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DEVELOPING PROJECT CONTROL STSTEM USING SPC-SVM METHOD

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ABSTRACT

Within the project period, project managers monitor and regulate the various expenses related with project duties. The traditional variances are computed by comparing the actual performance measures gathered during the execution phase to the baseline metrics chosen during the planning phase. These variances are taken into account throughout the control procedures in order to establish their relevance. In real-world projects, the question is whether traditional methodologies can provide a meaningful indicator for project control. The present paper used the exponentially weighted moving average (EWMA) control chart in conjunction with the support vector machine (SVM) to propose an excellent tool for construction project monitoring. The EWMA advances SPC schemes are used to study the chart's upper and lower control limits and to use cost performance index (CPI) data to determine out of control spots. The SVM findings then demonstrated a good indicator for predicting the overall egression of the project based on different time periods. The numerical results show that using the control chart method in conjunction with SVM to analyze the actual values of CPI indices improves project management teams' capacity to recognize cost problems on time.

Keywords: Statistical Control Charts, Project Performance Evaluation, cost performance index.

Introduction

There are many different approaches that can be used as cost management procedures in order to bring a building project to fruition. Contractors can benefit from using cost control measures more effectively if they have a firm grasp of their efficacy and how to implement them[1]. Project cost and time management is not a trivial task and requires familiarity with control methods. That's why it's crucial for construction professionals to have a firm grasp on how the theory of cost control works. A project manager, planning engineer, or similar professional needs to know that the success of a project depends on more than just picking the right strategy; it also depends on the time it takes to actually put that strategy into action. Appropriate project cost control strategies are a must in today's construction industry. Almost all projects need continuous direction in order to achieve the expected outcomes[2]. The ability to build with nearly flawless digital information and shifts in how business is done are compelling responses to the many challenges in the building industry's cost management process [1]. By highlighting "Accuracy, Timeliness, Cost, and Completeness," the Theory of Industrial Evolution facilitates growth as a decision-maker. This is leading to information creation in the construction business that is not only unnecessary but also adds to the confounding nature of the problem. [3]. Nonetheless, the project's budget will play a crucial role in selecting key factors. It's tough to tell if the project is headed in the correct path if no budgetary guidelines have been set in stone.

2 Cost control

The timeframe necessary to complete a construction project is of paramount importance to all parties. On the flip side, projects rarely end on schedule. To maximize the usefulness, efficiency, or output of one's limited time, one must engage in time management. This entails the planning, organization, and application of conscious control over one's limited time spent on certain tasks. A great number of researchers are committed to finding answers to narrow the gap between theory and practice. Researchers have suggested numerous strategies that might be used by project teams to better manage their time. Scheduling for a project should be done in accordance with the work breakdown structure or critical path analysis to ensure that the project's priorities are met. An effective risk mitigation plan[5] can help the project team, including all stakeholders, move past any unpleasant feelings that may occur over the project's life cycle. One of the most important tools for cost control in project management is Earned Value Management (EVM), which examines the performance and progress of a project in an objective manner by merging the scope, schedule, and cost components of the project. When it comes to managing the budget for a project, EVM is an important tool[6]. [7]. When creating a project specification, it is important to be as thorough as possible in describing the project's physical components. Once the measurements, the required function, and the anticipated occupancy rate have been taken into consideration, a number of other factors, such as the total floor area, floorplate size, height, interior and external appearance, floor loadings, heating and lighting needs, and other aspects, will be decided upon for the building project. The overall project cost can be broken down into its component parts, all of which contribute to the building of the physical pieces [8]. The significant amount of materials lost on most construction sites due to a variety of factors is a significant difficulty for the project manager. An issue like this requires a management to keep a close check on the money that is being lost. Waste can be generated during the acquiring,

warehousing, and utilization of any given material. Procurement waste can result from any combination of the following causes: buying materials without the correct specifications, ordering in excess to prepare for unlikely events, buying materials with a short shelf life too early, unnecessary and improper material handling, and unnecessary transportation. Damage from handling, lack of care and upkeep, short shelf life, and exposure to severe weather are just some of the ways in which the value of an object might depreciate if it is improperly stored. Inadequate pre-work preparation and coordination, incorrect bookkeeping, and bad storage methods are also to fault, as is the supervisor's carelessness and neglect. Long-term storage at the jobsite and excessive issuances from central stores without follow-up from the shops to return unusable surplus items are other factors[9]. Expenses for a project almost never stay the same once production has begun. There may be a more precise accounting of expenses as more data is available. It's possible for the final price to go up for a variety of reasons, even after it's been calculated. There is a major factor of delay. Delays, for whatever reason, almost always result in overspending. While it's possible that some of the reasons for the holdup may have been anticipated, others just couldn't have been. There are three distinct times where a pivotal choice can be made[10]. While costs can be estimated, they may increase depending on a number of factors. Delays are extremely significant. Every delay, no matter why it occurred, almost always causes an increase in costs. There could have been a number of reasons for the holdup, some of which could have been anticipated and some of which couldn't. There are three different points in time at which a critical assessment can be made[11]. The cost performance index (CPI) is widely used around the world to influence and support project management decisions. The CPI operational range is one of the aspects that will be considered to ensure that gets are based on the whole picture[12][13].

3 Support Vector Machine Algorithm

The Support Vector Machine (SVM) is one well-known supervised learning technique. Its potential applications extend beyond simple classification and regression. Its primary use in the field of machine learning is the solution of classification issues. In order to categorize data in an n-dimensional space, the Support Vector Machine (SVM) is the method of choice. Any new data points we receive in the future will be readily and swiftly categorized. We call this optimal decision boundary a hyperplane. The hyperplane's extreme points and vectors are chosen via support vector machines. The term "support vector" is used to describe these out-of-the-ordinary occurrences, which is how the Support Vector Machine earned its moniker. Check out the image below for a visual explanation. It demonstrates how two groups can be separated using a decision boundary and a hyperplane [27]. Different hyperplanes can be utilized to separate the two classes of information. Our goal is to locate the plane that separates the two groups of data by the greatest feasible margin. When the margin distance is largest, some reinforcement is provided, increasing the confidence with which subsequent data points can be classified. Using hyperplanes as decision boundaries aids in clustering the data. Classification of all data points on both sides of the hyperplane is feasible. The total number of surface characteristics also affects the size of a hyperplane. If there are only two input features, the hyperplane is a simple straight line. When only three input features are considered, the hyperplane flattens out to a two-dimensional plane. As the number of traits increases past a certain point, the difficulty of conception increases as well. The position and orientation of a hyperplane

are said to be supported by support vectors if they are influenced by surrounding data points. Making use of these support vectors allows us to increase the classifier's margin to its maximum. Taking away the support vectors will cause the hyperplane to shift. These parameters are relevant for the improvement of our SVM[14]. Because it chooses the best line along which to position each of your data points, the linear support vector machine (SVM) method is preferable to other classification methods like k-nearest neighbors. The line that most effectively separates the data is chosen, and it is placed as far away as feasible from the data points that are closest together. What we have, in brief, is a grid with some data points on it. Classifying these data points into the category requires doing so without misclassifying any of the underlying data. In other words, we want to find the line that joins the points that are most closely spaced while still allowing for some variation in distance between the other points. As a result, the two spots that are geographically closest to one another will serve as the line's support vectors. That dividing line is also known as the decision boundary.

$$g(x) = wTx + b \quad (1)$$

$$-Wt + B >= k \text{ for di} == 1 \quad (2)$$

$$-Wt + B <= k \text{ for di} == -1 \quad (3)$$

Value of g(x) depends upon IIwII, Keep IWI = 1 and maximize g(x) or g(x) >= 1 and minimize IIWII

$$\emptyset(w) = 0.5w^{T}w - \text{minimize} \quad (4)$$

subjected :

$$di\left(w^{T}w + b\right) \geq 1\forall i$$

4 METHODS FOR MONITORING PROCESS

In 2017, Kharbach et al. analyzed a huge dataset consisting of qualitative and quantitative data to ensure process reliability. Traditional statistical process control (SPC) for pharmaceuticals involves looking at the effect of a single element at a time using a Shewhart's chart [15]. Statistical Process Control (SPC) approaches were employed by Araghi et al. (2018) to aid in the evaluation of indoor real-time localization systems (I-RTLS). Methods from the field of statistical process control (SPC) were used to better track patients' journeys and provide more detailed data[16]. For pattern detection in control charts during an auto-correlated process, Bo et al. (2018) presented random forest as a classifier [17]. Addeh et al. [18] suggested a hybrid system that takes advantage of both statistical and form features, as well as a multilayer perceptron neural network. The predictive feature and statistical qualities of EWMA inspired Haghighati and Hassan to offer it as an imputation tool in 2018. The theory behind exponential smoothing is deep, and it has been successfully implemented in a number of business settings[19]. In 2018, Xu and Ma suggested a transfer-learning based approach for recognizing control charts[20]. In 2019, Golilarz et al. [21] introduced a new automatic technique for recognizing nine control chart patterns (CCPs) using deep learning and optimization algorithms. A novel integrated model for maintenance planning and quality control strategy for multi-component systems with EWMA Chart [22] was proposed by AL-Shayea et al. in 2019. The adaptive neuro-fuzzy inference system (ANFIS) for pattern recognition issues was created by Kalteh et al. in 2019 [23]. Two-dimensional spatial count data with spatial correlations were monitored

using control charts by Shang et al. in 2019. They're built with an innate [24] in mind. In 2020, Lu et al. developed a new generalized technique to machining condition monitoring using control chart pattern recognition (CCPR) with adaptively scaled observation windows for real-time data[25]. Elewe et al. [26] developed a new set of strategies for dealing with difficulties of this complexity by making use of the Firefly algorithm and refining it with the help of a scanning method. talib et al., in [27] and bin Hasnan et al., in [28] developed a way for taking on large difficulties by utilizing the MC-GPSO technique [29] and [30] respectively. An aggregated artificial neural network was developed for defect pattern recognition by Majeed et al. in [31]. Using quantitative models, approaches, tools, and databases, the process of cost estimation gathers and analyzes past data to predict future program costs. There are three distinct phases to this process: data collection, analysis, and prediction. The basic stages of the design process for creating a structure require careful consideration of many elements, one of the most important of which is cost. For construction projects to be successful, it is crucial to have a reliable model and strategy for cost estimation [32]. This can be done to guarantee reliable financial forecasts. The estimating method tends to get more complex as the cost parts become more diverse, making it difficult for users who directly do cost estimation to apply the results of recent research to a construction project in practice. A reliable assessment of building costs is crucial for planning and budgeting [33]. It is the total amount spent on getting everything you need to carry out the task [34].

5 SPC-SVM RESULTS

The budget will be sufficient to meet all necessary payments and expenses as they come up during the course of the project's lifetime. The success of the project will be calculated and judged by the project managers based on the set budget. The question that must be answered is whether or not the estimated project will offer a suitable appraisal of the project. As a result of this study, a novel SPC-SVM-based method for monitoring project expenses and schedules has been established. From this perspective, the methodology's primary function is to keep tabs on project expenses and duration. The present method will track the adjustments made to the project based on the different kinds of labor being performed. The SVM system is evaluated using a real-world example including the concrete and walls of the construction site. Project change management is an innovative approach. Establishing tools for managing changes as they occur is critical for projects of any size. In this thesis, the real costs are employed to generate the time-varying budget variances using a control mechanism. As a result, it will be less of a hassle to track how much is being spent at each step of a project.

Table 4.1: Process data occurred in construction operation

duration (day)	CPI	SPI	duration (day)	CPI	SPI
1	0.56	1.00	14	0.56	1.00
2	1.63	0.98	15	1.63	0.98
3	0.90	0.90	16	0.90	0.90
4	0.77	1.00	17	0.77	1.00
5	0.94	1.00	18	0.94	1.00
6	0.82	0.89	19	0.82	0.89
7	1.29	0.97	20	1.29	0.97
8	0.56	0.88	21	0.56	0.88
9	0.79	0.79	22	0.79	0.79
10	0.76	0.57	23	0.76	0.57
11	1.27	1.00	24	1.27	1.00

12	0.57	1.00	25	0.57	1.00
13	0.74	0.915			

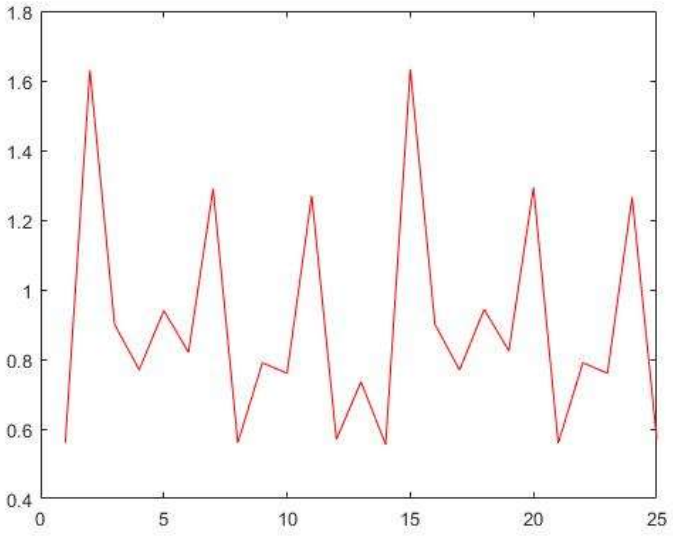

Figure 1. CPI variation during time of project

it can be seen that the variation in CPI during the project cannot be indicate the performance of project and cannot be used to monitor the project performance. For that, the CPI calculations applied with the traditional EWMA method to investigate the out of control point as seen in figure 2. An EWMA-based construction control chart can be used to reduce errors in the management of building projects. Due to the fact that even slight variations in construction processes can cause issues, EWMA has emerged as the most effective tool for monitoring variations that must be relatively close to the intended result. The effectiveness of the disturbance recognition system is readily observed. Because it can identify out-of-control process values from the numbers in the data set, it is more precise than a standard chart.

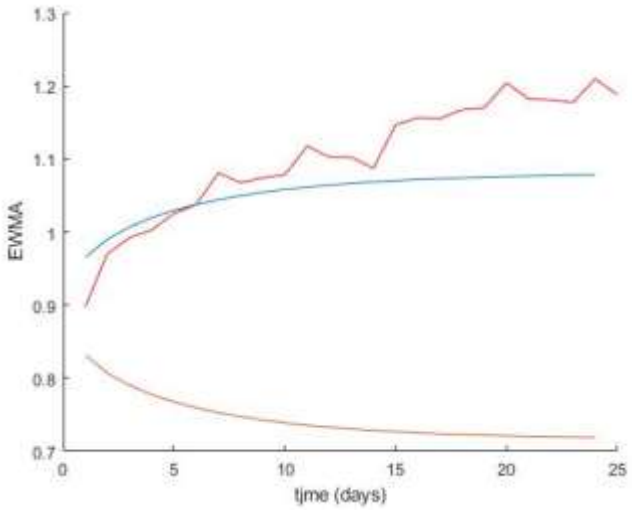

Figure 2. the EWMA control chart result

According to the principle of control charts, CPI measurements within the control boundaries do not necessitate rapid action, and their changes may be due to acceptable random factors. Nonetheless, some CPI measurements fell outside of control limits (e.g., a CPI measurement on day 6), indicating that the project performance significantly deviates from the baseline plan. Project managers should investigate the causes of these out-of-control points and take the necessary corrective actions to prevent this from happening again. The CPI measurement over the upper control limit (UCL) at a given time t indicates superior project performance relative to the baseline plan. Tracing the causes of such an improved performance and repeating them throughout the project life cycle will increase the overall performance of the project. In contrast, a CPI measurement below the lower control limit (LCL) indicates poor performance relative to the baseline plan for a given time slot. Detecting such a project performance measurement enables managers to better track connected causes and propose appropriate solutions to enhance the project's overall performance. The EWMA control cart also cannot observe the project performance. This method indicate that project will be out of control after the seventh day. But it not gives an indicator to the project performance situation. The SVM results present the total project performance as shown in figure 3.

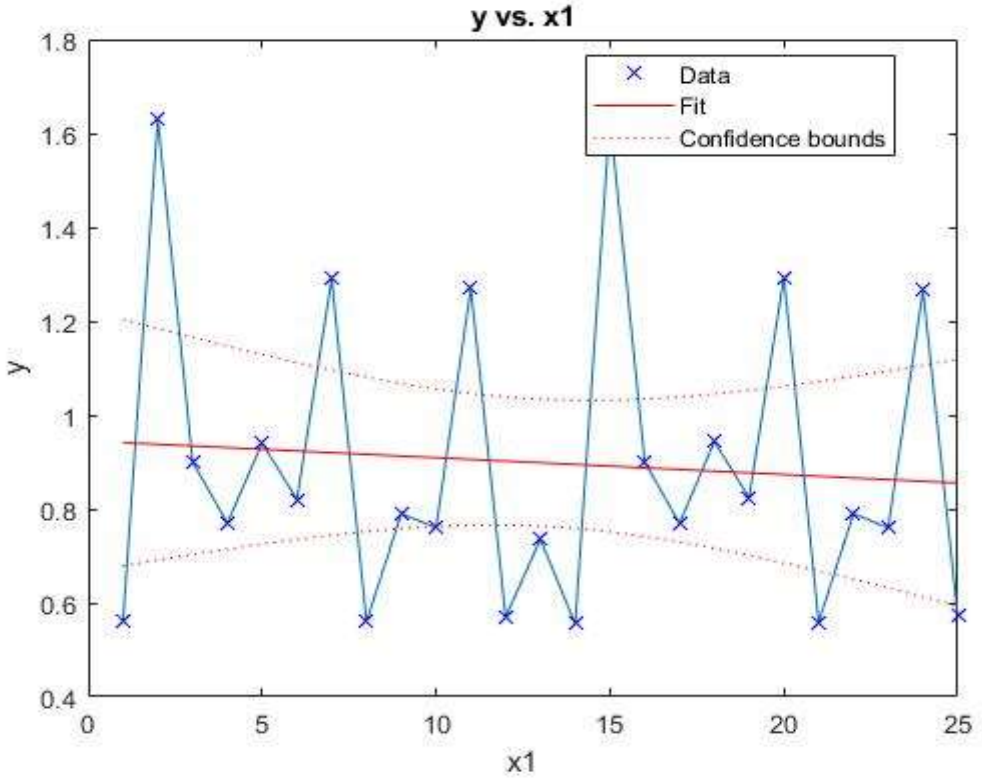

Figure 3. The SVM results of total project performance

The contribution in this paper is the combination between the EWMA results and SVM results. As shown in figure 4, the plot present both of project performance during the project time and the point when the project with go out of control.

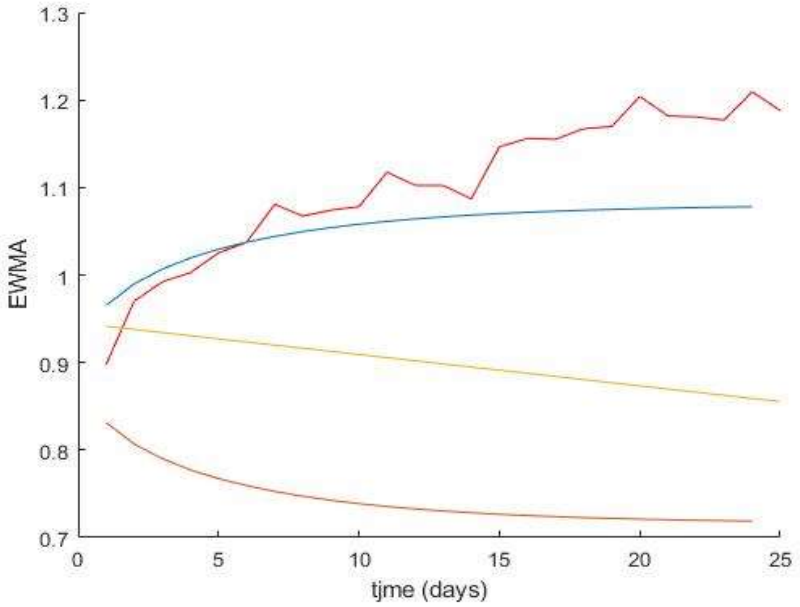

Figure 4. The SPC-SVM results of total project performance

6. CONCLUSION

There are several ways to accomplish this. The project manager oversees the project's objectives and expenses. If a project manager fails in this regard, project management is ineffective. This is because it determines the company's profitability. In traditional cost control strategies, a budget is applied during project planning. The budget includes all project payments and expenses. The project managers are responsible for all budget-based computations and performance evaluations. The question is whether the estimated project offers a suitable evaluation. This research created a novel approach for tracking a project's cost and duration using SPC-SVM intended values. This approach was created to monitor project cost and time. The current strategy tracks project changes based on task type. As an example, the genuine project's SPC-SVM system is tested. Change management is unique. Change control methods must be in place to account for any project-related changes. This research uses actual spending to calculate time-varying budget variances. This makes tracking budget spending across a project's stages straightforward. Monitor actual expenses versus monthly budgeted goals. Depending on the length of the project, weekly, monthly, or annual goals may be set.

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