Developing a Cyber Physical System to automate and improve Site Monitoring Activity

Final Year Project UG 2017

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has been accepted towards the requirements

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DEDICATION

We hereby dedicate this project to our parents, teachers, the labor force of Pakistan and the unfound potential of the construction industry. May we get to live our lives to the fullest of our potentials.

ACKNOWLEDGMENT

We express gratitude toward The Almighty Allah for giving us the quality and faith in ourselves for the endeavor of this final year project. We additionally accept the open door to offer our thanks and regard to our folks, without whose supplications and wishes we could never have possessed the capacity to fulfill our objectives.

It is of most extreme important to recognize and thank our advisor and mentor Dr. Muhammad Usman Hassan, for all his admirable direction, help and inspiration given all through degree of our project. It is with his bolster that we have been fruitful in accomplishing our goals.

We might likewise want to specify and thank every one of those contractors, general public/clients and laborer’s who furnished us with their time, help and information. Without their collaboration, active participation and help this project would not have seen the light of day.

ABSTRACT

Site monitoring is paramount to the successful execution of any Construction Project. Despite holding such importance in project management site monitoring method are archaic relying on a traditional pen and paper reporting system which is not only inefficient and vulnerable to flaws but also slow. With the requirement of business to grow faster, the construction industry is required to expedite its ability to complete projects whilst staying under the budget and time schedule. The slow outflow of information and relatively weak communication hampers severely the pace of construction projects despite new technologies which speed up the construction time

We plan to introduce an automated site monitoring system which will provide Project Managers real time information about the status of their site and enable them to make better and informed decision all from behind a screen.

Not only will this eliminate a huge barrier in communication but also empower site engineers to focus more towards the execution of their projects while keeping the project managers UpToDate. Our proposed system will also allow construction manager insight on their projects which would allow them to choose the next possible move for a successful project execution.

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LIST OF ABBREVIATIONS

RFID	Radio Frequency Identification
BIM	Building Information Modeling
CPS	Cyber Physical system
SKU	Stock Keeping Unit
UI	User Interface

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CHAPTER 1

INTRODUCTION

1.1 Background

There have been several attempts to improve the construction industry by integrating smart technologies to smooth out the whole process of construction, and some of them are even employed nowadays. Our goal for this project is to introduce a system that significantly improves the site monitoring capabilities of the construction team and raises the efficiency of the whole process. This research is oriented towards tapping into the massive potential that cyber-physical systems' integration into the construction industry brings about.

1.2 Problem Statement

The construction industry in Pakistan, alas, still relies on almost medieval practices, especially when it comes to monitoring and communication. Sure, the advent of technology has allowed contractors and construction firms to employ machinery in their arsenal. But, still, when it comes to the communication aspect, the methods employed are highly inefficient. They lack proper check and balance as to whether the information being communicated is right or wrong. As we can all imagine, this can be a very critical shortcoming that could potentially jeopardize the entire project.

The construction industry in Pakistan is booming. Projects are being initiated at both the government level and private level in great numbers. But the lack of a proper medium of communication between the site and the project manager is hurting the construction industry as a whole.

Therefore, this necessity of mitigating the lack of an efficient communication and monitoring system gives rise to innovations that can potentially plug this leak. Therefore, there is enormous potential here in terms of how to improve this drawback, and we aim to better the lack of monitoring and communication practices by proposing our system of remote site monitoring using cyber-physical systems that will integrate affordable, easy to use technologies to vastly improve the communication between the site and the project manager.

1.3 Research Objectives

This research is geared towards following objectives.

- Improving the project manager's site monitoring and communication capabilities.
- Improving the two-way communication between the project manager and the laborer.
- Proposing ways to enhance bi-directional communication media between virtual models and physical construction.
- present a system that can be deployed on any construction project that allows the project manager to effectively and efficiently monitor the resources, progress, and status of his workforce whilst also allowing the labor force to aptly communicate with the office as well.

Analyzing the trends adopted across Pakistan, the lack of cyber-physical system integration in the construction management domain is almost non-existent. Only a select few projects employ cyber-physical systems but not to a vast extent, so their potential is not fully realized ergo also not utilized.

1.4 Methodology

Our research involved studying the varying trends in our construction industry by interviewing people who have served in this industry for a considerable time. We also involved studying various research papers online and surveys that depict the trends and practices being currently used and came to know about the discrepancy. All our efforts in carrying out our preliminary studies pointed to the growing gap in cyber-physical systems' lack of integration in the construction industry.

Therefore, our research aims to improve the site monitoring and communication capabilities of a project manager significantly and improve the bi-directional media of communication using cyber-physical systems. Efficient and effective communication and monitoring will always lead to better results and client-contractor satisfaction.

1.5 Conclusion

Realizing the growing disparity in the integration of smart technology in construction management, we aim to introduce a cheap, affordable, efficient, and user-friendly system that integrates the cyber-physical systems to utilize their true potential and revamp the construction management practices currently deployed. Our proposed system will allow the project manager to monitor the various aspects of the site with efficacy, such as the progress of multiple tasks and milestones, resources being utilized, the status of the laborer’s, and their safety. This research will also serve as a stepping stone for further innovation and opportunities to improve further the construction practices employed in the current times.

CHAPTER 2

LITERATURE REVIEW

2.1 Project Management

Project management manages the resources at your disposal for a given project and achieves milestones set that will ultimately lead to its completion. Project management has various phases such as design, schedule, implementation, and completion. Each part is complex enough on its own, but project management becomes a nexus of complexities when combined[1]. To a considerable extent, these difficult phases are tackled effectively using project management software and their evolution into Building Information Modelling, allowing for 4d and 5d management practices[2].

2.1.1 Common Practices

Common trends and practices prevalent in Pakistan are, frankly, outdated, obsolete, and lack efficiency[3]. Although, still, outdated software is used, such as Primavera and even that is not widely used, to a huge extent, project management is handled nonchalantly and by just going with the flow of the project. This indifferent approach can be disastrous to the progress and health of the project[4].

2.1.2 Problems with the current practices

These old, useless practices are very detrimental to the project's progress, and it is very apparent why. Responsible, efficient management of a project is paramount to the successful completion of a project[5]. The project manager is the general commanding the army and the resources available at his disposal and the fact that the logistics of his army and communication are outworn and antiquated can be fatal for him. These outworn practices which have been deployed for the past several decades without any attempt to improve them do not cater to the growing technological advancements of the current times and also how this revolution is impacting the growth of the construction industry[6]. As more and more construction projects are being initiated at both the government and private sector level, the need for an advanced, up-to-date system is now more important than ever[7]. A system that can tackle the rapidity, logistical, communicational challenges that arise with each project.

2.1.3 Technologies available in the market for project management

Science has made tremendous progress and continues to grasp and overcome new thresholds of innovation[8]. Nowadays, it is very easier and also necessary to integrate modern technology to revitalize project management practices. The general know-how of project management combined with other disciplines of science such as computer sciences, deep learning, artificial intelligence, data science, and decision science can revamp the entire practice of project management for the better. Even now there are several software easily available in the market to ease the process of management such as Revit, Gantt pro and CoConstruct are only a few to name[9]. The new trend of Building Information Modelling has unparalleled potential to improve project management, especially, combined with artificial intelligence and augmented reality[10].

2.1.4 Issues Arising

The drawback that comes with these modern and vastly better practices of construction management is, in a way, not the fault of these practices but instead the fault of our very outdated, overused system and our complete dependency on it[11]. Also our rigidity and lack of flexibility to entertain new notions and ideas to adapt and learn to improve our system has set us back. The new practices currently being deployed worldwide are also continuously being improved at the same time to save time, money, and resources, also to improve efficiency. If we were to introduce these practices here, we would have to root out the deeply engrained disposition of our workforce to depend on the outdated practices and also the truism of "If it is not broken, do not fix it". Then after that, we would have to train the workforce to use these new practices and deploy them properly and effectively.

2.2 Site Monitoring

As we know, one crucial aspect of managing a construction project is the control of the project and its monitoring. There should be good coordination and communication between the teams working on this project so they can observe how it is going, at which phase they are according to the base schedule, to know if deadlines are being met or not, and costs are being accurately calculated and the project is going in a timely and precise manner[12]. The general contractor is primarily responsible for updating the A/E who further tells the owner. While on-site, the site engineer will conduct, at a minimum, the following reviews:

- Examine the construction site and determine its state of completion.
- Check for general agreement from the bank for proper interpretation of the General Contract.
- Workmanship and material quality will be examined
- construction financing agreement's provisions will be Checked for compliance
- Verify the accuracy of the contractor's invoice application.
- Identify and immediately report any changes and potential hazards.
- Note down the status of all site materials if necessary.
- Making sure that the construction schedule is being followed.
- Evaluate the availability of labor on the site.
- Double-check contract payments to be approved.

To check all these things, we need to set up a digitalized and more organized system, which will collect and store all data from the sites accurately and that point takes us to a cyber-physical system, which will help the construction industry in remote site monitoring[13]. Our manpower on site will be reduced, the communication gap will be no more as we are getting instant data from the site and construction can be fast-tracked and more optimized.

2.2.1 Traditional Methods

The construction industry is in its underdevelopment stages and it still uses the same conventional and customary methods for site monitoring i.e. a site engineer will inform the office staff which creates a large communication gap between team members[12][14]. This is a hectic process that results in project delays due to a communication gap and that's exactly the reason to develop a cyber-physical system[15]. While standard project progress tracking has the following mechanism as shown below;

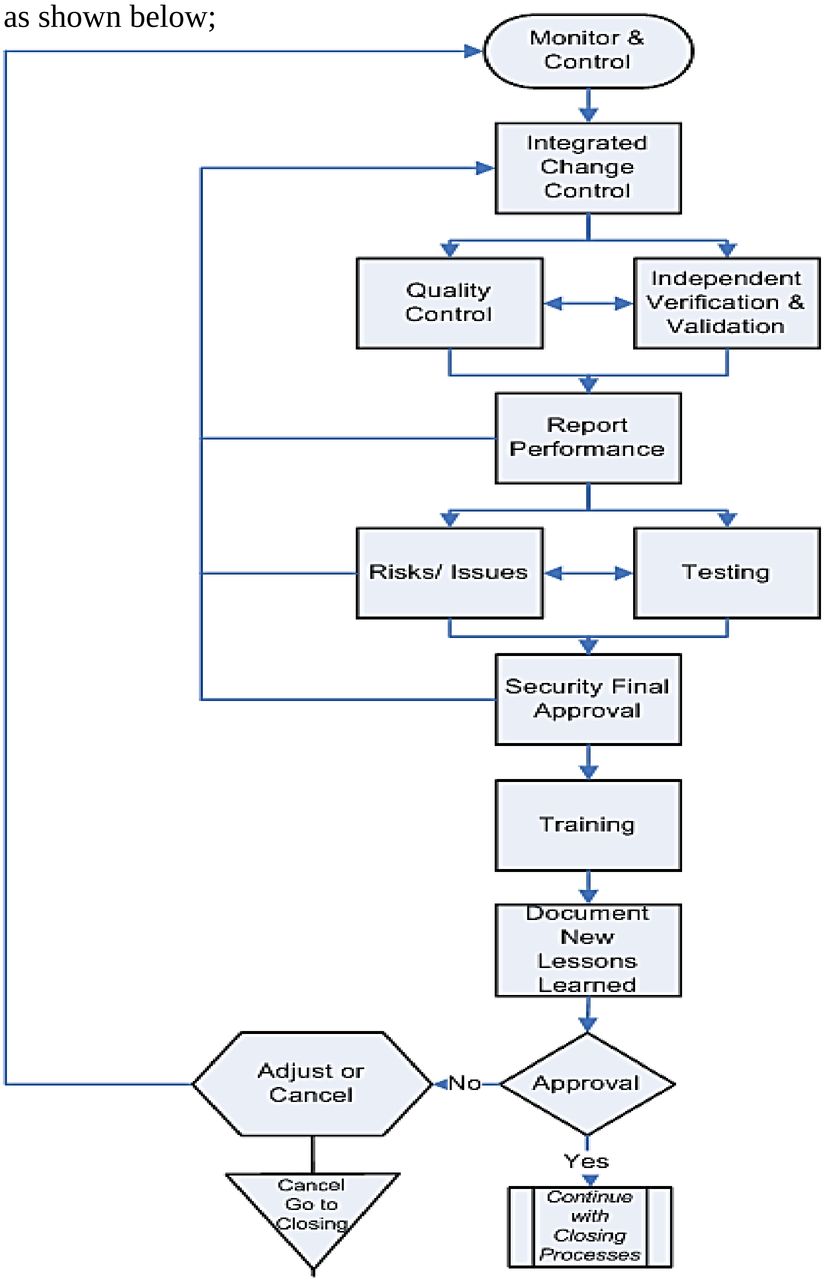

Figure 1: The traditional method for progress monitoring of the project.

The progress reports are revised on a regular basis and printed from month to month in most cases. Then, on the basis of these reports, project progress is calculated which determines if the project is on track or not as shown in

Figure 1 above. As we can see this process takes a long time, it needs to be improved by an automated process. These reports include images that demonstrate the completion of achievements. This conventional construction management system offers numerous reports to a project manager, including progress monitoring, received value management, and resource management[16]. Instead of executing and making timely decisions to complete the task within the assigned time frame, the project manager spends the majority of his time developing and reviewing these reports, which results in delays, extra time, and more staff members for manual work.

2.3 Cyber-physical systems

Cyber-physical systems, also known as the next generation of engineering systems, are automated systems that help in viewing the operations of the field digitally on the computer screen with the help of different types of viewing instruments i.e. cameras, drones, sensors, etc. [17]. Embedded computers with networks in these systems use sensors and actuators to track and automate physical processes. The manual process of site monitoring is automated in this system[18].

The cyber-physical system to be developed is generally made up of a control unit, usually one or more microcontrollers, that controls and processes the data obtained from the sensors and actuators required to interact with the real world[19][20]. A communication interface is also needed for these embedded systems to share data with other embedded systems or the cloud[21]. The most important aspect of a CPS is data sharing since data can be connected and analyzed centrally, for example. A CPS, to put it simply, is an embedded platform that can send and receive data over a network[22].

2.3.1 Adaptations in other fields

The cyber-physical system has been already implemented in many fields as it revolutionizes the industry and fulfills its monitoring needs[23][24]. The ***Table 1*** that follows provides more information on the CPS applications[25][26].

Table 1: Cyber-physical system usage in different fields.

Type of Domain	Scale/Functionality
Smart Manufacturing	It has been implemented up to medium level for goods manufacturing, optimization of productivity, and shipping services.
Emergency Response	It has been implemented up to a medium-large level for the safety of valuable buildings and nature.
Air Transportation	It has been implemented up to a large level for the management of aircraft systems.
Critical Infrastructure	It has been implemented up to a large level for gas, electricity, and water supply.
Medical field	It has been implemented up to medium level for monitoring and diagnosis of patients.
Efficient transportation	It has been implemented up to a medium-large level for real-time traffic updates and its management.

Robotics	It has been implemented up to a small-medium level for different jobs and needed services.

2.3.2 adaptations in the construction industry

While several publications have been published and research has been conducted for using a cyber-physical system in civil jobs, it has only been applied to a limited degree[27][28][29]. Here are a few examples in **Table *2***, of systems that have already been implemented.

Table 2: Adaptions

automated systems	**Scale/Functionality**
Navon's Robot	It is used for the installation of tiles and progress monitoring through the use of camera recognition It is vulnerable to poor lighting and requires human intervention
Camera vision	It uses Photo Classification Algorithms to compare as-built structure with as planned structure from an installed camera on site. Suffers from Occlusions, Weather Interferences, and Luminosity Fluctuations

Drone image reconstruction	It uses Lidar Sensing and Photogrammetry to generate 3D BIM models from point cloud data for progress monitoring Suffers from Occlusions and requires immense computing power

The goal of the paper is to design a better cyber physical system for remote site monitoring and thus, for implementation in construction industry[30]–[33].

2.4 RFID

RFID is an acronym for radio frequency identification, which uses tags and sensors to record data through the radio waves which is then stored in a database and thus, forming a major supplement for developing a cyber-physical system keeping in mind its advantages over barcode tracking, which requires matching with an optical scanner, and camera technology, which has a limited view and may have an obstruction in view[34][35].

The basic principle of RFID systems is that tags are used to identify objects[36]. These tags have transponders that send out messages that can be read by RFID readers. Most RFID tags contain a unique identifier, which is detected by a reader with its specific SKU code. Moreover, these tags also have writeable memory, if we need to put some tags data to view this in our CPS. These tags can also be attached to moving objects as they will be used for labor movement detection in our system[35][37]–[40].

There are two major types of RFID tags having different ranges;

- Active tags have their own source of electricity, which could be a battery.
- Passive tags get power from the signals of the RFID reader.

Similarly, there are readers to detect these tags. Moreover, these RFID systems have the following challenges and applications other than their use in CPS, which are as follow;

2.4.1 Business application

- supply chain management[41], [42]
- security
- movement tracking

2.4.2 Challenges & issues in RFID

- privacy concerns
- security
- integration with legacy systems

RFID's provide a pivotal role in our cyber-physical system for the detection of labor movements, which will further help in digitizing the site monitoring process through a cyber-physical system for remote site monitoring[35][43].

2.5 BIM

Building information modeling is used for digital viewing of physical and functional specifications of a project which is already built or to be built. For our cyber-physical system, 4D BIM which includes a 3D model and schedule for building construction will be used which will be showing us the progress on our construction site digitally using the Revit model[9]. 4D model will indicate how much work has been done and will help in the project tracking using construction schedule which has been made for timely completion of our project[8].

When people work together on a project, it's necessary to record the project's basic characteristics to communicate them to the various parties involved. This reporting was traditionally done on paper or in documents[44]. BIM converts conventional paper-based construction tools into a virtual world, allowing for higher levels of performance, connectivity, and collaboration in comparison to the traditional method already in use and automating the whole process in the form of a CPS.

2.6 Equipment

The following Equipment was studied for use within the project are shown in **Figure 2** and **Figure 3**;

2.6.1 LR 6 Reader by Tag Master

Figure 2: LR-6 Reader.

The Technical Parameters of the LR-6 Reader are as follows

Operating Frequency	2.400-2.484 Ghz
Read Range	Upto 10 meters
Write Range	Upto 0.25 meters
Power Supply	10-30 VDC supply
Power Consumption	5 W
Controller	180 Mhz ARM902T CPU, Linux OS
Interfaces	RS232, RS485, Ethernet, Magstripe

The **Figure 2**, LR-6 reader is a tool which is optimized for traffic and fleet management systems. It come with a built in controller that allows for easy integration with other electronic devices. LR-6 reader is built around the standard Linux operating system and has an open development platform. It allows for integrators to develop new custom applications for the reader as per their requirement. The reader can be controlled either through an ethernet interface via an internet connection. The LR-6 Reader has a variable read range gated by the tag which it is paired up with. Due to its protective casing it is suitable for outdoor activities and purposes

2.6.2 Mark Tag Classic by Tag Master

Figure 3: Mark tag Classic.

The **Figure 3**, Mark Tag Classic is a passive RFID tag used for identification purposes. It was developed for use alongside the LR 6 Reader. The tag with its operating frequency of 2.45 Ghz is capable of being read from both sides. The tag possesses a unique 8-bit identification key which is verified through a 32-bit checksum. Once the lifetime of the tag comes to an end, it can be verified through the reader's interface.

CHAPTER 3

METHODOLOGY

3.1 Introduction

We aim to develop a system that assists project managers to obtain real-time information about the conditions of their site, increasing their capacity to make informed decisions and better manage projects. We seek to do this by automating data collection on-site through a cyber-physical system, a network of sensors sharing real-time information to a computer through the internet. With this data automation, we seek not only to reduce the time it takes to get information but also to remove errors that arise from traditional data gathering.

Within a construction schedule, each activity has a designated completion time and quantity of work associated with its completion. Activity duration is determined through the quantity of work to be executed and the labor working rates per hour. Thus if a quantity of work is known we are capable of translating them into labor hours required for the completion of a single activity. By computing how many labor hours have been spent on a particular activity we can track progress for a specified activity in the schedule.

We achieve this progress tracking by the geolocation tracking of laborers throughout the construction site. Whenever a laborer is near a scheduled construction activity zone that laborer is said to be assigned to work on that activity and contributing to its progress. By monitoring the virtual data and comparing it with actual site conditions we can abstract necessary information such as labor productivity as well relative progress of actual construction with the scheduled activities.

Below is the architecture of the system shown in **Figure 4**;

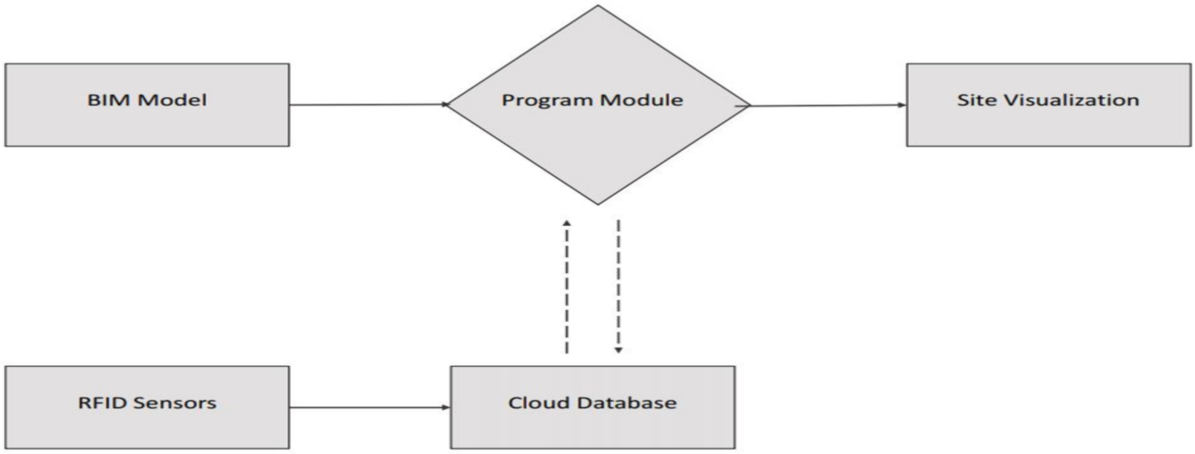

Figure 4: System Architecture.

The system is operated and interacted through a 2 D User Interface which allows the project manager to do the following

- Check site Conditions
- Evaluate Schedule
- Project Dashboard

Checking Site Conditions

Real time monitoring of the construction site is done through labour tracking activities and the culmination of progress from previous days. Each activity has a status state and has additional details stored within the project database for evaluation of project.

Scheduling

The software creates a schedule during initialization through a hierarchal algorithm which can then be manipulated and changed by the project manager depending on the project conditions.

Project Dashboard

Project metrics regarding cost, time and performance can be tracked on a dashboard by the project manager. This dashboard would allow the project manager to make informed decisions

3.1.1 System Workflow

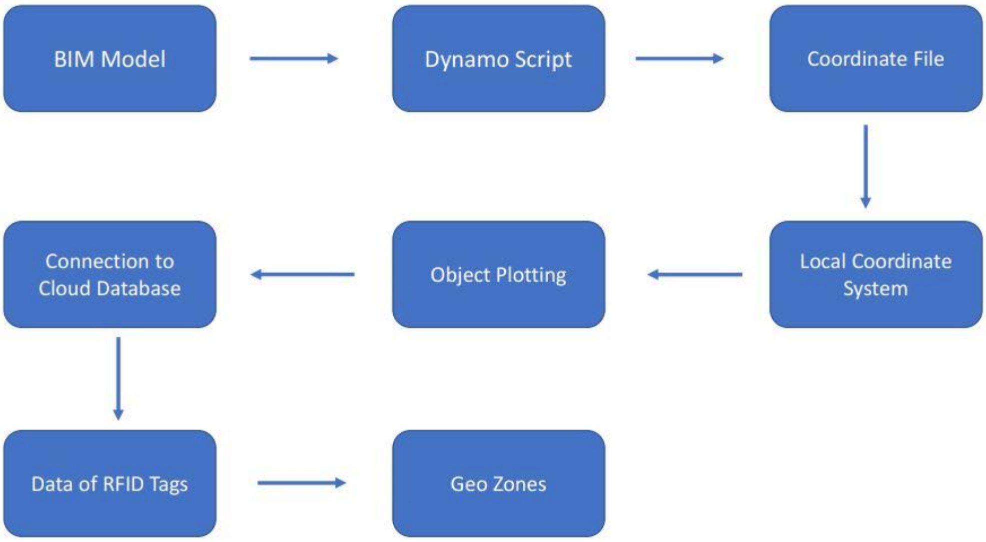

Figure 5: System Workflow.

The system workflow as shown in **Figure 5**, works by importing a database file extracted from a BIM model using a dynamo script. This file consists of site element coordinate data. Using this coordinate data the system will draw the site elements onto the computer screen. Then the system accesses the RFID database to create zones where the labor movement is detected. Each zone is bound by 4 unique RFID tags such that whenever a sensor detects those unique tags it is a part of that zone which is then seen on screen in real-time. As the sensor move throughout the site, the zone it is in changes and thus labor movement is tracked. Sensors are adjusted to note time whenever a new signature is detected thus time spent by a sensor in a zone is noted which is then used to measure progress in each zone.

3.2 Technological Components:

3.2.1 BIM

A BIM model of the construction project has to be designed, containing the grey structural elements of the project. A dynamo script is then used to extract coordinate data and unique ID of the structural elements and the construction site from the BIM model onto a data file which is stored in the local computer database. This data file will be utilized for the project initialization by data parsing[44]–[47]. Once the data file is loaded it will create objects for each structural element. Below is **Table *3***, which shows a list of structural elements and the information which is stored for each element into the data file.

Table 3: information extracted from BIM model.

Object	**Information Stored**
Column	Column Height Z, Column Radius R, Column Center
Beam	8 Coordinate points
Slab	8 Coordinate Points

In a 2D user interface there is an overlap between objects having same dimensions which cannot be interacted with each other. In order to differentiate between various objects they are separated from each other on the basis of their Z coordinate with objects having lower Z coordinates being plotted before.

Each object has certain parameters which are calculated using the following formulas

3.2.1.1 Volume

The volume of a structural object is calculated by the product between its height, breadth and length.

$$\textbf{Volume Formula} = (\Delta Y * \Delta X * \Delta Z) \qquad (3.2.1.1)$$

The linear dimensions are calculated by subtracting the highest maximum of a particular dimension coordinate from the minimum. Below is **Table *4***, representing volume calculation coordinates.

Table 4: volume calculation coordinates.

Object	**Height**	**Length**	**Breadth**
Column	Height	Radius	Radius
Beam	ΔZ	ΔX or ΔY	ΔX or ΔY
Slab	ΔZ	ΔX	ΔY

3.2.1.2 Steel work

The quantity of steel for any object is calculated from its volume. The percentage of steel within reinforced concrete element is 3 percent according to ACI codes. Accounting for wastage and stirrup reinforcement the factor becomes 3.5 percent

$$\textbf{Steel work} = 7900 * (\textbf{Volume in cubic meter} * 0.035) \qquad (3.2.1.2)$$

3.2.1.3 Formwork

The quantity of formwork is calculated for each object based off the surface area for each face of that particular object. When surface area for each face is calculated then we can know, where we need to have formwork and then we can calculate the total amount of formwork. After the total amount of formwork is found, we can calculate the required cost for that specific amount of formwork. **Table *5*** shows the faces which are exposed for each object.

Table 5: formwork exposed sides.

Object	Front Face	Upper Face	Side Face
Column	2	0	2
Beam	2	1	2
Slab	2	1	2

The faces are calculated as follows

Front Face (Δ**Y** * Δ**Z**) **(3.2.1.2)(i)**

Upper Face (Δ**X** * Δ**Y**) **(3.2.1.2)(ii)**

Front Face (Δ**X** * Δ**Z**) **(3.2.1.2)(iii)**

3.2.1.4 Labor Hours

The labor hours for each activity are computed from dividing the specific quantity by for that object by its rate stored within the system. The working rates will vary from project to project depending upon the contractor and labor efficiency rates.

3.2.2 RFID Sensors

A system consisting of RFID Sensors is used for real time monitoring. What sets our system apart is that the RFID sensors are not placed in a static position rather they are attached to the tracking objects and connected to the internet using a wireless connection. RFID tags are installed onto site components and encoded with information initially during the site setup phase and then further installed over the course of a construction project as structural height increases. The tags used are passive tags of the ultra-high frequency range as they have a higher detection range with their compatible sensors. The tags being utilized for the study (Mark Tag Classic) has a read range of 5 meters. The specifications for tags and readers are provided in **Figure 6** and **Figure 7** . The reason for keeping the sensor mobile is due to the clutter on the construction site alongside the risk of constant damage, in comparison to tags which can be replaced relatively easily and cheaply.

3.2.2.1 Geo-fence

A geo-fence or a geo-zone is a boundary which is utilized when working with geographical coordinates each having its own unqiue. In our project we are utilizing this concept of geofence and creating bounded plane within which structural elements shall be assigned. This concept of geofences will be used to estimate labor locations as each sensor will be configured to show with these geofences[48].

Geofences are created by the combination of 4 unique tags within the site. The coordinates of the tags serve as point between which a geofence is created. Once the bound of the geofence are set each site element is assigned to the geofence. An object can lie in multiple geofences depending upon its coordinates.

3.2.2.2 Labor Tracking

Labor tracking is done utilizing sensors and geofence. The RFID sensors are programmed to read the signal of the nearest 4 tags whose unique id constitutes a geo-fence. When a sensor attached to a labourer reads the signal of the tags it is considered to be present within the geofenced area. When the labouer moves such that the signals of the tags which it is reading changes the sensor updates into the database into what geofence it currently is in now and the location of the labour is then plotted onto the screen within the new updated geofence.

3.2.2.3 Progress Tracking

When the sensor of a particular laborer detects a change in the geofence the time of change is recorded as well. Now when an activity is being conducted within a geofence and the laborer is currently present within a geofence, it is assumed that the laborer is working on the activity. Now when the laborer would move from the geofence into a new one the time shall be noted once again. With this the progress of work can be measured from the amount of time a labourer spends working on a specific activity. In case a laborer is working within a single geozone only its progress cannot be measured until it moves. In order to safeguard against this defect the sensor can be set to update readings every full hour for measuring work. This also accounts for broken sensors as the lack of hourly updates in the database would indicate something that is wrong.

3.3 Scheduling

Scheduling in the project is automated using an algorithm that chooses activities based on an if statement loop. The activities are assigned durations based of the calculated labor hours required for the completion of the project. Each activity revolves around a single structural element and all works required for its completion e.g. steel fixing, formwork concreting and curing for a concrete column, although each works is handled separately thus allowing greater control over project schedule.

3.3.1 *Activity Status*

Each structural object is assigned a state which switches from inactive to active. This state allows for the object to not be considered for measured progress of work for that activity until it is set to active. The activity status of the object is manipulated in two ways.

The first one is when the activity is due to start and all of its predecessors have been completed. If both of these conditions are true then the activity itself will be set to active and all measured work done within a geozone will start to contribute towards the given activity.

The other is through manual setting by the project manager. This option is provided in order to stop or delay certain activities or expedite them varying from project to project. In such a case the activity will only start again if the delay duration induced has been completed, an indefinite delay is not possible to provide.

3.3.2 *Scheduling logic*

The program selects activities to schedule based of the following criteria

Beam → Slab →Column

The structural elements are further broken down in to sub activities

Steel Fixing → Formwork → Concreting → Curing

The activities are bound by their logic and their precedence is given based of their Z coordinate with those having lower values being assigned start dates earlier. If multiple objects are present that can be started at a time such as multiple beams or columns then they will be scheduled to start on the same dates ignoring labour limitations. The project manager is capable of changing the activity start dates according to the project's status and the remaining scheduled successors will be updated accordingly. A Gannt Chart can be generated as well for assistance.

3.4 Project Management Dashboard

The project management dashboard contains information regarding the cost and time status of the project. The system extracts the project completion date from the scheduled activities and compares it with the current state of the project. Depending upon the speed of the works the project can be either over on or under schedule.

Cost of the project is calculated using activity durations, material quantity required for said work and labour hours which are required for activity completion. Once all the quantities are generated their cost are calculated according to the MSR system built into the system which can be manipulated as needed. From the quantities and rates the budgeted cost of work and the actual cost of work performed is calculated due to which the project can be either above below or on its cost schedule. S-Curves are generated by using day to day cost data from the cost of work performed within a day

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1Results

The research we have conducted so far has led us to formulate the result that the Construction Industry in Pakistan is decades behind the global standards. It is still heavily dependent on obsolete and traditional methods of site monitoring and other such construction activities. The utilization of artificial intelligence is almost negligible. A lot of crucial time is wasted communicating information between the stakeholders. A system that can automatically report missing laborers, activities lagging behind schedule, and keep track of resources concerning the scheduled construction activity can help reduce the time of the project considerably. While other industries in Pakistan are seeing a shift in this regard by utilizing artificial intelligence technologies to monitor the progress of the activities, Construction Industry needs to do the same. This will help speed up the construction process by streamlining different phases of construction. By monitoring different construction activities on a single screen, the project manager can conveniently tend to other matters. We believe that utilizing cyber-physical systems to monitor a site remotely can save lots of crucial resources, time being one of them. The quality of construction can also be improved.

4.2 Research Conclusions

Following are the conclusions based on researching numerous journals and articles.

1. The construction industry in Pakistan is still dependent on obsolete methods and practices. This leads to an astronomical wastage of time communicating both trivial and significant details among the stakeholders.

2. Real-time monitoring of the construction project will help the client better understand the construction activities and will acquaint them with the perspective of the contractor/engineer.
3. Lower literacy rates and widespread distrust of new technologies among the clients and contractors in Pakistan have led to the construction industry being overall reluctant to adopt artificial intelligence to better monitor and manage construction activities.
4. Reduced capital investments by both public and private stakeholders are one of the biggest obstructions to the application of cyber-physical systems as RFID technologies require a decent amount of initial investment.
5. Laborers spend a lot of time on site idle which can lead to reduced working efficiency and increase the time required for the activities to complete. By having a convenient way to monitor all labor on-site, this phenomenon can be tackled.
6. This system has been designed to alert in case of lagging activities and scheduling conflicts. This can drastically decrease the time consumed conveying information to the client and the contractors as they will be directly alerted about the conflicts in real-time.
7. The system is a theoretical model as extreme computer programing skills are required to form a practical version. Also keeping in view, the unavailability of RFID tags due to the lockdown, only a demonstration of how the system is supposed to function could be created.
8. This system can contribute a lot to the construction industry. Some of the benefits include efficient monitoring of the different activities, monitoring labor activity and movements, alerting in case of lagging activities and missing/misplaced labor, quantity survey and takeoff, and tracking the equipment.

Although Pakistan's construction industry is lagging behind in most aspects, there is still potential for immense change and growth. With the right amount of resources and management, we can revamp the quality standards of the construction practices and be able to challenge the international standards. With the scrutinized spending of the limited resources and adopting new technologies such as artificial intelligence and RFID-based cyber-physical monitoring systems, we can achieve wonders in a short span of time.

4.3 Recommendations

Keeping in view the conclusions drawn above, the following recommendations are made. These recommendations can help implement a cyber-physical system in the construction projects:

1. The construction industry is in dire need of a system that shifts the site monitoring to a virtual setup so that clients, contractors, and engineers can access the sites remotely. For that to happen, the parties involved need to be educated about the merits of such a cyber-physical system that is bound to make their everyday activities easier to perform.
2. The process of implementing such a cyber-physical is very time-consuming. The implementation might even seem to increase the initial budget allocated for the project because of the purchase of RFID tags but keeping in mind the numerous monitoring benefits and streamlined activities, the overall cost is projected to decrease as a result of fewer scheduling conflicts. Due to the numerous other benefits of this system, it is recommended to start implementing it on smaller scale construction activities as soon as possible.
3. Laborers should also be educated about the use and handling of RFID tags as their real-time location will be tracked using these tags.

In this fast-paced world, we should always be looking out for new ways to improve the framework of our activities[19]. Time is more important now than it has ever been. By implementing new ways to reduce the time required for our activities, we can indirectly save a lot of other resources which are tied to the consumption of time. We should commit more resources to research newer ways to improve the quality of construction activities. Artificial intelligence is a promising field. It has assisted many other fields like medical sciences, electronics, and mechanical engineering. It has a lot of potentials to transform the construction industry into the likes of its information age counterparts where a lot is available at a distance of a click on a screen. The complete process of transformation may be time-consuming at first but once the transition is complete, the fruits of our hard work will be evident and the industry will make unprecedented leaps in the years to come.

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LR-6 Reader

DATASHEET

The LR-6 is a 2.45 GHz RFID reader with a read-range of up to 10 metres

KEY FEATURES

- Read-range, up to 10 metres
- Robust and weatherproof design, IP66
- Integrated controller
- Ethernet, RS232, RS485 and Wiegand/Magstripe interfaces
- Bright LED indicator and buzzer
- Licence-free worldwide

The LR-6 Reader is optimised for Traffic and Access applications:

- Industrial AVI
- Fleet Management
- Traffic Management

High quality RFID reader

The TagMaster LR-6 Reader is optimised for vehicle access that requires hands-free long-range identification up to 10 metres. With it´s "all-in-one" design, including integrated antenna and controller unit, the LR-6 is certified for outdoor use and is easy to install and easy to use. The built-in controller makes it possible to integrate the LR-6 reader with other products like cameras, barriers, inductive loop detectors etc.

TagMaster´s LR-6 reader can also be used to add further value to a client´s business. For example, it can be linked to fuel pumps or weighing scales, where the weight and ID-tag data of the vehicle are transmitted to a central host. By weighing the vehicle before and after loading/unloading, the weight is automatically entered into the system. The information can then be used for invoicing, time stamps or waste control management.

The LR-6 is built around a standard Linux operating system and has an open development platform. This enables integrators to develop and implement new applications for the LR-6 Reader using the TagMaster Software Development Kit.

Supports several interfaces

The Reader can be configured and controlled via the Ethernet interface, either locally or remotely via an Internet connection. The LR-6 supports several standard interfaces including Ethernet (TCP/IP), RS232, RS485 and Wiegand, Magstripe.

Options for extended read range

If you need a longer read range, TagMaster also provides the LR-6XL in its product portfolio. The LR-6XL reads up to 14 metres and is an excellent choice for wide gates and access for heavy trucks which need an even longer read range for entry and exit lanes.

The read range also depends on type of ID-tag, for more information see the table at page 2, Technical information.

PART NO. INFORMATION

LR-6 Reader	154600
Universal Mounting Kit	193600
TagMaster SDK	174000

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06-094-17

TECHNICAL INFORMATION	
Operating frequency	CW: 2.435 to 2.465 GHz, FHSS: 2.400 to 2.484 GHz
Read range	Up to 10 metres* (33 ft)
Write range	Up to 0.25 metres (0.8 ft)
Dimensions	290 x 165 x 55 mm (11.4 x 5.2 x 2.2 inch)
Weight	1.0 kg (2.2 lbs)
Protection	IP66
Operating temperature	-40°C (-40°F) to +70°C (+158°F)
Housing	UL94 certified plastic XENOY™ housing and cover
Power supply	10–30 VDC supply
Power consumption	5 W (max 15 W)
Output power	10 mW e.i.r.p
Controller	180 MHz ARM902T CPU, 32MB RAM, 16MB Flash, Linux operating system
Interfaces	RS232, RS485, Wiegand/Magstripe, Ethernet (TCP/IP)
Certificates	CE Certificate according to R&TTE-Directive 1999/5/EC, FCC M39LRXX
Manuals and documentation	LR-series Installation Manual, LR-series Datasheet, GEN4 Reader User´s Manual

* Reading range depends on type of ID-tag and reader settings

TYPE OF ID-TAG	READING RANGE IN METRES AND (FT)
MarkTag Classic	6 (20)
MarkTag MeM	10 (33)
MarkTag Outdoor	6 (20)

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Due to TagMaster's continuous effort to develop the products in response to customer needs, the above specifications are subject to change. 06-094-17

Figure 6: Technical Specifications of LR-6 Reader.

MarkTag Classic

DATASHEET

The MarkTag Classic is the high-end choice for long-range in parking and access control

KEY FEATURES

- Highly reliable long-range tag
- Can be read in any orientation
- Licence-free worldwide

The MarkTag Classic is a long-time proven high-end choice for vehicle identification within parking and access control. Easy to use, highly reliable, can be read from both sides, and is licence-free worldwide as it is using the 2.45GHz frequency band. The tag is placed behind the windshield using an easily installed WinFix.

The tag has a pre-programmed 8-digit unique identity code. A 32-bit checksum ensures a correct reading.

The tag emits no radio signals, it only reflects a modulated response to a reader request. As the tag electronics are always powered up and the power consumption is constant, the tag lifetime is fully predictable +6 years independently of the number of reads. As battery levels are getting low, the tag generates a battery low alarm to the reader, which can then inform the host systems.

PART NO. INFORMATION	DESCRIPTION
125500, MarkTag Classic	Tag for use with LR-6
195100, Winfix	Holder for MarkTag Classic

www.tagmaster.com sales@tagmaster.com

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04-020-05

Figure 7: Technical Specifications of MarkTag Classic.