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A CRITICAL REVIEW ON THE AUTOMATED METHODS AND SYSTEMS FOR CONSTRUCTION PLANNING AND SCHEDULING

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ABSTRACT

Automation in Construction Scheduling Methods and Systems is the primary focus of this article. One of the most important and difficult aspects of managing and completing construction projects is creating and updating construction plans and schedules. Each work must be defined and its resource and timeframes estimated, as well as any interconnections that may exist between the tasks. The budgets and project timeline are both built on a solid building plan. Although it may not be written down, developing a construction plan is essential in managing a project [1]. Making management choices concerning the connections involving construction stakeholders and perhaps even which companies to participate in a project may be important regarding such specific components of design development. For instance, decision-making about the utilization of subcontracting on a project is often made during the preliminary stages. Consequently, these stages are essential components of integrating all of the project management operations over a whole construction project, starting from the very beginning and completing it [1]. Different, yet linked, are these two. Without the other, neither will operate. It is essential, to begin with, thorough planning of the construction project, which involves identifying all of the necessary steps as well as policies and procedures to be implemented. When the building project has been designed, the next step is to schedule it, which involves breaking the high-level operations into more particular tasks.

Keywords—Construction Planning, Construction Scheduling, Automation, Construction Projects

I. INTRODUCTION

Many unforeseen circumstances arise throughout a building project, making it difficult to complete on schedule. One possible approach is using as-built timetables, which record prior occurrences for comparable future projects, to develop a solid strategy to deal with these kinds of uncertainties. In light of the ever-changing construction environment, many schedulers use comparable prior scheduling practices to create new schedules. Therefore, construction schedulers often use comparable prior timetables as a reference point for their present work [2]. One of the most typical approaches to designing a construction plan is to focus on cost or time controls. Projects fail due to many expenditure problems, each with its expenses. In these situations, the focus of construction planning is on minimizing costs[2]. Additional costs include things like interest on project loans and overhead expenses. Regarding other kinds of projects, the strategic planning of the sequence of workplace activities over time is important and is given a lot of attention during development. Planners in this situation ensure that the right order of operations is maintained and that the available resources are effectively scheduled [2]. Conventional project management methods focused on keeping the order of tasks (which led to project plan scheduling methods or making the effective use of limited over time (which occurred in the process of merchandise scheduling methods).

Last but not least, the majority of complicated projects necessitate planning that considers both cost and schedule over time. A fundamental challenge in these situations is the integration of budget and schedule variables. In construction projects, a project schedule is a vital management tool that aids project managers and their teams in various ways. Construction schedules help them manage everything from costs to resources to timetables [2,3]. The construction schedule is one of the most important tools for project management since it ensures that the management team has access to appropriate information. Due to the significance of project schedules, their creation is approached with great attention. Due to the nature of building projects, it is typical to use the developer's knowledge and experience to kickstart and establish a construction timeline [2]. Unless the scheduler is well versed in the project's scope, the purportedly beneficial construction schedule will develop into a time and money-wasting instrument, which will also mislead the project employees.

II. RESEARCH PROBLEM

The main problem this study will address and resolve are the issues facing construction planning and scheduling by utilizing automation techniques and systems. Although there have been breakthroughs, planning and scheduling for most construction developments, not all—remain entirely manual. Many fundamental concerns have hampered the automation of planning techniques and systems, which this article explores via an in-depth literature analysis [3]. Planning and scheduling for a developed facility include creating sequences of various construction operations and the various construction zones in which the activities are carried out. The efficient plan of a building project's hundreds of operations spread over various work zones and areas. It's impractical for construction companies to do it manually. Buildings with many components, particularly multistory ones with complicated geometric arrangements, might be challenging to design when manually producing the schedules of building projects for various spaces/zones of the structure[4].

III. LITERATURE REVIEW

A. Machine-Based Approaches and Tools

Civil Engineering scholars have been working on automating schedule generation to address the issue of inadequate data. Some researchers utilized the prior three accumulated constructions as a database and planned future projects per this information. Others have also utilized project information models as a source of input to achieve their goals [5]. It was typical for academics to employ expert systems to construct timetables when they first became popular as research tools. Researchers in this discipline now have a new technique to emulate how the human brain functions regarding project schedules, thanks to the introduction of neural networks. Scientists interested in applying Genetic Algorithms to improve project resource allocation and levelling have expressed their interest (GA). Prediction Market and System Dynamics are two more computer-aided methodologies used to help construct project schedules [6]. The following subcategories include prior research: Case-Based Model-based, Genetic Algorithm-based, Expert Systems, Neural Networks, and a few more examples of reasoning and knowledge-based systems. After a brief introduction to each technique, we'll go into how it has been used in prior research projects, where it is discussed in more detail. Afterwards, the conclusion section will summarize the data to provide a clearer idea of how these strategies are used.

B. Construction planning and scheduling using case-based reasoning

There haven't been many experiments on reusing old schedules by employing case-based reasoning (CBR), and the ones that exist are restricted to certain subfields of the construction industry, such as the construction of apartment buildings and the production of boilers. CBR is a field of cognitive science and artificial intelligence study exploding. A new way of storing and retrieving information is being used to assist users in solving difficulties [7]. It is founded on the principle that "a case-based reasoner solves new issues by modifying techniques that have been utilized to address previous difficulties. Experience may be recorded and arranged as a series of historical examples, which are utilized to solve problems or provide solutions by remembering comparable situations, thanks to CBR approaches [7].

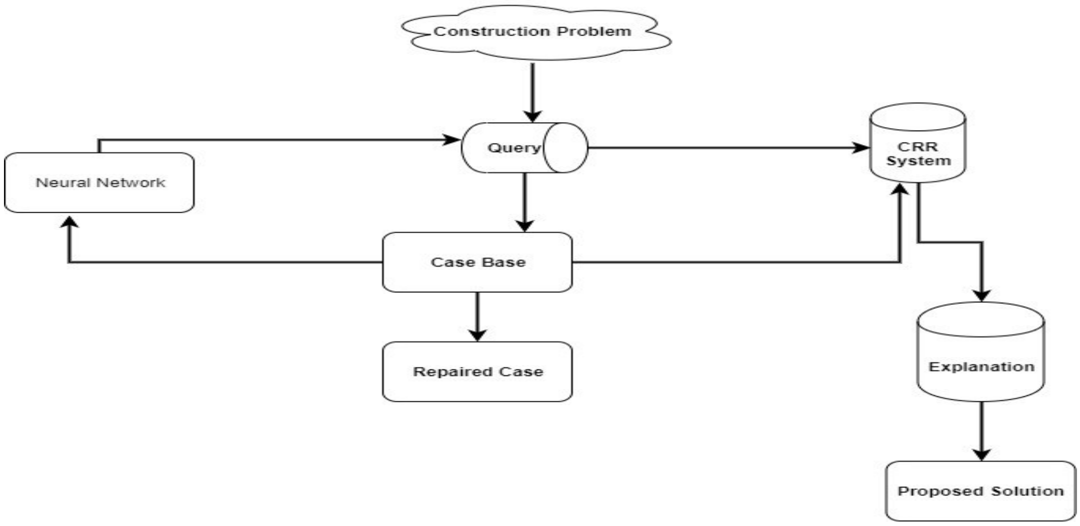

Figure 1: The overall design of the CBR system.

C. Genetic algorithms

A simplified bridge-building scenario shows the challenges of scheduling construction projects when resources are limited. Projects with or without limited resources may benefit from a genetic algorithm outlined. Gene encoding the dates on which certain activities began are used to construct genomes in these applications. Due to this decision, two new mathematical operators (the datum operator and the left compression operator) were introduced, with one genetic operator being the primary focus (fine mutation operator). Evaluations of the fitness function are made. The sample problem is used to test the method. Using a heuristic search, the GA simulates the natural evolution process [8]. Initial genomes created at random can develop into optimal solutions to a particular issue by employing a fitness function that is both well-defined and used as either the objective variable or the core measure of the process. The fitness function defines the objective(s) on which this optimization is based. As a common meta-heuristic optimization approach, the GA may be used to solve a wide range of multi-objective problems, such as schedule construction [8].

GAs may be extended for usage in confined issues just as readily as in unconstrained ones by performing a few more fitness value computations. Additionally, this research shows that GAs may be used for a wider range of issues without much trouble. Nonlinearities of any kind, as well as difficulties with actual cost values and durations that are difficult to predict, are among the issues encountered. Chromosomes represent schedules that include temporal variables, or start dates, in the scenario investigated in this work. The datum operator and the left compression operator, which were established in this work using a time-oriented representation, gain prominence as a result [9]. In CPM, the forward pass does the same job as these operators. Rather, a natural mutational interpretation is provided by a local search operator.

D. Selecting the Right Technology and Building Method

The selection of acceptable technology and techniques for the building is frequently ill-structured but vital to the project's success in creating relevant alternatives for facility design. For instance, whether or not to pump mortar or carry it in buckets would directly impact the cost and duration of the activities included in the project construction process. When deciding between these two options, it is important to examine the relative prices, reliability, and availability of transportation equipment for each technique. Since of this, it's difficult to predict the precise results of any given procedure because there are so many variables that are not predicted in advance, such as the level of experience and competence of the employees or the specific conditions of the subsurface at a certain location. Construction projects based on alternative techniques or assumptions may be essential when picking from various methods and technologies [8]. Alternative techniques are evaluated in terms of their effects on costs, timeliness, and dependability once the whole plan is revealed. Design options and building techniques are evaluated for cost-effectiveness through bidding contests, where many bidders can submit their proposals. In this scenario, prospective builders may desire to develop strategies for each optimized design using the recommended construction method and prepare plans for other building methods that would be presented as part of the value design project.

When drawing up a building plan, it's helpful to imagine or utilize numerical simulations of the construction phase to get a sense of how things will go [9,10]. It is possible to compare other strategies or find flaws in the current strategy by looking at the results. A choice to utilize a certain piece of equipment for a procedure instantly raises the issue of whether the equipment has enough access space. Simulating space needs for operations and detecting potential interferences may be done using computer-aided design (CAD) systems. As a result of the simulation of the building process, difficulties in resource availability may be efficiently prevented by providing extra resources as part of the construction plan.

E. Defining Tasks for the Workplace

As part of the planning process, it is important to identify the different job activities that are completed. These work assignments provide the foundation for scheduling construction operations, calculating the resources needed for each activity, and determining required standardizations or sequences. "Activities" and "tasks" are typically used interchangeably in construction plans when referring specifically to work. Projects are termed "jobs", and activities are called "operations" in job shop or manufacturing language, but the meaning is the same [11]. One of the planning concerns is to come up with a set of starting dates, resource availability, and project end dates that will ensure the work is executed on schedule and under budget. The planning stage of construction must always come before the project's planning phase. Tasks and technologies are often defined simultaneously or iteratively during this planning phase.

The rigorous scheduling techniques are required to spend time defining what tasks should be assigned to whom. The defining phase of a building project may be costly and time-consuming since it involves many separate jobs. Due to this, it's possible to reuse many of the same duties in other portions of a facility or to utilize previous facility development plans as a general model for future projects. Some construction operations may be repeated with minimal variations on each subsequent level, for example, while constructing a new building's floor. In addition, most tasks have standard definitions and terminologies. Consequently, each aspect of the project does not have to be approached from the start by the individual planner who defines work responsibilities [12]. While replication of activities in other places or duplication of activities from earlier projects decreases the effort needed, there are relatively few computer tools for the process of defining activities. It is possible to keep track of former projects' activity using databases and information systems. Numerous computer tools are available to help with the actual scheduling procedure. However, the construction planner's expertise, judgment, and experience will likely be relied upon for the crucial duty of identifying tasks.

A formal definition of activity is a breakdown of the work involved in completing a project. A project's collection of activities should be extensive enough to contain all required duties. Each facility design element often has a project activity connected with it. As detailed in the next section, it takes time and resources, including labour and equipment, to carry out an activity. The time it takes to complete a task is the task's duration. Signposts or milestones mark the beginning and finish of each activity, showing how far along the project has progressed [13,14,15]. To recognize noteworthy occasions, it is sometimes necessary to designate activities with no time limit. For example, the arrival of construction equipment on the construction site may be considered an activity since subsequent activities would rely on the availability of the equipment, and the project manager may welcome official notification of the arrival. It will also be included in the project plan if regulatory permissions are received [16].

The amount of work required in building project planning in any activity might vary greatly. Even yet, it's often uncommon to begin by defining activities in broad strokes and then progressively subdivide them as the strategy is well defined. Because the plan is being prepared, the definition of activities changes. The upshot of this process is a natural hierarchy of activities in which vast, abstract functional activities are constantly subdivided into more and more particular sub-tasks [17]. Placing concrete on the job site would include sub-activities such as putting forms in place, installing reinforcing steel, pouring concrete, and completing it.

IV. SIGNIFICANCE TO THE U.S

Automation of construction scheduling and planning is important to the United States in various ways, including reducing costs and increasing efficiency. Establishing a topographic foundation is a time-consuming but necessary step in developing the building's subsurface infrastructure and geodetic support. In contrast to more conventional ways, using current unmanned aerial vehicles that are fitted with high-precision technology to create geographic information and three-dimensional simulations is an efficient alternative [16,17]. Using these techniques enables a 15–20% reduction in the time and resources required to construct topographic surveys while maintaining the same level of quality [17]. Surface models produced by this process are useful not only in terms of fixing geodetic axes but also in calculating earthwork proportions and evaluating the progress of their execution. The use of contemporary construction equipment and techniques of automated labour is another facet of work automation in real estate development. Today's software makes it feasible to keep track of the technical status and productivity of equipment in real-time, spot overworked equipment, and adjust their work schedules accordingly. Without the use of automation and digital modelling tools, modern manufacturing is impossible. Even in the building business, sophisticated design, calculation, and management technologies allow huge cost reductions and prevent vital mistakes. By using a digital model of a building site during design, it is possible to minimize the negative and destructive effects of these aspects as well as to save time and money. A 3D model of the proposed structure may be used to determine the most efficient ways of work production, arrange the construction site, monitor technical activities, and manage financial resources operationally.

V. FUTURE IN THE UNITED STATES

Big Data will significantly influence the future of project planning and scheduling. Big Data has the potential to fundamentally alter how issues are approached and resolved. With Big Data, we can quickly produce and optimize plans based on historical data sets or "As-built" schedules already used. There are many ways that Big Data may help us make better decisions about which projects to undertake, how to deliver projects, and how to maximize project outcomes. The ability to systematically examine a huge amount of data is useful for finding more precise solutions to challenging situations. Artificial intelligence, virtual reality, and augmented reality are crucial technical breakthroughs in the future of project controls [18]. Every industry has embraced AI in some form or another to increase productivity. AI robots and algorithms can now complete even the most difficult jobs.

In the future, virtual reality (VR) and augmented reality (AR) will have a much greater influence on project planning and scheduling than artificial intelligence (AI). Since their inception as gaming tools, augmented reality and virtual reality have found applications in various fields. Using 3D models and facilitating communication, cooperation, and exchanging information through AR and VR in project control may help the industry become more efficient [18].

AI is predicted to enhance strategic and decision-making processes regarding project planning and scheduling. With AR and VR in project controls, stakeholders and communities will be more engaged, and 3D models will be used to better plan and monitor site development. Increased digitization may have a favourable effect on the ties between firms and the interactions between employers and workers. Despite common opinion, digitalization is not the primary cause of employment losses. Instead, digitalization aids workers in doing their tasks more quickly and efficiently. Regarding project planning and scheduling, digitalization can potentially make workers more effective at their employment in the future. Digitization will integrate schedules (e.g. 4D and 5D), costs, and ERP systems more seamlessly. Forensics, risk assessment, and scheduling health analysis will all benefit from new diagnostic techniques. Instead of manually accumulating and reporting data, digitization gives us more opportunities for analysis and issue solutions [19]. When done right, digitization can potentially make us all more productive in the future.

VI. CONCLUSION

This paper conducted an in-depth assessment of this study's Automated Construction Planning and Scheduling methods. The data demonstrate that experts throughout the globe have been interested in automating the preparation of building schedules for over three decades. They can keep track of a variety of variables by using building schedules. The construction timetable is one of the most important mechanisms for managing operations, if not the most. This plan is because of the capacity to guarantee that the management team has appropriate access to all of the necessary information. The formulation of project timelines should be done meticulously. In designing a building timetable, the developer's background and expertise play a significant part. For example, a construction timetable meant to be beneficial if the scheduler is adequately aware of the project's scope may develop into an expensive and time-consuming instrument that will also mislead employees. Scientists have been working on automating schedule generation to combat the issue of inadequate data.

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