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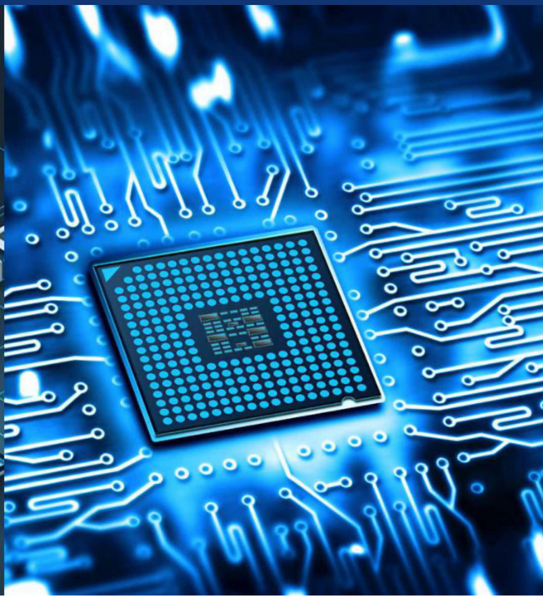


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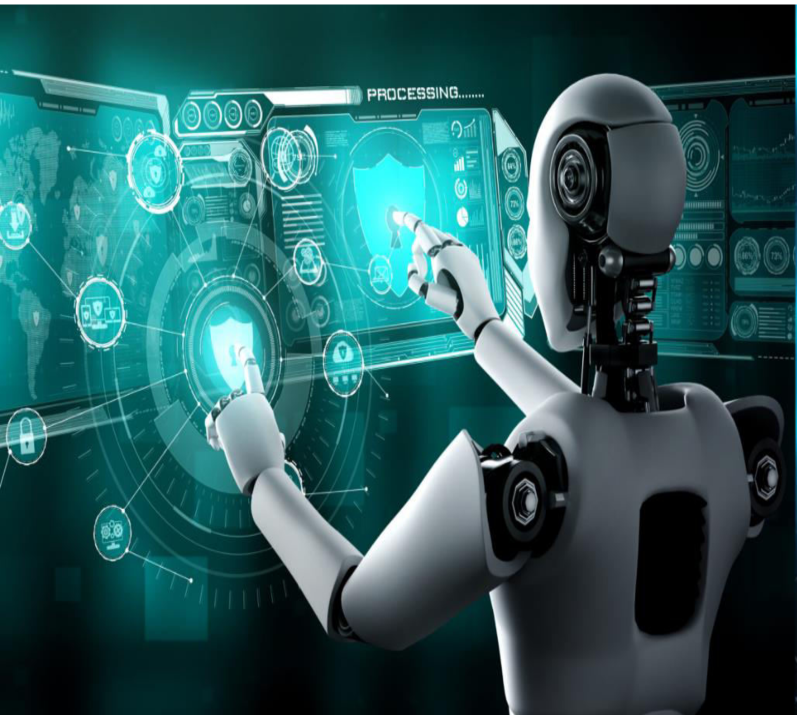

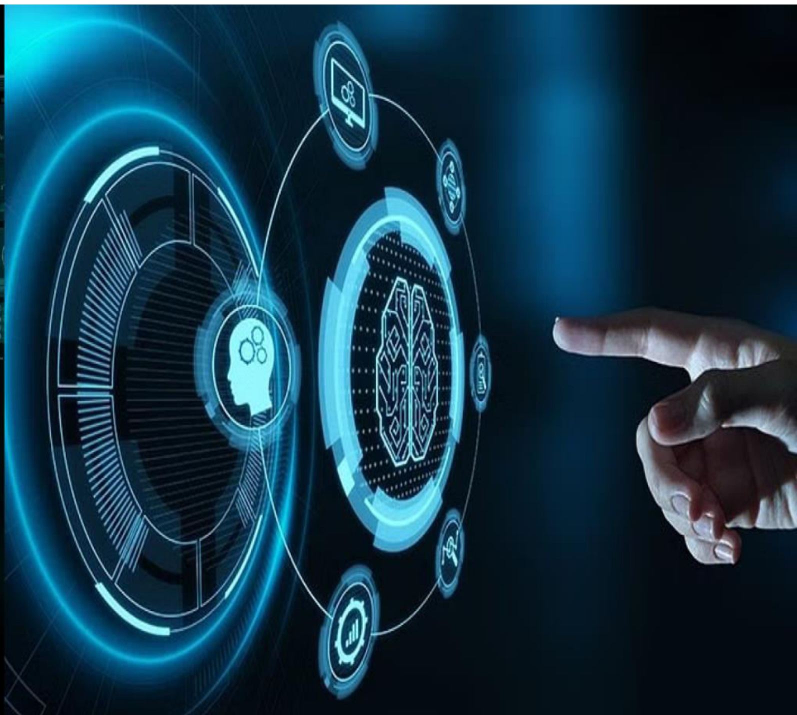

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Daily Update on Construction Site Progress

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ABSTRACT: This study offers a thorough method for automating the tracking of building progress through the use of computer vision and image processing tools. The device can precisely identify and measure a variety of objects, including doors, windows, cracks, plastered walls, and floors, by examining photos taken from building sites. The system offers useful insights into building progress, including spotting any problems and keeping track of the project's overall timetable, by combining picture preprocessing, feature extraction, and object identification algorithms. Effective decision-making is made possible by the system's user-friendly interface and modular architecture, which allow it to be tailored to different building sites. To improve the system's accuracy and resilience in difficult lighting situations and intricate settings, more study is needed.

KEYWORDS: construction progress tracking, computer vision, image processing, object detection, crack detection, plastering analysis, door detection, window detection, floor counting, automation, construction management.

I. INTRODUCTION

For ages, the construction industry was noted with its rather poor adoption nature when it had to relate new technological inventions or introduce such advanced systems in building work The possibility is rather quite high about developing and transformation in the managerial practice within the building sector through digitization. However, this indicates that such an autonomous monitoring system regarding timely observation of every single activity along the projects related to building will have tremendous potential. This research is focused on the ambitious goal of establishing a comprehensive system dedicated to Construction Progress Tracking, often referred to as CPT. In this endeavour, various advanced techniques from the fields of machine learning and image processing are strategically applied to significantly enhance and automate the entire process of tracking construction progress. Historically, the conventional methods employed for monitoring construction projects have depended heavily on traditional techniques that necessitate direct observations at the site, along with the subjective judgments and interpretations made by individuals involved in the process. Companies in the construction industry point out ongoing work as the most time-consuming and problematic area for project managers to focus on.[17]

According to research, a great percentage of a construction project manager's working time is spent in the measurement, recording, and reporting of work carried out. Due to these high human dependencies, existing methods of monitoring are slow and often inaccurate, thus limiting the possibility of infrastructure managers monitoring project performance measures such as schedule and cost.[18] Quantifying the different construction activities involved in the building construction arena in days is the conventional measurement for time. In real-time or immediate terms, proper monitoring of performance can give a ready insight to the problems at construction site work. Therefore, monitoring progress of any construction project is of utmost importance. It is usually assumed that the reliability of progress data received and read by persons during the survey is very poor, therefore, over the last nearly five decades, so much research and even more extensive experiments have occurred targeted at automation for monitoring project progress. In the past few years, automation of the monitoring of advancement has almost exponentially increased with potential to enhance not only effectiveness but also accuracy.[19] Advanced progress monitoring methods should employ object/material recognition to obtain situational data. Photographic files can provide a reliable means of identifying kinds of materials that other tools could identify tools. In most companies, images they shoot are primarily used for, among other purposes, site watch to secure their premises; this observation has raised reality that even if the advanced technological tools like AI and MLs are not considered, using traditional image processing techniques is incredibly useful in a project that necessitates complex reasoning and informed decision making. It could be rather beneficial in allowing an increased amount of image data to be included in the construction and buildings sectors. This is due to the several techniques and example applications that are properly analysed and discussed in the course of the research.[20]

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The code we've worked on explains a systematic approach for crack identification in wall images by applying some of the Digital Image Processing methodologies enabled by OpenCV. The process starts with image acquisition; the actual image is converted to the grey scale, thus enabling easy computation as the information dimensionality reduces from three-dimensional RGB to a one-channel intensity dimension. A Gaussian blur filter is applied, to some extent reducing the noise effect, and making edge detection sharper by smoothing out the image through convolution with a Gaussian kernel. This will reduce minor fluctuations in pixel intensity that could be mistakenly detected as cracks. Following the noise reduction procedure, the Canny Edge Detection algorithm identifies the edges within the given image. This algorithm works by detecting areas with drastic changes in intensity that are often associated with the boundary or discontinuity that exist within the structure such as cracks in walls. These edges are then subjected to contour detection techniques that assist in identifying and isolating the closed or almost closed geometric shapes formed by the edges. The determined contours enable an approximation of the extent of cracking based on the area enclosed by these. The algorithm calculates the percentage of the total area of the contour in relation to the total area of the wall image to determine the level of damage. This percentage is taken as a measure of cracks with respect to the total surface area of the wall. [16]

Using a default threshold value of 1%, the wall can be classified as either cracked or uncracked. If the obtained percentage surpasses the threshold percentage, the wall is considered as cracked with the obtained percentage of cracks being recorded, otherwise it would be labelled as not cracked. It has employed some of the key computational techniques for noise filtering (Gaussian blur), edge detection (Canny algorithm), and geometric analysis (contour area calculation) to integrate and provide a robust mechanism of structural integrity assessment. It can be used as a basis for further research on automated structural damage assessment, especially in large infrastructure that is prone to human errors and is labour intensive when checked manually. Contour detection, a geometric analysis technique, extracts closed shapes from the edge-detected image. The application of Polygon Approximation refines these shapes further, such that rectangles are identified and these rectangles can be said to represent windows and doors. The code further consists of a minimum area threshold that will remove noise and negligible small contours, and therefore is robust in various conditions of imaging. Through this incorporation, the system develops a framework for object detection, which could be used for far-reaching applications, including counting of objects, structural analysis, and quality inspection in architectural and construction sites. This study shows practical implementation of computer vision to the automation of tasks that have all been carried out based on human judgment.

II. LITERATURE SURVEY

The potential of deep learning and computer vision to automate building progress monitoring has been investigated recently. Systems that use image analysis techniques to track daily updates on building site progress have been proposed in a number of studies. These systems use a variety of deep learning methods, including object identification, semantic segmentation, and picture localization, to examine on-site photos and extract useful data. These systems can enhance the construction industry's efficiency, accuracy, and decision-making by automating the process of tracking construction progress. [9]

The study articles use a range of cutting-edge methods to provide automated building progress tracking. These techniques include object detection models like YOLOv8 and deep learning algorithms for image processing like convolutional neural networks (CNNs). Researchers use cloud-edge computing architectures and portable data acquisition devices to collect data from construction sites for effective data processing and analysis. [7] Additionally, methods such as semantic segmentation, point cloud creation, and picture localization are used to extract useful information from images. By integrating these techniques, researchers hope to precisely monitor the status of construction, spot any problems, and give project managers insightful information. [5] Researchers frequently use systematic literature review techniques to find pertinent research and classify important ideas, instruments, and technology. This makes it easier to guarantee a thorough and objective analysis of the body of current literature. [10]

Computer vision algorithms can automate progress tracking in building tasks like wall erection, floor completion, and window installation. They can also detect potential quality issues by analyzing photos and videos of building sites. Real-time monitoring is possible through cameras and sensors that send data to a central system, enabling prompt intervention and decision-making. Computer vision can also be used to identify safety risks, such as hazardous working

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conditions or unapproved workers. Additionally, productivity analysis can be performed by evaluating employee and equipment productivity, identifying bottlenecks, and optimizing resource allocation. [3]
A method of monitoring building sites that makes use of deep learning and image processing techniques. This system provides quality inspection, prediction capabilities, and automated building progress detection. The technology creates real-time reports and offers insightful information to increase construction productivity by evaluating on-site photos. This creative solution efficiently monitors and inspects building sites by utilizing cutting-edge deep learning algorithms and a modular system design.[1]

A computer vision-based system intended to track the status of construction in real time. The system takes pictures of building sites with portable data gathering devices, then uses cloud-edge collaborative computing to process the photos. The technology can monitor building progress, spot any problems, and give project managers regular updates by analyzing these photos. This creative method might greatly increase construction project management's accuracy and efficiency. Future study in this field, including the investigation of cutting-edge technology to further improve the capabilities of construction progress monitoring systems, is made possible by the article.[2]

The Activity-Level Progress Monitoring System (ALPMS), a method for tracking building progress. ALPMS analyzes photos of construction sites using deep learning-based semantic segmentation and 3D Building Information Models (BIM). ALPMS provides a fine-grained degree of progress monitoring by precisely estimating the completion percentage of each activity by classifying photos into distinct activity types. Among the many benefits of this system are its capacity to automate the mapping of project schedule activities, forecast completion dates, and produce timely updates. ALPMS's skills for site analysis and documentation are further enhanced by its ability to generate as-built point clouds from photos of building sites.[3]

A framework for automatically utilizing unedered site photos to track the development of construction sites every day. The system makes it possible to detect building progress, even in circumstances of partial completion, by fusing deep learning-based semantic segmentation with picture localization approaches. Because it delivers precise and timely insights into project progress, this method is a useful tool for construction managers. The results of the study show how computer vision techniques may be used to improve quality control and efficiency on building sites.[4]

Use of the YOLOv8 object detection model for building site surveillance. The technology can automatically recognize and monitor construction elements by analyzing real-time photos, making progress tracking precise and efficient. Compared to conventional manual inspection techniques, this approach has a number of benefits, such as increased cost-effectiveness, efficiency, and dependability. Extending the training dataset to encompass a range of building situations and carrying out thorough real-world testing to evaluate the model's performance in realistic environments are two potential avenues for future study.[5]

Structure for automated tracking and management of building progress. The technology makes it possible to track and evaluate building site operations in real time by combining computer vision techniques with Internet of Things devices. By automating the data collecting, processing, and decision-making processes, the suggested solution overcomes the drawbacks of conventional manual monitoring techniques. The multimodal data-driven method makes it possible to analyze construction progress more accurately and reliably, which enables prompt interventions and modifications to resource allocation and project timetables. By offering a reliable and scalable method for tracking and managing building projects, this research advances automated construction management systems.[6]

A method for monitoring building sites that makes use of computer vision and deep learning techniques. The suggested system efficiently analyzes on-site photos to identify construction activities, personnel, equipment, and supplies by utilizing a Convolutional Neural Network (CNN) and Single Shot Detection (SSD). Through the provision of real-time insights on project progress, safety, and quality, this automatic picture analysis greatly improves the efficiency of construction management. The study shows how deep learning may transform the way that construction sites are monitored.[7]

Offers an automated approach for tracking building progress that combines Building Information Modeling (BIM) and computer vision technology. The system can correctly identify items like tools, supplies, and structural components in photos of building sites by using a Convolutional Neural Network (CNN) model. Furthermore, accurate positioning

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data is provided via the integration of Geographic Information Positioning Systems (GIPS), allowing for real-time tracking of building progress. Enhanced accuracy, efficiency, and data-driven decision-making are just a few benefits of this automated method. This technology has the ability to transform construction project management and expedite the whole construction process by overcoming the drawbacks of conventional manual monitoring techniques.[8]

Presents a cutting-edge method for employing computer vision to track worker activities on building sites. The suggested approach tracks individual workers in real-time by utilizing the capabilities of Multi-Domain Convolutional Neural Networks (MD-CNN). The system can evaluate worker productivity, spot any safety risks, and track the overall status of construction by examining video footage. With an average F-measure of 67 and an average distance error of 7.64 pixels, the authors present encouraging findings. Future research should examine the possibilities of automatic worker identification and the recognition of risky activities, even if this study makes a substantial addition to the area.[9]

Offers a novel method for automated building progress tracking. The suggested system can efficiently track daily updates on building site development by utilizing machine learning and image processing techniques. When compared to human approaches, this automation greatly increases accuracy and efficiency. The study demonstrates how machine learning may be used to analyze construction photos, pinpoint important details, and gauge advancement. To further maximize the system's performance, future research paths will focus on improving machine learning models' accuracy and incorporating more sophisticated image processing methods.[10]

Provide a computer vision-based method for automating the tracking of building progress. Their technology records daily updates by analyzing photos of building sites, which increases accuracy and efficiency over human approaches. The study presents a thorough framework for CV-CPM that takes into account four stages of progress tracking. In order to classify ideas, tools, and algorithms and find pertinent research, the authors also carried out a systematic literature review utilizing the PRISMA framework. Improving the precision of monitoring methods and using cutting-edge machine learning algorithms for more complex analysis are two potential avenues for future study.[11]

When taken as a whole, the research articles show notable improvements in automated building progress monitoring. They provide cutting-edge methods that efficiently monitor building progress, spot quality problems, and offer real-time insights by utilizing computer vision and deep learning algorithms. It has been demonstrated that these systems can precisely identify construction-related items, calculate completion rates, and track employee productivity. These technologies increase productivity, lower human error, and facilitate data-driven decision-making by automating these processes. The study also emphasizes how these technologies might fill in the gaps in current progress tracking techniques and offer useful data for project management and improvement.

Table 01: Existing systems, Study of Methodologies, Implementations

Sl.No	Papers	Methods Used	Results	Applications
1.	Construction of Interactive Construction Progress and Quality Monitoring System Based on Image Processing	Advanced deep learning algorithms for image processing. Modular system architecture for monitoring and inspection.	Effective monitoring of construction site progress achieved. Real-time reports and improvement suggestions provided to users.	Automatic recognition and progress prediction of construction images. Quality inspection and real-time monitoring reports generation.
2.	Design of Computer Vision-Based Construction Progress Monitoring System	Portable data acquisition devices for monitoring Cloud-edge collaborative computing architecture for data processing	Proposed a computer vision-based construction progress monitoring system. Established groundwork for system development and validation.	Monitoring construction progress in real-time. Improving project management and budget control.
3.	Activity-level	Creates as-built point	ALPMS reports activity-wise	Activity-level progress

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	construction progress monitoring through semantic segmentation of 3D-informed orthographic images	clouds from construction site images. Applies deep learning-based semantic segmentation for progress reasoning.	completion percentages with <6% mean absolute error. Framework enhances progress tracking beyond binary status reporting.	monitoring in construction projects. Estimating completion percentages for project schedule updates.
4.	A Framework for Automated Daily Construction Progress Monitoring Leveraging Unordered Site Photographs	Image localization Deep learning-based semantic segmentation	Framework successfully detects daily progress Provides partial completion percentage	Automated daily construction progress monitoring framework. Detection of partial completion percentages in construction activities.
5.	Computer Vision for Construction Progress Monitoring: A Real-Time Object Detection Approach	Automated construction progress monitoring using object detection algorithms LeveragingYOLOv8's real-time capabilities and high accuracy	Significant improvement over existing methods Reliable, efficient, and cost-effective means for monitoring project progress	Automated construction progress monitoring using object detection. Monitoring window installation and other construction tasks.
6.	Automated Construction Progress Monitoring and Controlling Framework Based on Computer Vision and Internet of Things System	Automated construction progress monitoring using computer vision and IoT system. Multimodal data-driven approach for progress status identification, evaluation, and control.	Establishes automated construction progress monitoring and management method. Addresses gaps in progress management systems and methodologies.	Computer vision application framework for progress monitoring. Data collection and transmission using surveillance cameras and sensors.
7.	Applying Deep Learning and Single Shot Detection in Construction Site Image Recognition	Deep learning with convolution neural network (CNN) Single shot detection (SSD)	The paper proposes a construction activity image recognition system using deep learning. The system improves construction management efficiency by recognizing construction workers, machines, and materials.	Construction safety and job site configuration management. Progress control and quality management in construction.
8.	Automated Construction Progress Management Using Computer Vision-based CNN Model and BIM	Object recognition technology of CNN model Positional information by GIPS	Automated site monitoring method using CNN model Applicable to construction site management for precise data creation	Automated site monitoring using object recognition technology. Updating 4D BIM data with extracted site information.
9.	Computer Vision-Based Tracking of Workers in Construction Sites Based on MDNet	Multi-Domain Convolutional Neural Networks (MD-CNN) Online visual tracking	Average distance error: 7.64 pixels Average F-measure: 67	Productivity assessment and progress monitoring in construction. Unsafe behavior recognition for hazard prevention.
10.	Automated progress	Machine learning	Improved progress monitoring	Automated progress

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	monitoring of construction projects using Machine learning and image processing approach	techniques for progress monitoring. Image processing for construction project analysis.	in construction projects. Utilizes Machine learning and image processing for automation.	monitoring of construction projects. Machine learning and image processing techniques applied.
11.	Computer vision-based construction progress monitoring	PRISMA framework for identifying relevant studies Categorization of concepts, tools, technologies, and algorithms	The paper develops an integrated process framework for Computer-Vision-Based Construction Progress Monitoring (CV-CPM). The paper discusses the four levels of progress monitoring and their influence on the framework.	Construction progress monitoring using computer vision techniques. Enhancing project management through visual data analysis.

III. METHODOLOGY

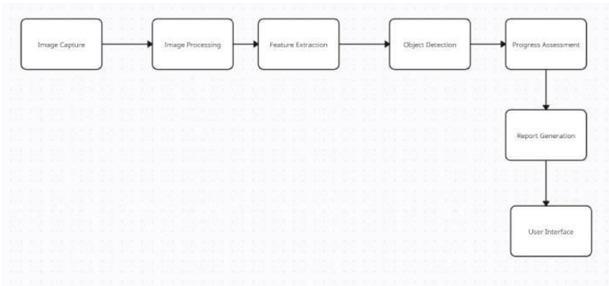

Fig.1 Methodology

A. Capturing Images
In order to accurately analyze data in well-lit areas, high-resolution photos must be taken utilizing mobile devices.

B. Image Preprocessing
Improving image quality for improved analysis is the aim of image preprocessing. This includes geometric correction, which corrects distortions from perspective or the camera lens, contrast improvement, color correction, and noise reduction, which eliminates unwanted noise. The goal of these techniques is to enhance the overall quality of the image.

C. Extraction of Features
Using edge detection, texture analysis, and color analysis, the objective is to extract features from an image. Color analysis recognizes certain regions, texture analysis looks for patterns inside areas, and edge detection finds the boundaries between objects and the background.

D. Identifying Objects:
Using techniques like door and window recognition, crack detection, plastering analysis, and floor counting, the goal is to pinpoint particular features in an image. Rectangular shapes with particular aspect ratios and texture patterns are identified by door detection; frames and glass-like shapes are identified by window detection; linear features with opposing intensity levels are identified by crack detection; and square or rectangular shapes with particular texture patterns are identified by floor counting.

E. Evaluation of Progress
The objective is to evaluate the building's condition by comparing current images with old documents, spotting changes from the original schedule, and tracking advancement by figuring out how much work has been finished.

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F. Creation of Reports

The goal is to create thorough reports that include quantitative measurements, qualitative observations, potential risks, and an overview of the analysis's findings.

G. User Interface

By offering tools for picture annotation and visualization, choices for exporting and making reports, and the ability to customize analytic setup settings, the system seeks to improve the user experience.

IV. RESULTS AND DISCUSSION

The developed system demonstrates the use of OpenCV and Pillow for automating the detection of cracks, bricks, doors, and plastered walls, contributing to efficient construction site monitoring [12]. Each functionality is tailored to address specific tasks, enabling project managers to assess progress and identify issues effectively.

The **crack detection algorithm** applies edge detection, contour analysis, and area calculations to determine the presence and extent of cracks [13]. Walls with small hairline cracks, below a defined threshold of 1%, are correctly identified as intact, while significantly cracked walls are flagged, with the percentage of cracked area calculated accurately. However, the system may struggle with faint or subtle cracks in images affected by noise or inconsistent lighting, necessitating fine-tuning of detection thresholds.

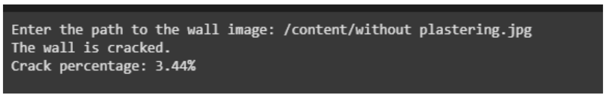

Fig.2 Detected: Crack Detection

For **brick detection**, the system uses contour approximation to identify rectangular shapes, successfully detecting bricks in unplastered walls [15]. Bounding boxes are drawn around detected bricks, providing clear visual feedback. While the system minimizes false positives, challenges arise in irregular masonry or when objects overlap, leading to reduced detection accuracy. This function is particularly useful for identifying unfinished or exposed wall sections, highlighting areas needing attention.

The **plastering analysis** evaluates whether walls are plastered by calculating the proportion of white pixels in an image. Walls with over 95% white pixels are classified as plastered, demonstrating reliable performance in differentiating between plastered and unplastered surfaces. However, factors such as overexposure or poor lighting can impact the accuracy of the analysis, particularly for partially plastered walls or walls with varied textures [14].

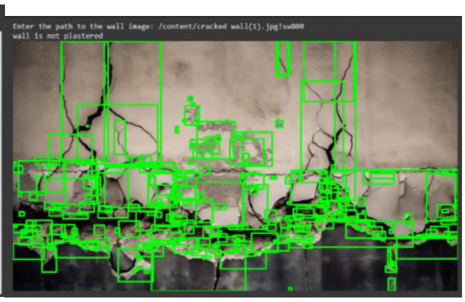

Fig.3 Detected: Plastered Wall. Fig.4 Detected: Wall is not Plastered.

In the case of **door detection**, rectangular contours are analyzed to identify potential doors, with bounding boxes drawn for visualization and the total number of detected doors displayed. The algorithm performs well in detecting doors in structured environments with sufficient lighting but faces challenges with partially visible doors or those made of reflective materials, such as glass [15]. Cluttered environments and shadows further reduce its performance.

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Fig.5 Detected: Number of Doors

A similar algorithm was extended to detect **windows detection** in construction images by identifying rectangular contours of appropriate proportions [14]. The system reliably detected windows in well-lit and uncluttered images, outlining them with bounding boxes for visualization. However, issues arose when detecting partially obstructed windows or those with reflective glass surfaces, leading to occasional false negatives. The window detection feature provides insights into the progress of window installations and their alignment, which is critical for maintaining construction timelines and ensuring quality.

Fig.6 Detected: Number of Windows.

This system's automation of repetitive tasks, such as crack detection and plastering analysis, offers significant advantages in construction site monitoring. Its modular design makes it adaptable to various sites, while the visual outputs—annotated images with bounding boxes and highlighted areas—provide actionable insights. However, the reliance on image quality and optimal lighting conditions, as well as occasional false positives or negatives, highlight the need for further refinement [15].

The floor detection system uses edge-based methods, like Canny Edge Detection and Hough Line Transform, to spot horizontal lines in images that indicate distinct floor levels. It performs well in organized environments where floor boundaries are clear, delivering reliable results when the images are well-lit and free of obstructions. One of its key advantages is its ability to highlight prominent edges and detect horizontal patterns with adjustable settings, making it flexible for different situations. However, it struggles with blurry, noisy, or low-quality images where detecting lines becomes difficult. Challenges like furniture, shadows, or angled camera views can also make the process less accurate. These findings align with studies in construction monitoring, such as the work of Yadav and Jain (2021), which highlights the effectiveness of computer vision techniques like edge detection and Hough Transform in automating structural analysis tasks [15].

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V. CONCLUSION

The created system demonstrates how computer vision methods may be used to automate different parts of building site monitoring. Through the efficient detection of bricks, doors, plastered walls, and cracks, the technology provides project managers with important information that helps them make wise decisions and streamline building procedures. The efficiency and accuracy of site inspections are improved by the system's capacity to automate repetitive processes and offer visual feedback. However, elements like image quality, illumination, and the intricacy of the work site affect how well the system performs. Subtle fissures, uneven stonework, partially visible items, and reflecting surfaces are difficult to discern. To increase the system's accuracy and resilience in managing a variety of difficult situations, more study and development are required.

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