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Amalgamation of smart AIoT based construction site monitoring with robotics: viAct's extended horizon

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Abstract
The paper presents research insights on amalgamation AIoT and Robotic technology for construction site monitoring. For this purpose the paper studies the special case of viAct's smart cloud controlled robotic system *with embedded camera that enables real time capturing of images, detecting various safety non-compliances by workers for maintaining a safe construction ecosystem. Furthermore, the automatic wheel base carries LiDar that can detect the objects in the form of point clouds generating a as-is model which is compared with the as-planned BIM model. This helps in regular day to day progress tracking of the real time scenario helping contractors and owners to have human prejudice free inspection of their construction sites. viAct's smart robotic system working in a collaborative robot background, is thus a value addition to the viAct's existing monitoring solution based on AIoT, making the entire monitoring more accurate, optimal and error free.*
Keywords: *AIoT, viAct, Robotics, LiDar, Construction monitoring, BIM, Productivity monitoring, Collaborative Robot Background*

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I. Introduction

The construction industry is growing its horizon with monitoring automation and robotics technologies. The working knowledge of electronics, mechanical and computer software has been used to operate robotic systems in construction job-sites in a collaborative robot background (Feng et al.,2015). This helps in improving the construction job-site for improving safety and productivity related concerns thereby improving quality of the construction workplace (Nguyen & Choi, 2018). The earlier research depicts there is very low inclusion of automation in the construction industry. This has been often linked to critical and dynamic working conditions leading to slow adaptation of technological innovations in the construction job-sites. To fulfill this gap, the last decade has witnessed boom in research on construction automation integrating robotics for various purposes including designing, planning, monitoring safety and estimating productivity of construction project (Kim et al., 2013; Klein et al., 2012). Thereby it could be stated that the construction ecosystem is transforming from traditional construction to "Construction + Technology", formally called "ConTech" ecosystem. Robots are emerging as a crucial part of this automatic ConTech ecosystem. Robots used for construction monitoring are electronically controlled systems using hydraulics making them suitable for working in large scale dynamic construction projects in a collaborative robot background. Automation in construction monitoring is redefined with machines and advanced technology with emerging of ConTech startups.

This chapter puts forward new a revolution in construction automations with amalgamation AI and robotics for fine tune accuracy in monitoring of construction project taking in consideration special case of viAct, Asia's leading ConTech startup. viAct is a startup from Hong Kong that provides "Scenario-based Vision Intelligence" solutions exclusively for construction industry all across Asia & Europe by successfully deploying around 30 sites. viAct's smart AI modules has been successfully providing extremely granular insights on safety prepositions, productivity forethoughts and environmental compliances in jobsites by not only tracking objects but by transforming vision to practical actions. Thus, the case study presented in this paper fulfills all the requisites for stating viAct as one of its own kind in proving holistic scenario based solution providers leveraging the power of AIoT and robotics. The chapter depicts the principal, working and applications of an autonomous wheel based robotic system controlled via. cloud that carries camera, LiDar and a digital display to automatically collect data using the existing (as-planned) BIM model by navigating through the dynamic construction site, collecting and processing data by detecting various workforce related safety non-compliances, daily productivity checks and therefore producing real time reports. In the former case, any safety negligence is instantly alerted to the concerned authority. However in the later case, detecting the progress a progress (as-built) model is generated which can be compared to the as-planned model in order to generate an error free progress report with minimum human interference and prejudice.

II. AI & Robotics in construction monitoring: viAct's special case

2.1 Principle & Working

Robotic system used by viAct is designed taking in consideration the locomotive aspect. It is designed to carry camera, Lidar and a digital display. As construction job-site is a dynamic environment, the robots used for construction job-site monitoring is designed with outdoor all-terrain wheels. The wheel based locomotive robot is effective systems as it can efficiently move through rough and dynamic terrains of construction job-site detecting various complex scenarios in the construction site. The robotic system is precise than onsite mounted job-site cameras in scenarios which are difficult to be captured by the later ones. Thus the robotic system is more approachable than conventional construction monitoring methods, providing a holistic watch on every nook and corner of the job-site. Thus, terrain locomotion system with wheels is used in viAct for achieving optimum navigation with high levels of control and precision, without hampering freedom of movement in the site as well as allowing reduction of human prejudice and biasness. This in-turn is indicative of a collaborative robot environment for efficient monitoring. Apart from this actuators, are used to facilitate a fully autonomous behavior in the wheel based robots. As the robotic systems need to interact with the environment in terms of removing obstacles, opening doors or accessing elevators. An actuator produces motion via conversion of energy and signals passing into the system. Thus, for making a robotic system efficient to work along with human in a collaborative robot background, actuators are used for a fully autonomous behavior.

Furthermore, as the robot needs to collect colored visual information, structural geometry data of the building, surface reflectance information, therefore various sensors like 3D Laser scanner. Thus, 3D Laser Scanner is another important functional component of the robotic technology. In terms of technical aspect, the 3D laser scanning uses a laser beam for capturing features of objects in multiple directions within and around a structure (Patil et al., 2017; Shrestha & Jeong, 2017). The captured data points are aggregated into a "point cloud" and assigned *X*, *Y*, and *Z* coordinates which are then digitally saved. These cloud points are then used for describing the spatial relationships between objects, providing a full characteristic depiction of the receiving entities (Bueno et al., 2018). Its principal is based on measuring reflected pulses from the object's surface by sensors when a high speed rotating laser beam is subjected to objects (Ibrahim et al., 2019). The relative location of the object to the scanner and the resolution angle is used to measure the resolution or the distance (mm) between aforementioned points (Reboli et al., 2017). Apart from this, shape of the objects can also be determined the point cloud data. Thus, 3D laser scanning is used for speedy collection of spatial data for improving resolution of detection and minimizing unwanted data noise. Once the point cloud has been created in a 3D spatial form, the data is exported for constructing complex geometric BIM models.

Another key aspect of viAct's autonomous wheel based localization system is that it uses BIM model of the building in conjunction with LiDARs for mapping precise and real-time position of the robot. BIM which is a design document consisting of digital files or data (Bosche et al., 2015; Lagüela et al., 2013). It uses various tools and technologies to generate digital representation of physical and functional characteristics of places containing close relationships with each other in terms of space, size, quantity, and material of each structure. In order to support progress measurements, project management, and project control; BIM's information is exchanged and associated online together through the software. Thus, by amalgamation of various building and construction related information such as plans, financial budgets, and construction progress, it helps in creating a virtual reality model of the building for optimal monitoring of the construction site by the robotic system for an enhanced operational management. Thus, applying 3D laser scanning technology with a BIM model, an exact volume schedule can be approved at each point of various construction phases or stages in order to accurately determine the quantity of work done.

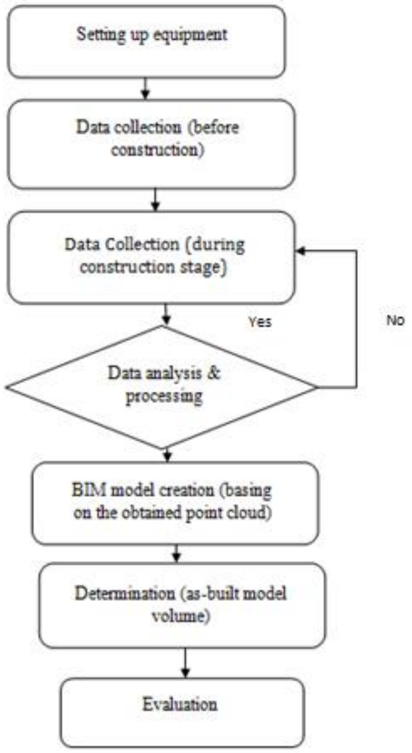

Figure 1: BIM-3D laser scanning process

2.2 Application of viAct's robotic system
viAct's wheel based robotic system is an add-on to the existing application of viAct's smart monitoring system (Fig 2).

Figure 2: Application of viAct's robotic system

1.2.1 Worker PPE Detection

Workers working in viAct's collaborative robot environment are safer than traditional construction sites. In addition to providing holistic monitoring through existing cameras, viAct's robotic system is a new companion in the construction job-site that can help in detecting and monitoring PPE compliances in job-site. The robotic system is fed with the scenario based intelligence of viAct which is controlled and operated through viAct's smart cloud in order to provide holistic, error-free monitoring of helmets, masks, PPE kits etc. In case of any non-compliance detection, instant alert is sent to site managers and remote authorities for instant actions.

1.2.2 360° Photo Capturing

A large part of project monitoring involves documentation. Manual documentation involves capturing pictures of the jobsite for the purpose of record keeping. However when a project site is too large and dynamic, accuracy of manual documentation through manual capturing is an error prone task. In this respect, viAct's smart robotic system has been designed to automatically capture 360° pictures of the jobsite. These pictures don't just help in record keeping but also helps owners to keep a track of their ongoing projects with real time images captured by the robotic system and stored in the cloud.

1.2.3 Progress Tracking through BIM

BIM along with 3D laser scanning is another advanced feature of the robotics system viAct. The 3D laser scanner installed in the robotic system helps to capture cloud data points. This helps in comparing every day progress of the construction site with the as-planned BIM model. Such accurate progress tracking helps contractors to keep a strict watch on progress. At the same time as the progress reports are updated on viAct's cloud system real time progress reports can also been accessed by the property owners for having a transparent workflow between contractors and workers.

III. Conclusion

The paper presents research insights on amalgamation AIoT and Robotic technology for construction site monitoring. For this purpose the paper studies the special case of viAct's smart cloud controlled robotic system with embedded camera that enables real time capture of images, detecting various safety non-compliances by workers for maintaining a safe construction ecosystem. Furthermore, the automatic wheel base carries LiDar that can detect the object in the form of point clouds generating a as-is model which is compared with the as-planned BIM model. This helps in regular day to day progress tracking of the real time scenario helping contractors and owners to have human prejudice free inspection of the construction site. viAct's smart robotic system working in a collaborative robot background, is thus a value addition to the existing monitoring solution based on AIoT, making the entire monitoring further accurate, optimal and error free.

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