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Automating Quantity Takeoff Lists: A Comprehensive Survey and Methodology

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Abstract – *This paper surveys available technologies relevant to the project and then outlines the proposed automated methodology for generating quantity takeoff lists. This project proposes the development of an innovative system to automate the quantity takeoff list process in the construction industry. Currently reliant on manual methods using Excel or expensive software, our solution aims to streamline and enhance efficiency by leveraging advanced technology. The system will analyze 2D residential construction plans, automatically extracting precise measurements, and conducting computations to generate an accurate and detailed quantity takeoff list. By employing automation, this project seeks to significantly reduce time and resource expenditures traditionally associated with the quantity takeoff process, ultimately contributing to increased productivity and cost-effectiveness in the construction sector.*

Key Words: **Quantity Takeoff, Building Information Modelling, YOLO , Optical Character Recognition, Construction plans.**

1.INTRODUCTION

The construction industry, characterized by its complexity and diverse range of projects, relies heavily on accurate quantity takeoff lists for successful project management. The construction industry is renowned for its intricate and varied projects, necessitating precise quantity takeoff lists to effectively manage endeavors. These lists meticulously outline the materials, labor, and associated costs vital to project execution, serving as indispensable resources for estimation and budgeting. Traditionally, engineers have relied on manual methods to conduct this process, employing tools such as spreadsheets or dedicated software. However, this manual approach is inherently time-consuming, susceptible to errors, and can impede overall project efficiency.

The meticulous measurements and calculations required often consume significant time and resources, leaving room for human error and potentially impacting project timelines and budgets negatively. As a result, there is a growing imperative within the industry to explore automated solutions that streamline the quantity takeoff process, enhance accuracy, and optimize project management practices. By leveraging technology and automation, construction professionals can mitigate the drawbacks of manual quantity takeoff methods, leading to improved efficiency, accuracy, and ultimately, project success.

In the current scenario, engineers often utilize Excel or expensive software to perform the quantity takeoff process. This involves painstakingly analyzing 2D construction plans, manually measuring components, and inputting data into spreadsheets or software applications. While these tools can assist in generating accurate lists, the process remains resource-intensive and time-consuming, diverting engineering talent from more strategic and value-added tasks.

The manual nature of this process poses several challenges. Firstly, it is inherently time-consuming, as engineers need to dedicate significant hours to accurately measure and input data for each element within the plans. This not only delays the overall project timeline but also diverts engineering talent away from more strategic and value-added tasks, such as design optimization, project planning, or problem-solving. The repetitive nature of manual quantity takeoff tasks can lead to increased chances of errors, introducing inaccuracies that may cascade throughout the project life cycle.

Moreover, the reliance on expensive software tools for automated quantity takeoff can be a barrier for smaller firms or projects with limited budgets. The high costs associated with these software solutions may restrict their accessibility, potentially impeding the adoption of more efficient and advanced technologies in the industry.

Our project aims to revolutionize this process by introducing an automated system that leverages cutting-edge technology to extract measurements directly from 2D residential plans. By utilizing Optical Character Recognition, our strategy eliminates the need for manual measurements and computations. This innovation not only saves time but also enhances accuracy, reducing the likelihood of errors inherent in manual methods.

2. RELATED WORK

In our pursuit of enhancing quantity takeoff processes within the construction industry, we have engaged in an extensive review of relevant literature and research papers. Through this exploration, we have gained insights into various methodologies, techniques, and technologies proposed by scholars and practitioners to optimize and

automate quantity takeoff procedures. These research papers delve into a range of topics, including computer vision-based approaches for image analysis, and the integration of Building Information Modeling (BIM) systems with quantity takeoff tools. By synthesizing and analyzing these diverse perspectives, we aim to identify promising avenues for innovation and develop practical solutions that address the inherent challenges of manual quantity takeoff methods.

In this research paper,[1] the integration of artificial intelligence (AI) techniques has been proposed and explored with the primary goal of automating and quantifying elements within 2D construction plans. The focus is on leveraging Natural Language Processing (NLP) to perform textual analysis and extract relevant keywords from textual descriptions in the plans. This step facilitates the extraction of critical information necessary for the automation process.

The use of NLP in conjunction with text mining allows the system to understand and interpret textual information embedded in construction plans. By identifying key terms and concepts, the AI system can extract meaningful data, contributing to the overall goal of automating the measurement and quantification processes.

Additionally, the research paper incorporates Image Processing (IP) and Machine Learning (ML) techniques to enhance the automation process further. Image processing is employed to identify similar spaces within the 2D drawings, contributing to the spatial understanding of the construction plans. Machine learning algorithms are then applied to calculate both the count and area of these identified spaces. This integrated approach aims to provide a comprehensive solution to automate the measurement and quantification processes, addressing the complexities associated with diverse construction plans.

Furthermore, the paper explores the key features of a quantity takeoff software, underscoring the importance of integrating various AI techniques for a robust solution. The researchers present a case study involving a 3000 square foot building with 30 pages of construction plans. In this scenario, an Expert System (ES) is integrated into the methodology to estimate costs. The utilization of an ES adds another layer of intelligence to the system, allowing it to make informed decisions based on predefined rules and knowledge.

This paper [2], in addition to addressing the challenges posed by the diverse set of objects within complex floor plans, the research paper delved into the technical aspects of the chosen neural network architecture – Cascade Mask R-CNN. This sophisticated model has proven to be highly effective in the realm of object detection and segmentation tasks, particularly in the context of intricate floor plans with various architectural and furnishing elements.

Cascade Mask R-CNN operates through a series of stages, progressively refining the process of object detection and segmentation. This cascade structure allows the model to iteratively improve the accuracy of its predictions, making it particularly well-suited for complex scenes with diverse structural components such as walls, windows, stairs, and furniture objects. By addressing these complexities in a step-wise manner, Cascade Mask R-CNN demonstrates a remarkable ability to capture the intricate details of floor plans, offering a robust solution for automating the analysis and understanding of such architectural drawings.

The comparative analysis presented in the study, pitting Cascade Mask R-CNN against Faster R-CNN, a widely used object detection model, adds significant weight to the findings. The research indicates that Cascade Mask R-CNN outperformed Faster R-CNN, showcasing superior accuracy and efficiency in identifying and segmenting objects within the challenging context of complex floor plans. This comparison highlights the specific strengths of Cascade Mask R-CNN, making a compelling case for its adoption in AI-based automation applications within the construction domain.

Furthermore, the study's conclusion not only underscores the superior performance of Cascade Mask R-CNN but also positions it as a potential cornerstone for future advancements in AI-driven automation for construction projects. The model's ability to handle intricate floor plans with diverse elements opens up possibilities for streamlining various tasks, from quantity takeoffs to spatial analysis.

[3]The research paper's focus on developing a stroke extraction algorithm tailored for handwritten mathematical expressions represents a significant contribution to the field of handwriting recognition, particularly in the context of transitioning from offline to online recognition methodologies. The utilization of the CROHME dataset spanning multiple years (2014, 2016, and 2019) adds depth to the study, showcasing the algorithm's adaptability to various datasets and handwriting styles.

The proposed model, composed of three integral stages – preprocessing, tracing, and post-processing, demonstrates a systematic and comprehensive approach to stroke extraction. The preprocessing phase likely involves tasks such as image enhancement, noise reduction, and feature extraction to prepare the handwritten mathematical expressions for subsequent analysis. The tracing stage, crucial to the algorithm's success, is likely responsible for accurately capturing and delineating individual strokes within the expressions. Finally, the post-processing stage may involve refining the extracted strokes and preparing them for further recognition or analysis.

The paper's [4] focus on the development of an Intelligent Marking and Assessment System (InMAS) using the YOLOv3 algorithm represents a pioneering effort in leveraging artificial intelligence for the efficient and accurate scoring of

student test papers and assignments. The design methodology proposed in the study aims to enhance the evaluation process by automating the identification and interpretation of arithmetic problems, a common element in student assessments.

The proposed InMAS system is outlined to operate in two main stages: localization and recognition. In the localization stage, the effectiveness of identifying marked regions on the test papers is evaluated using the Intersection over Union (IoU) standard. This metric ensures precise identification of relevant regions, showcasing the algorithm's proficiency in locating and isolating areas that require assessment. The subsequent recognition stage involves interpreting the marked content, and the evaluation employs Baidu OCR (Optical Character Recognition) to assess the system's ability to understand and extract information from the identified regions within student test papers.

[5] This paper offers a comprehensive review of extraction methods aimed at converting data from various types of documents into machine-readable formats, with a particular focus on Optical Character Recognition (OCR) technologies. The authors emphasize the increasing demand for quick search capabilities amidst the vast amounts of data generated daily across industries like Healthcare, Education, Banking, and Insurance. To address this need, the paper explores techniques such as OCR, data parsing and structuring, handwriting recognition, table extraction, and information retrieval, highlighting their significance in streamlining document processing workflows.

The discussion delves into the efficacy of OCR technology, which plays a pivotal role in efficiently processing and saving scanned documents. By analyzing scanned images, OCR software identifies characters and converts them into editable and searchable text, significantly reducing the time and effort previously required for manual data collection. Additionally, the paper examines data parsing and structuring techniques, which utilize natural language processing (NLP) and regular expressions to extract and organize information from unstructured documents such as emails, reports, and invoices.

Moreover, the review encompasses handwriting recognition methods, essential for converting handwritten content into machine-readable text, and table extraction techniques used to capture tabular data from documents accurately. Information retrieval methods are also discussed, enabling the extraction of specific data points based on user-defined queries or keywords. By offering insights into these extraction methods and their applications across diverse document types, the paper aims to advance OCR research, facilitating informed decision-making in selecting the most suitable techniques for various document processing tasks.

The paper [6] introduces a pioneering method aimed at extracting text from images, particularly handwritten text, through the intricate process of character segmentation and recognition. It underscores the complexity inherent in this task, attributable to variations in image capture conditions and the inherent uniqueness of each individual's handwriting. One of the critical challenges addressed in the study is the difficulty in accurately detecting and interpreting handwritten characters within images, a task far more nuanced than recognizing machine-generated text. To surmount these obstacles, the authors propose leveraging advanced technologies, with a particular emphasis on Convolutional Neural Networks (CNNs), renowned for their prowess in pattern recognition tasks.

Central to the proposed methodology is the integration of EasyOCR and Regular Expressions, foundational components that facilitate the extraction of text from images. EasyOCR stands out for its user-friendly interface and robust optical character recognition capabilities, making it an indispensable tool in the process. By harnessing the power of EasyOCR, the researchers aim to streamline the text extraction process, allowing for efficient identification and interpretation of handwritten characters. This integration signifies a significant advancement in the field of character recognition, enabling researchers to delve deeper into the complexities of handwritten text analysis.

This paper [7] explores how well EasyOCR can recognize Latin characters when images aren't perfect. They looked at things like how dark the characters are compared to the background, blurriness, and how big the characters are. EasyOCR did a good job at telling apart different lowercase and uppercase letters.

In the discussion, they talked about how EasyOCR did overall with recognizing Latin characters, and they found some interesting things. EasyOCR often thought similar-shaped characters were uppercase, even if they were lowercase. Sometimes, adding blurriness actually helped EasyOCR to recognize characters better. They found that EasyOCR struggled more when the characters were really small, which affected its accuracy. Even though EasyOCR had some limitations, it was still pretty good at telling apart characters with different shapes. They suggested that in the future, researchers could try different OCR models and ways to make EasyOCR work better for small characters.

In the conclusion, they highlighted EasyOCR's strengths in accurately detecting clear letters with confidence. EasyOCR demonstrated proficiency in distinguishing characters with distinct shapes, showcasing its robustness in recognizing well-defined text. Despite encountering challenges with similar-looking uppercase and lowercase letters, EasyOCR consistently showcased its capability to accurately identify characters within images. This reliability in recognizing clear letters underscores EasyOCR's effectiveness as a tool for character recognition tasks.

[8] In this paper, the authors present a comprehensive approach to license plate recognition. The system outlined comprises three primary components: Image retrieval, License plate identification, and Character interpretation. To begin with, data retrieval is facilitated using the OpenCV library within the PyTorch framework. Subsequently, license plate detection is achieved through the implementation of YOLOv5. Afterward, special computer programs called OCR, like Tesseract OCR and EasyOCR, are used to find and understand the letters and numbers on the identified license plates. Results indicate that EasyOCR demonstrates superior performance compared to Tesseract OCR, achieving over 95% accuracy in predicting number plates. This notable accuracy boost is attributed to EasyOCR's utilization.

In conclusion, the findings of this study underscore the effectiveness of EasyOCR as a preferred choice .Its deep learning-based approach not only yields higher accuracy rates but also ensures efficient real-time prediction capabilities, outperforming traditional OCR methods like Tesseract OCR. This suggests that EasyOCR is well-suited for deployment in various practical scenarios.

This paper [9] introduces a new method for extracting and recognizing text from images, with a special focus on license plates. They faced challenges in reading text from images due to factors like poor lighting and background noise. To address this, they used EasyOCR, a specialized tool, to pull out the text from the license plates. EasyOCR made it easier to read the characters and numbers on the license plates accurately. The study achieved impressive results, with EasyOCR playing a crucial role in accurately detecting and recognizing text from the images.

Furthermore, the paper highlights the effectiveness of EasyOCR in extracting text from license plates, achieving a high level of accuracy. The authors found that EasyOCR performed well in recognizing the characters and numbers, contributing significantly to the success of their method. They utilized EasyOCR's capabilities to enhance the accuracy of text extraction, enabling them to achieve satisfactory results in their detection and recognition tasks. In conclusion, the paper underscores EasyOCR's importance in text extraction from images. The study's success in accurately identifying and reading text from images is attributed to the utilization of EasyOCR, showcasing its effectiveness as a tool for text recognition tasks. Overall, EasyOCR emerges as a valuable asset in the field of computer vision.

3. PROPOSED METHODOLOGY

In contrast to the traditional quantity takeoff process, which often involves the use of Excel or costly software applications, our proposed idea aims to introduce a more streamlined and cost-effective solution. Our focus is on addressing the challenges posed by the time-consuming and resource-intensive nature of the current methods. To achieve this, we propose developing a model specifically tailored for 2D residential construction plans. By concentrating on residential plans initially, we aim to provide a targeted solution for a common sector in the construction industry.

The core innovation lies in the system's ability to automatically extract measurements from 2D residential construction plans. Instead of relying on manual measurements and data input, our model will utilize advanced algorithms trained with material cost data to perform accurate calculations of the required raw materials. This approach not only eliminates the need for expensive software but also significantly reduces the time engineers would spend on manual tasks.

Our proposed idea represents a shift towards automation and optimization in the construction industry's quantity takeoff process. By leveraging technology to handle the extraction of measurements and computation of material costs, we aim to empower engineers with a tool that enhances efficiency and reduce cost.

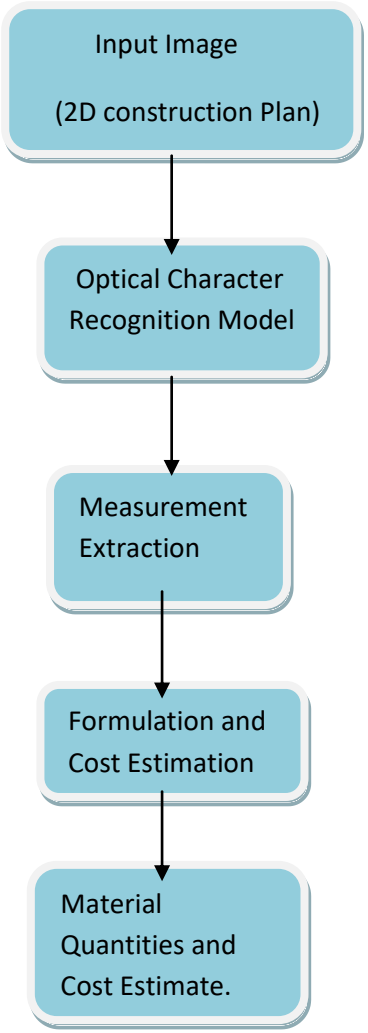

Fig:3.1 System work flow

Fig no. 3.1 shows the system work flow. Input Image : This block represents the initial stage of the automated quantity takeoff process, where a 2D construction plan image is provided as input to the system. This image serves as the foundational data source from which measurements will be extracted.

The OCR (Optical Character Recognition) model is a crucial component that processes the input image, identifying and extracting text data embedded within the plan. This block encompasses the algorithms and techniques used to recognize and interpret the textual content, including dimensions, annotations, and labels present in the construction plan.

Following the OCR process, the extracted text data undergoes further processing in the Measurement Extraction block. Here, specialized algorithms parse through the identified text to isolate and extract relevant measurements such as lengths, areas, and quantities associated with different elements depicted in the construction plan.

With the extracted measurements at hand, the Formulation and Cost Estimation block performs the crucial task of utilizing this data to formulate quantities of materials required for construction and estimate the associated costs. Seamlessly integrating the hard-coded formulas, the system will automatically compute the quantities of raw materials required for construction. The integration ensures that the calculations are accurate and align with industry-standard engineering practices. This block integrates mathematical formulas, and cost databases to generate accurate estimations based on the extracted measurements.

The final output of the automated quantity takeoff process is presented in the Material Quantities and Cost Estimate block. Here, the estimated quantities of materials, along with the corresponding costs, are compiled and presented. This output serves as valuable information for project planning, budgeting, and procurement decisions.

In the formulation and cost estimation process, various materials and items are considered to accurately compute the quantities required for construction. These materials typically include sand, cement, laterite stone, rubble, metal, and khadi, each playing a crucial role in different aspects of the construction process. Sand is often utilized for its versatility, serving as a key ingredient in concrete mixtures and plastering applications. Cement acts as the binding agent in concrete and mortar, providing structural strength and stability to the construction. Laterite stone, known for its durability and weather-resistant properties, is commonly used in foundation construction and building walls. Khadi, a coarse material made from crushed stone or gravel, is frequently employed as a base layer in concrete. In addition to materials, the estimation process considers various construction items critical for different components of the structure. These items include walls, foundation, plastering, plinth, slab concrete11 and floor concrete.

4. CONCLUSION

In conclusion, our project marks a significant advancement in streamlining the generation of quantity takeoff lists from 2D residential construction plans by integrating cutting-edge technology. Harnessing the power of Optical Character Recognition (OCR), we aim to revolutionize the traditional approach to quantity estimation in engineering. Through this endeavor, we seek to enhance the overall efficiency and accuracy of quantity takeoff processes, facilitating smoother project management and cost estimation in the construction industry. Moving forward, our focus shifts to the implementation phase, where we will translate our conceptual framework into a fully functional automated system. This next stage of development represents a crucial milestone in our project, as we strive to deliver a practical solution seamlessly integrating into existing engineering workflows. By utilizing OCR to extract measurements, we reaffirm our commitment to leveraging technology for the advancement of engineering practices.

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