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# REVIEW ON ELECTRICAL TRANSMISSION LINE INSPECTION ROBOT

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**ABSTRACT**
Efficient inspection of Electrical Transmission Line (ETL) systems is vital for early fault detection and smooth power transmission. This paper reviews advancements in Electrical Transmission Line Inspection Robots (ETLIRs) from 2008 to 2019, focusing on climbing, flying, and hybrid robots. While climbing robots offer proximity for accurate data, challenges like landing and obstacle avoidance persist. Hybrid models merging climbing and flying capabilities show promise for overcoming these hurdles. Future research aims to enhance battery capacity, improve fault detection, and address obstacles like electromagnetic interference and external disturbances.

**Keywords:**
Inspection Robots, Electrical Transmission Line, Efficient inspection.

## LITERATURE SURVEY

**Zhu X, Wang H, Fang L, Zhao M, Zhou J (01):**
When encountering obstacles, one arm of the inspection robot grasps overhead ground wires (OGWs), while the other arm is positioned away from them. Returning the arm to the OGWs poses a challenge due to their unknown precise position. To ensure accurate repositioning for autonomous obstacle negotiation, two laser sensors verify boundary points on the OGWs, determining their orientation. An algorithm, utilizing the robot's kinematic model, is proposed to program rotary angles, enabling reliable realignment with the OGWs. Simulation tests validate the feasibility of the algorithm.

**Toussaint K, Pouliot N, Montambault S (2):**
This paper offers a detailed overview of mobile robotics' impact on power line inspection and maintenance, focusing on robots designed to navigate obstacles along transmission lines. It explores current research and development and addresses ongoing challenges hindering full autonomy. Maintenance tasks, including inspection and repairs, are highlighted as significant applications, especially in live-line transmission work. Insights from practical experiences inform discussions on the future direction of mobile robotics in transmission line maintenance.

**Alhassan AB, Zhang X, Shen H, Xu H (03):**
In summary, regular inspection of power transmission line (PTL) systems is crucial for early fault detection and maintenance, ensuring efficient power transmission. While manual methods are laborious and costly, robotic inspection solutions have advanced significantly, attracting global research interest. This paper comprehensively reviews PTL inspection robots (PTLIRs) from 2008 to 2019, focusing on climbing, flying, and hybrid models. Challenges such as landing and obstacle avoidance persist, but hybrid robots show promise. Key challenges include power supply and obstacle detection. Future research should prioritize battery capacity, fault detection, electromagnetic shielding, de-icing mechanisms, and control techniques for wind disturbances, fostering progress in robotic PTL inspection for enhanced power transmission reliability.

**Yoo JH, Kim C, Kim DH (04):**
In conclusion, our paper introduces a novel method for simultaneous obstacle recognition and distance estimation using a single camera on a power transmission line (PTL) inspection robot. This method enables autonomous navigation along PTLs, identifying and avoiding obstacles while accurately locating endpoints such as insulators. We employ a robust PTL detection method based on vanishing point estimation, followed by obstacle modeling and delineation of regions-of-interest (ROIs) along the PTLs. Experimental results validate the effectiveness of our approach in accurately recognizing obstacles and estimating distances during PTL inspections, showcasing its potential for improving robotic capabilities in this field.

**P. B. Wale and K. Kamal Sandeep (05):**

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In conclusion, this paper emphasizes the significance of integrating robotics for transmission line maintenance, especially in condition monitoring and damage detection. Robotic adoption addresses challenges in overhead line maintenance, reducing task duration and facilitating predictive maintenance. It also enhances worker safety and streamlines inspection processes, replacing costly aviation methods. The proposed robotic system, designed for continuous operation along 500kv power lines, incorporates essential sensors and communication modules. Simulation studies using Proteus software confirm the feasibility and efficacy of this system, promising improved efficiency and safety in electrical infrastructure management.

**P. Debenest, M. Guarnieri, K. Takita, E. Fukushima, S. Hirose, K. Tamura (06):**

This paper addresses the hazards and time-consuming nature of high-voltage transmission line inspection, requiring skilled workers to operate at heights near live lines. It introduces a tele-operated robot designed specifically for preventive maintenance, prioritizing mobility to navigate obstacles like cable spacers and suspension clamps. The robot's conceptualization, prototyping, and test results in simulated real-world conditions are detailed, offering insights into its performance.

**S. Jiang, Y. Hu, Y. Wang, H. Jiao and L. Ren (07):**

In this study, a novel mechanical structure has been developed for an inspection robot to overcome various obstacles encountered along 500 kV high-voltage transmission lines, including counterweights, strain clamps, suspension clamps, isolator strings, and insulation sticks. Each component of this mechanical structure is comprehensively described. Additionally, a control system has been devised for the robot, utilizing long-distance wireless monitoring principles. This control system comprises both the main body control system onboard the robot and the ground monitoring system. Experimental results conducted on simulated transmission lines demonstrate the robot's ability to autonomously navigate obstacles and successfully accomplish designated inspection tasks.

**L. Wang, L. Fang, H. Wang, and M. Zhao (08):**

This paper introduces a mobile robot designed for traversing power transmission lines, featuring a unique movement mechanism with two manipulators and a body. It analyses the robot's configuration, movement kinematics, and obstacle navigation process. Autonomous control is enabled through a task-oriented integrated control architecture, organized as a multi-agent system coordinated via a distributed blackboard. Automatic obstacle navigation employs a camera-in-hand system to locate the power transmission line accurately. A dynamic position-based look-and-move control structure, based on a power line locating algorithm, facilitates line-grasping control. Experimental results confirm the robot's ability to autonomously navigate obstacles, validating the effectiveness of the control methodology.

**L. Zheng and R. Yi (09):**

In conclusion, mobile robotics integration has significantly improved efficiency and safety in power line inspection and maintenance. This paper introduces a teleoperated robot with 11 motors, arms, wheels, and claws to overcome obstacles on overhead ground wires. Tasks such as observation, grasping, walking, rolling, turning, rising, and declining are performed. Sensor fusion enhances autonomy, with an embedded computer as the control system core. A programmable pan-and-tilt camera integrates visible light and thermal infrared cameras for teleoperation feedback. Communication relies on Mesh wireless networks in the 700 MHz bands. An expert system developed in Visual C++ enables automatic control. Optoelectronic laser sensors and a laser range scanner aid obstacle navigation and wire grasping. Designed for 500KV line inspection, the prototype demonstrates precise and reliable navigation and inspection capabilities, promising improved maintenance.

**Buringer M, Berchtold J, Buchel M, et al (10):**

In summary, this paper presents a comprehensive overview of the groundbreaking "Cable Crawler," a mobile teleoperated robot designed for meticulous inspection of high-voltage power lines, including the challenging terrain of the topmost ground cable. Unlike conventional designs limited to traversing between masts, the Cable Crawler autonomously crosses mast tops and negotiates obstacles with precision. Its design features a robust chassis and six motorized rubber-coated rollers for optimal weight distribution and traction, including vertically oriented rollers with springs for slip-less propulsion. Detailed design considerations and prototype testing confirm the Cable Crawler's feasibility and efficacy, marking a new era in cost-effective, autonomous power line inspection.

**Li Z, Ruan Y (11):**

This paper discusses the development of a mobile robot designed for clearing obstacles on 500KV power towers to automate line inspection. Equipped with 13 motors, it features two four-degree-of-freedom arms with claws for gripping. An embedded PC/104 computer serves as the core control system, while cameras provide video and temperature data. Wireless LAN TCP/IP protocol facilitates communication. Careful attention to mobility and

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sensor configuration enhances the robot's ability to grip overhead wires, aided by a bridge on the torsion tower. Experimental results validate its efficacy in navigation and inspection tasks.

**Alexander LM, Mangum OK (12):**

The operational success of transport helicopters in regions like Korea and the Canadian Rockies highlights their versatility and effectiveness in transportation. Inspired by this, a study was initiated to explore using commercially available transport helicopters for transmission line maintenance and repair, focusing on the Parker-Davis Project overseen by the Bureau of Reclamation. Spanning Arizona, California, and Nevada, this project's transmission network poses unique challenges and opportunities for helicopter-based operations. This study aims to provide insights into the practicality of using helicopters for critical infrastructure tasks, potentially improving maintenance strategies, and enhancing transmission network.

## CONCLUSION

In conclusion, the inspection robot developed for electrical transmission lines has yielded several significant outcomes. It has proven to be notably efficient, surpassing manual inspections by reducing time and human resource requirements. With advanced sensors and AI algorithms, the robot ensures high accuracy in defect detection and hazard identification, enhancing overall safety by eliminating the need for human inspectors to climb towers. Despite initial investment costs, its long-term cost-effectiveness is evident, along with its reliability in various conditions and scalability for different line types. Moreover, the robot's data collection capabilities enable proactive maintenance and minimize the risk of unexpected failures, presenting a comprehensive solution that optimizes power distribution infrastructure.

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