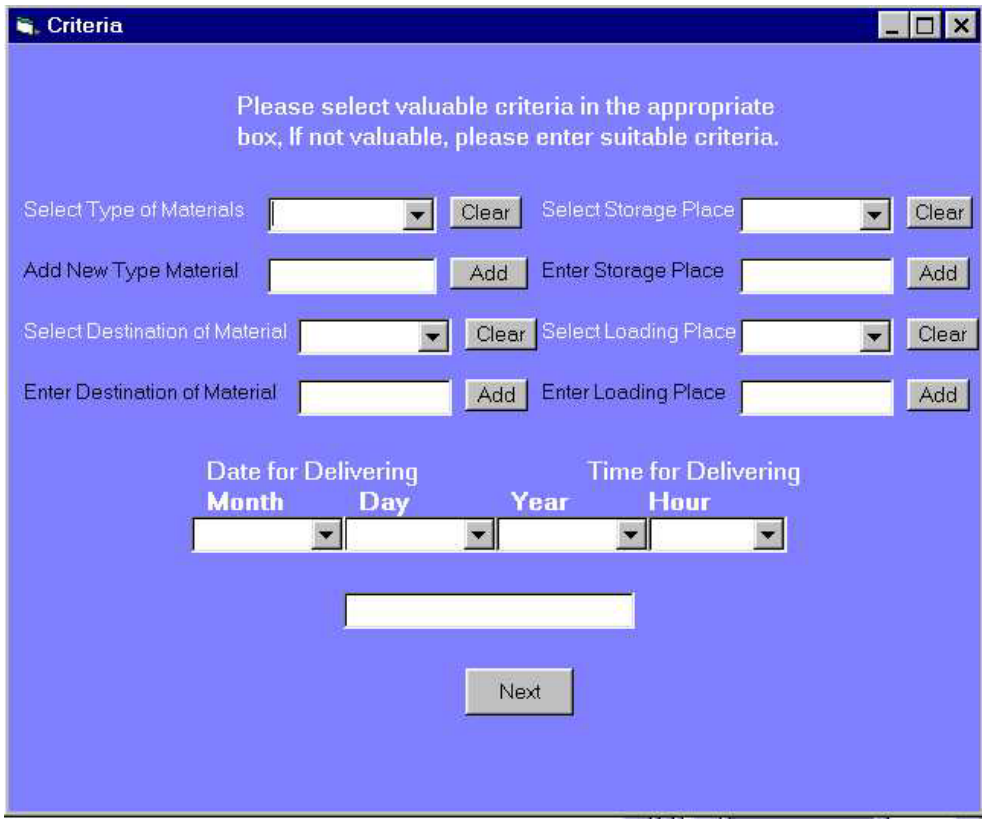


Figure 5 Criteria entry and selection in VCMR

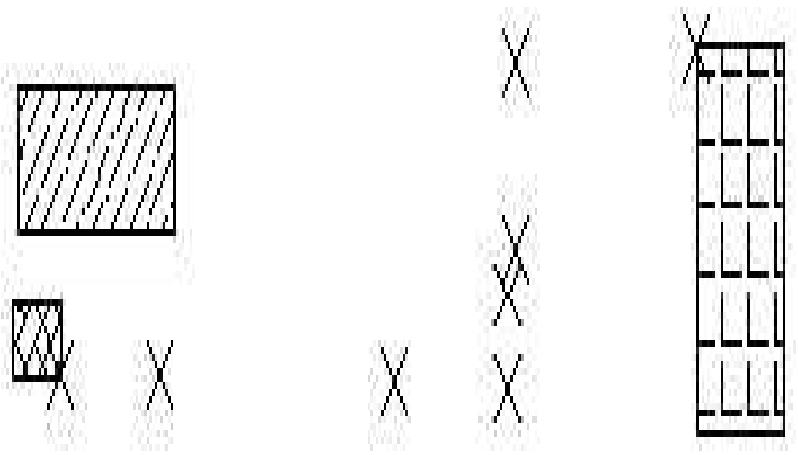


Figure 6 Related nodes of routes

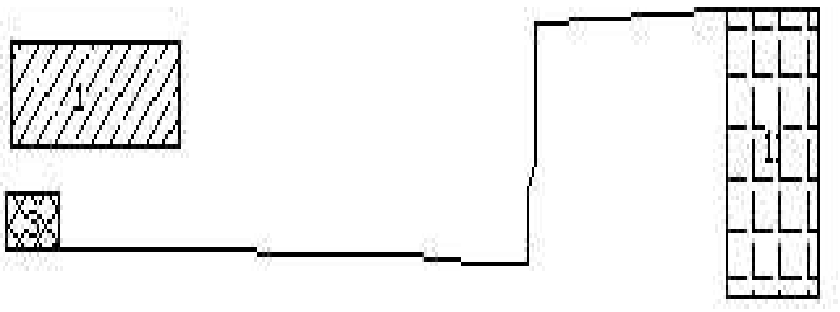


Figure 7 Route for material movement

Conclusion

The GIS- fuzzy logic based decision support tool that is described in this paper is in an ongoing research project. The prototype currently implemented is functional systems only in few limited senses. The decision support system based on site information, which considers the spatial allocation, scheduling and sequence of construction activities.
While results presented here are preliminary, there is a guarded optimism about the potential of the system (Virtual Construction Material Router). With further development system, it is believed that use of this system will be able quickly to perform selection of criteria and simulate the final route of material movement in a visualisation package. Also there is an expectation that effective querying system will ensure the route displayed automatically.

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