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Technological Intervention to Improve Tower Crane Safety through the Development of Anti-Collision Devices

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Abstract*: The rise of extensive construction initiatives has led to an increased utilization of tower cranes, which are vital for managing materials at considerable elevations. Nevertheless, as the density of cranes in close quarters escalates, collisions have become a critical safety issue. This manuscript delineates the conceptualization and execution of an anti-collision apparatus for tower cranes, with an emphasis on facilitating secure operations within congested construction environments. The proposed framework employs sophisticated technologies, including GPS, sensors, and instantaneous data transmission, to oversee crane locations and issue collision alerts. Through the integration of real-time data analysis and automated control, the system contributes to preventing crane collisions, thereby safeguarding personnel and minimizing project interruptions*

Keywords: Tower cranes, Anti-collision device, Safety, GPS, Real-time monitoring, Construction

I. INTRODUCTION

Tower cranes represent essential components in the construction industry, particularly within metropolitan contexts where large buildings and structures shape the skyline. Nevertheless, the operation of numerous cranes in proximity heightens the likelihood of collisions, which could result in significant structural damage, injuries, or even loss of life. Traditional methodologies for crane operation depend on manual coordination, a process that is inherently susceptible to human error. To minimize severity of these hazards, there is a requirement for escalating demand for automated anti-collision systems.

This article examines the innovation of a sophisticated anti-collision apparatus aimed at augmenting the safety of crane operations. By integrating Global Positioning System (GPS) technology, advanced sensors, and instantaneous data communication, the apparatus can track the location and trajectory of multiple cranes, thereby executing precautionary measures in anticipation of potential collisions.

II. LITERATURE REVIEW

Developing an anti-collision device for tower cranes is crucial for enhancing safety on construction sites, particularly given the increasing reliance on these machines for heavy lifting. Numerous studies have proposed innovative solutions that integrate advanced technologies to mitigate collision risks effectively. The following sections outline key contributions from recent research in this area.

Anti-Collision Algorithms

- Zhang and Li developed an advanced collision monitoring algorithm that employs dynamic calibration of alarm zones surrounding obstacles, thereby augmenting the predictive efficacy of tower cranes through the application of trajectory prediction algorithms and Kalman filters (Zhang & Li, 2023).

- He et al.,2022, proposed an anti-collision system tailored specifically for contexts involving heavy lifting operations, overcoming the constraints of conventional systems by considering the hazardous areas associated with cylindrical heavy objects.

Object Detection and Sensor Integration

- Yong et al. developed a system combining deep learning-based object detection with ultrasonic distance measurement to prevent collisions during crane operations, effectively addressing blind spots and worker safety (Yong et al., 2023).
- Pei and Yin proposed a 3D deep learning model for active anti-collision warnings, enhancing real-time response capabilities in crane operations (Pei & Yin, 2024).

Hardware and Software Innovations

- Zuo et al. explored the integration of hardware-in-the-loop systems for robotized tower cranes, emphasizing the importance of real-time data processing for safety and efficiency (Zuo et al., 2024).
- While these advancements significantly improve safety measures, challenges remain in ensuring consistent performance across diverse construction environments and conditions.

III. METHODOLOGY

The anti-collision system designed for this study integrates three core components:

1. **Positioning System (GPS):** Each crane is equipped with a GPS module that provides real-time positional data, including the latitude, longitude, and height of the crane's boom. This information is continuously relayed to a central control system that monitors crane activity across the construction site.
2. **Sensor Network:** Proximity sensors are installed on critical points of each crane, such as the jib, counter-jib, and trolley. These sensors provide localized data regarding the distance between adjacent cranes or other structures, serving as a secondary safety mechanism.
3. **Real-Time Communication and Control:** A wireless communication network ensures continuous data transmission between cranes and the central control system. The control system processes incoming data using algorithms to detect potential collisions and automatically adjusts crane operations. This includes slowing down or halting the crane's movement to avoid collisions.

3.1 System Architecture

The system architecture consists of three key layers:

- **Sensing Layer:** Captures data from the GPS and sensors installed on each crane.
- **Processing Layer:** Uses data processing algorithms to predict potential collisions based on crane positions and movements.
- **Control Layer:** Implements safety measures such as visual and audio alarms, and automatic overrides to crane operation systems when necessary.

IV. RESULTS AND DISCUSSION

The proposed anti-collision system was assessed in a simulated environment replicating real-world construction site conditions with multiple tower cranes operating simultaneously. The simulation was designed to emulate common scenarios that lead to collisions, including the simultaneous operation of cranes in proximity, wind-induced swaying, and human errors.

4.1 Performance Metrics

Key performance metrics for evaluating the system included:

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- **Collision Prevention:** The system successfully identified and prevented all potential collisions in the simulated environment. This was achieved through early detection and timely intervention by the control system.
- **Response Time:** The average response time from the detection of a potential collision to the crane's movement adjustment was less than 3 seconds, indicating the system's capability to react swiftly in dynamic environments.
- **Crane Operators Feedback:** Crane operators participating in the trials reported that the system's alerts and automatic interventions enhanced their awareness and provided additional confidence in operating cranes in complex conditions.

4.2 System Benefits

The integration of the anti-collision system offers several key benefits, including:

- **Enhanced Safety:** Minimizing human errors and automating collision prevention, the system significantly reduces the risk of accidents.
- **Improved Efficiency:** Automation of crane movement control helps in maintaining a smooth workflow, reducing downtime caused by safety concerns or manual interventions.
- **Cost Reduction:** Fewer accidents translate to lower repair costs, less project downtime, and reduced insurance premiums for construction companies.

V. CHALLENGES AND FUTURE WORK

While the anti-collision apparatus exhibited commendable performance during simulation trials, the implementation in practical scenarios may yield unanticipated complications. A predominant obstacle lies in the dependency on Global Positioning System (GPS) technology, which is susceptible to signal attenuation in densely populated metropolitan regions or during inclement weather phenomena. Furthermore, the financial implications associated with the system may pose a significant impediment to smaller-scale construction initiatives.

Prospective research endeavors could prioritize the augmentation of the GPS system's resilience, integrating alternative localization technologies such as Light Detection and Ranging (LiDAR) or Ultra-Wideband (UWB) to achieve enhanced precision. Additionally, further empirical evaluations in authentic environmental contexts are imperative to substantiate the system's efficacy across various operational scenarios.

VI. CONCLUSION

The intervention of an anti-collision apparatus for tower cranes signifies a notable progression in the realm of safety at construction sites. Through the integration of Global Positioning System (GPS) technology, various sensors, and real-time data transmission, the system proficiently oversees the positioning of cranes and mitigates the risk of collisions instantaneously. This automated methodology not only bolsters the safety of crane operations but also enhances the overall efficacy and economic viability of construction endeavors. Prospective developments in positioning technologies, alongside further empirical testing in real-world scenarios, will be instrumental in refining the system and facilitating its extensive implementation.

REFERENCES

[1]. Dongfeng He, Jun-Tao He, Zhibin Li, Bo Huang, Hongliang Cheng, 2022, An anti-collision system for tower cranes considering lifting heavy objects.

[2]. Bingran Zuo, T. K. Ku, Wei Tech Ang, 2024, Robotised Tower Cranes with Hardware-in-The-Loop: Advancing Construction Safety and Efficiency

[3]. Ding Youliang, Ding Li,2022,Anti-collision early warning monitoring method for building construction group tower cranes.

[4]. Jae-Yeol Song, Yun Ho Ko,2022**,** Crane Collision Prevention Through the Use of Simultaneous Localization and Mapping (SLAM) Based on Feature Extraction

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[5]. Muhammad Redza Rosman, Muhammad Naim Mahyuddin, et.al., 2022, Increase Safety in High-Rise Building Construction with Innovation on Cranes.

[6]. Yang Zhang, Xinrong Li, 2023, Tower crane anti-collision algorithm design and simulation.

[7]. Yik Pong Yong, Seo Joon Lee et.al, 2023, Object Detection and Distance Measurement Algorithm for Collision Avoidance of Precast Concrete Installation during Crane Lifting Process.

[8]. P.C. Wong, Chin Pok Lam, et.al., 2023, Predictive Safety Monitoring for Lifting Operations with Vision-Based Crane-Worker Conflict Prediction.

[9]. Yu Ho Yeong, Kim Min Gyu et.al., 2021, Crane collision prevention apparatus and method.

[10]. Ding Youliang, Ding Li, 2021, Anti-collision early warning monitoring method for building construction group tower cranes