



Automated Setout Robo

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Abstract —An essential part of any construction work, set out refers to the process of ensuring that components of a project are built to the correct tolerances to ensure structural integrity, exactness and quality. This often entails time-consuming work using measuring tapes, chalk lines and even total stations. However, using human or animal-powered methods for set out in the construction industry is unreliable, as even the smallest margins of error are exacerbated by repetition, leading to potential rework and even project delays. In this study, an Internet of Things (IoT)-based Automated Setout Robot (ASR) was fabricated to alleviate tedious, unreliable set out work processes and to improve the precision, reliability and productivity of on-site layout work. The IoT-based ASR uses an ESP32 mainboard equipped with communication functions such as Wi-Fi, Bluetooth, and GPS to obtain the set out points from the cloud, and, subsequently, works the pre-defined path to facilitate autonomous working. By adopting odometry and a path-planning algorithm for control, the ASR helps to ensure the ASR to ensure accuracy and reliability throughout the process. Based on the concept of enhancing on-site construction productivity by employing automation technologies in line with the smart construction framework of Industry 4.0, a working ASR was developed and tested under simulated set out working conditions. The experimental testing proved that the ASR was able to improve the work accuracy and reliability and to shorten the time for on-site set out works, while compared with the current existing manual approach, the proposed ASR obviously achieves the advantages of the reduction of the amount of on-site work as well as increased productivity

Index Terms - autonomous mobile robot; construction site layout; IoT-enabled robotics; cloud-assisted control; embedded systems; motor control; smart construction; Industry 4.0.

I. INTRODUCTION

Out in the field, machines haven't taken over like they have on factory floors or car assembly lines. Instead of robots, people still stretch tape measures across dusty sites to mark where walls, doors, and posts go. Chalk snaps leave temporary lines- drawn by eye after reading complex blueprints. Skill matters here, since every footstep and judgment call shapes what comes next. Hours pile up while crews measure twice, then triple-check before cutting or building. Even a small slip at one corner can grow into bigger mismatches down the line. When reality doesn't match plans, something's got to give- time stretches out, budgets tighten, work halts. Mistakes mean tearing apart parts already built just to fix alignment drifts that crept in early. Facing tougher projects and fewer workers, builders now rely more on automated solutions. Not just stuck in factories anymore, mobile robots handle materials where people once did. Thanks to smarter sensors and live data links, machines today move through sites without constant human help. Tiny computers built into equipment make exact markings easier than older manual methods. Even routine jobs like measuring walls benefit from linked devices that share updates instantly. Out there among tools that mark building plans, one stands apart- Smart ASR, a small machine alive with sensors and motion. It runs on an ESP32 chip, the brain guiding its every move. Messages arrive by wireless link, carrying exact positions needed on site. Once it gets them, wheels turn, guided by motors, taking it where it must go. At

the right spot, a marker drops down, driven by a servo arm, leaving a clear sign behind. Most parts cost very little, keeping everything within reach financially. Built tough but simply, it works without constant watching. Mistakes shrink when hands stay out of the process. Speed picks up too, since it moves fast yet stays precise. Fewer workers need to stand and measure all day. Each task flows smoother than before.

II. EXISTING ROBOTIC SYSTEMS FOR CONSTRUCTION SITE LAYOUT DRAWINGS

Some studies looked into robots doing jobs like marking lines and placing objects on building sites. Early versions often relied on precise tools- laser scanners, full survey setups, or camera-based detection- to position things accurately. Even though they worked well indoors or in labs, real-world adoption slowed because prices stayed high, installation took too much effort, and day-to-day use brought challenges. Out in the open on building zones, a few self-moving machines lean on outside help- think overhead cameras or lasers fixed to walls just to know where they stand. Around ten millimeters is how close these setups get when drawing lines, yet each one needs careful setup work ahead of time. Their reach stretches only so far, boxed in by where the gear can see. Swapping single tools for clusters of detectors sometimes boosts sharpness further down the scale. Shifting parts by hand pops up again and again though, tagging along with high-end measurement kits that cost too much for average job sizes. New research shows factories and storage areas now use internet-connected robots. These machines rely on built-in control units alongside Wi Fi or Bluetooth signals. Still, similar smart bots are rarely seen drawing outlines at building sites. A gap exists where affordable, self-driving robots could step in. Such devices would mark plans on construction grounds with less need for people nearby. Precision matters too but does not require perfection. One idea floats: a simple robot that connects online and works mostly alone. It must trace blueprints fast without constant oversight. Accuracy should stay within usable limits though extreme detail isn't critical. Machines like this might change how crews prepare plots. Fewer errors may occur when automated tools handle repetitive lines. The core challenge involves cost versus performance balance. Builders want reliable marks without high expenses. Current methods still depend heavily on manual labor. That slows progress and raises risks of mistakes. An alternative path appears through basic robotics linked wirelessly. They do not need advanced features just steady function. Marking tasks repeat often so consistency counts more than speed. Human workers then shift to supervising instead of measuring every spot. This reduces physical strain across long shifts. Technology already supports pieces of this vision. What holds it back is integration into real-world settings. Some worry about durability under dusty outdoor conditions. Others question if maintenance will become complex. Yet simpler designs avoid those traps by focusing only on essential jobs. The goal stays clear- help teams lay out structures quicker. Not replace them entirely. Just make routine steps smoother with subtle support.

III. METHODOLOGY

One way to start is by picturing a machine that reads building plans and draws marks exactly where needed. Instead of people stretching tape measures across floors, this device moves on its own, guided by numbers from a blueprint. Communication happens through invisible signals sent between devices nearby. A small computer brain inside handles decisions about direction and distance. It uses motors to roll into position then leaves precise lines behind. Workers often make small mistakes when marking spots manually, especially over long shifts. This setup skips those issues because it follows data without guessing. Another point: laying out walls or columns becomes faster since no one waits for measurements to be checked twice. Errors drop when machines repeat tasks perfectly each time. Speed increases too- movements happen steadily without breaks. What stands out most is how real world points match digital designs closely. There's less rework later because initial marks were correct. Tools like string lines still exist but now have company. Accuracy ties directly to fewer delays down the road. A series of distinct phases makes up the full process. Right away, a machine setup takes shape by pulling spatial details from an offsite source via radio signals, then sorting that information with an ESP32 chip. Following that, movement across set points begins- directions flow into the system, guiding motion step by step using calculated adjustments. Near the end, marks appear on the flooring as a pen, moved by a small motor, traces lines exactly where needed.

HARDWARE COMPONENTS

The system uses several hardware components to achieve accurate movement, control, and marking operations.

3.1 ESP32 Microcontroller

From inside the robot, the ESP32 runs everything. Through Wi-Fi, it pulls in position details then feeds them into its decision code. Once sorted, those numbers turn into movement commands sent straight to wheels and moving arms. Speed adjustments come next, handled by timed electrical pulses shaped just right. Communication stays open at all times, linking machines like phones or laptops without wires.

3.2 Motor Driver (L298N)

Now here comes the L298N chip- it links the ESP32 brain to those spinning wheels. Power needs of motors go way beyond what tiny controller pins deliver, so this module steps up, boosting signal strength while feeding enough juice. Movement goes both ways, forward or back, thanks to its switching logic. Speed tweaks happen through rapid pulses sent by the board, shaping how fast each spin turns. Separate channels mean different motors move on their own rhythm, making robot travel steady and balanced. That quiet coordination keeps everything rolling without hiccups.

3.3 Locomotion System

Four DC gear motors link to wheels, creating a movable base for the robot. These motors deliver enough power to keep motion steady, despite added weight like batteries or tools that mark surfaces. Movement follows set paths tied to building plans, guided by adjustments in speed and rotation. Direction changes happen through signals sent via the motor controller, shaping how the machine travels across space.

3.4 Marking Mechanism

Down at the tip of things, a pen gets pressed by motion from inside. From digital plans, real marks appear where needed. As the machine arrives at certain spots, the arm drops slowly- then back up it goes. Controlled by precise motor steps, the holder dips just enough to leave a trace. Between each point, the inkmaker pulls away, readying for what comes next. Lines form where walls will stand, columns take place, references stay fixed- all because one small part knows when to touch.

3.5 Power Supply

A small battery gives energy to the tiny computer, the motor controller, because it needs steady flow. Voltage stays balanced so parts do not get damaged while running. Parts work smoothly since electricity moves without spikes thanks to design.

IV. SYSTEM OPERATION

The Setout Robot works by following a routine of specific actions to undertake tasks in a highly automated fashion step by step. The purpose of this piece of kit is to lay out corridors and zones by automatically generating control lines on the surface of the floor or wall from the blue prints which are a digital format that represents a structure in 2-D and/or 3-D that obviates the need to have to do field measurements which can result in errors. The robot achieves this integration of work by utilizing radio connectivity, microcontrollers and the motions of its wheels to make the linking of information contained within construction blueprints and the ground surface (as a working surface) result in adequate reference points for alignment from the surface of the ground to a prescribed level of accuracy. The main function of this system is the reception of digital plans. The digital plans contain coordinate information of all objects like walls, columns and more. They are no longer needed as paper drawings because with this system the digital plans can be received via wireless transmission. The ESP32 in the robot can capture the data. It has the Wi-Fi functions built in. This can be used to receive the data in the digital plans easily and reliably(Fig 1). After the ESP32 receives the coordinates, it will compute the routes and paths to follow in order to get to all points. The decisions are made internally to the ESP32, and it will choose the best path for the most accurate navigation to the points that have to be reached. The guidance system enables the robot to navigate across the site surface, whether on horizontal planes (floors) or on vertical planes (walls, etc.). The robot does not stop between the different tasks, rather they are interlaced and performed in a continuous manner from start to finish. After the movement way has been defined, the ESP32 sends the command signals to the L298N motor driver module, and this module acts as a bridge between the microcontroller and the geared DC motors. After the signal processing, the L298N motor driver module provides the required voltage and current, as well as the direction of the motors, so that the robot can move forward, backward or turn. The geared motors are used to ensure a stable movement on the uneven surfaces

of the site, by controlling the speed of the robot and providing the necessary torque. As the robot is moving towards the target coordinate, the robot system continuously checks its position. The position is only marked after the robot has verified that it is correctly positioned at the target coordinate. Once the robot has confirmed it is in the correct position, the system marks the correct position. A small mechanical arm with a pen or marker attached to the end tips will move down and touch the floor or paper surface creating a solid mark at the exact location that was targeted in the digital plan. When marking is complete, the arm retracts to rest position. With the marking task done, the robot at once moves on to the next point in its set-out. The cycle for each point in the set-out involves moving, placing, marking and retracting, before moving on to the next point.

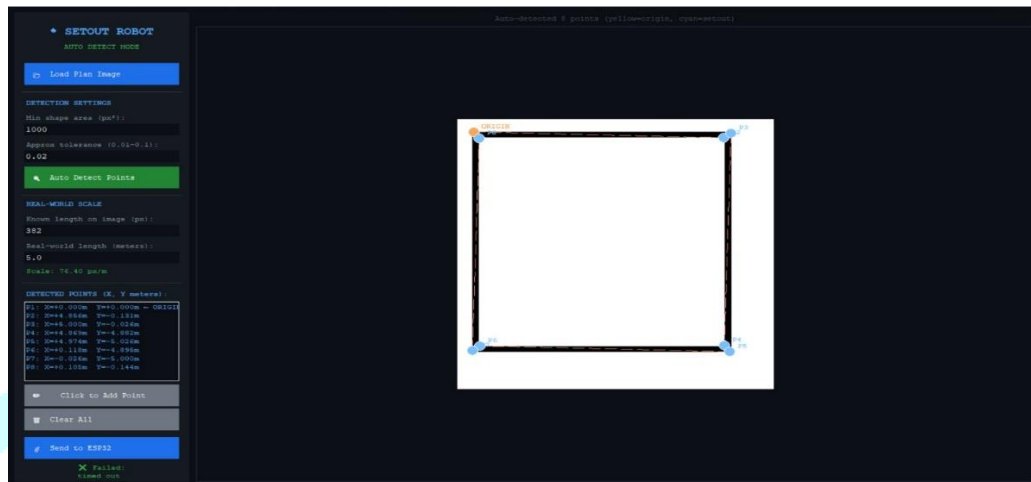


Fig. 1. Plan image processing and point detection for Setout Robo

With controlled and repeated action, the robot thus traces out in exact detail the area of the set-out and marks each designated point within it to an exactness determined by the width of the marking tool and to an accuracy and consistency defined by the details of the set-out. The robot is in continuous communication with the monitoring system or main hub. The system is receiving status updates such as completion of tasks, robot's position and status of the system components at regular time intervals. The site operations can be monitored remotely in real time and any potential problems can be identified quickly. The continuous wireless communication provides reliable communication links regardless of the movements at the site. The automated setout robot bridges the digital world of design and the physical world of construction. The digital lines and points on the screen are transferred to the site as physical reference points. The hundreds of individual coordinates are automatically translated from the digital model into the real world using sophisticated software and control systems. Work is carried out automatically, without the need for measurement and without the use of paper. In this way, the system significantly increases the efficiency, accuracy and productivity of the setout process. Hence, digital design, wireless communication and automation in the construction process are brought together in a modern way

V. RESULT

One foot forward, then another- the machine follows blueprints by drawing lines right where they belong. Signals travel through air, passing data like whispers between parts. Decisions form inside its core, quiet and unseen. Rather than hands guiding it, sensors keep track of every inch along concrete or plaster. When location checks out, the tool leaves its mark without waiting. No gaps sit between steps; each part flows into what comes next. Start to end stays steady, never skipping, never slowing. Away from offices, screens show exact spots where things must sit. As soon as layout lines appear, machines mark each place on the ground. Signals fly without wires right into a tiny computer mind. The ESP32 grabs what it needs by tuning into invisible network pulses. Once digits travel through space, printed drawings fade out of view. Locked positions appear as the machine hits precise spots. Fast signals connect digital plans to exact points on the ground. Lines once flat on screens turn into clear marks across the floor. Step by step, numbers from the model settle into real corners of space. A constant wireless thread ties desk work to concrete progress. Each update moves without delay from blueprint to base. From the moment it receives information, calculations begin inside the ESP32 to decide movement direction. Following those results, commands travel toward the L298N component. Motion comes alive as electric

pulses reach the compact gear-driven motors, urging wheels forward along the surface. When position is confirmed, a slender mechanical limb extends, guiding a writing tip into contact with the sheet below. After hitting that spot, the arm lifts slowly back to where it began. Since there is no force applied anymore, the frame tilts slightly toward a new position, repeating the same steps without change. Every now and then, the robot checks in with the central station, sharing bits about its progress or condition. Heading forward, it visits each point on the layout in sequence, marking them off along the way.

VI. CONCLUSION

A fresh take on construction tools shows how a small machine places marks exactly where needed. Running on an ESP32 brain, it moves using geared motors powered by a driver board. Wireless signals travel through IoT links, guiding each shift across floors or walls. Instead of hands, a rotating arm lowers a pen at precise spots- no guesswork involved. Digital plans turn into real-world dots without delays. Movement flows smoothly thanks to synced motor control. Accuracy rises when code meets concrete surfaces. Marks appear only where calculations allow. This build skips traditional methods entirely. From start to finish, old-school site marking leans on people power and simple gear- slow going, often off by a few inches. Wireless signals feed position data into the robot, guiding it forward as it moves itself into place for precise marks without human touch. Trials showed solid results: the machine handled signal transfers, route planning, and drawing lines within expected tolerances. One step at a time, a working model shows how affordable robots might fit into building work, especially on modest job sites. Alongside basic functions, future versions could add tools like motion trackers, tilt detectors, or light scanners- maybe even camera guidance and digital blueprint routing- to move better through messy real-world spaces. From start to finish, this self-guided layout machine points toward a shift: machines and connected tech slowly reshaping how structures rise, making them less risky, sharper, faster- all without flash or promise.

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