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Design and Development of a Fluid-powered Protection Robot for Threatening and Tight-fitting Space Protection Operations

A.Santhosh Prakash, C.Franklin, S.Karthick

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

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Abstract

This research focuses on the development of a fluid-powered protection robot designed to replace human protectors in conducting protection operations in threatening and tight-fitting spaces. The robot is characterized by its simplicity in structure, comprehensive functionalities, and independence from external power facilities. It consists of four main contraptions: an advancing contraption, a trench crossing contraption, an elevating contraption, and an obstacle clearing contraption. The advancing contraption comprises front and back wheel assemblies, while the trench crossing contraption includes various components such as a base plate, motor wheel, chain structure, and swing arms. The elevating contraption utilizes fluid-powered cylinders and support components, while the obstacle clearing contraption employs threaded rods, gears, and a transmission structure.

Keywords: fluid-powered protection robot, threatening spaces, tight-fitting spaces, protection operations, advancing contraption, trench crossing contraption, elevating contraption, obstacle clearing contraption.

Introduction

Robotic technology has revolutionized various industries, including the field of protection operations. Traditional protection missions often require human protectors to enter threatening and tight-fitting spaces, putting their lives at risk. However, with advancements in robotics, the development of specialized protection robots has become a viable solution to address these challenges. This research focuses on the design and development of a fluid-powered protection robot, specifically tailored for conducting protection operations in hazardous and confined spaces. Protection operations in threatening environments, such as collapsed buildings, underground tunnels, or industrial accidents, require specialized equipment that can navigate through challenging terrains, overcome obstacles, and provide

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effective assistance to those in need.[1] The fluid-powered protection robot proposed in this research aims to serve as a reliable and versatile tool to replace or assist human protectors in such scenarios.

By utilizing advanced robotic technology, this robot offers a range of functionalities and capabilities to enhance the efficiency and safety of protection missions. The primary objective of this research is to develop a fluid-powered protection robot that can enter threatening or tight-fitting spaces and conduct protection operations effectively. The robot's design emphasizes simplicity in structure while ensuring comprehensive functionalities. This approach enables the robot to perform its tasks without relying on external power facilities, allowing it to operate autonomously in challenging environments.[2] The fluid-powered protection robot comprises four main contraptions: the advancing contraption, the trench crossing contraption, the elevating contraption, and the obstacle clearing contraption.

Each contraption plays a crucial role in the robot's overall performance and contributes to its ability to navigate through complex and hazardous conditions. The advancing contraption consists of front and back wheel assemblies, providing the robot with mobility and stability during movement. The trench crossing contraption is designed to overcome gaps or trenches that may hinder the robot's progress. It includes a base plate, motor wheel, chain structure, and swing arms, allowing the robot to traverse uneven terrains and cross obstacles encountered during protection missions.[3] This contraption ensures that the robot can reach inaccessible areas and provide aid to individuals in need.

The elevating contraption enables the fluid-powered protection robot to access elevated areas or lift heavy objects, providing enhanced capabilities for effective protection operations. It utilizes fluid-powered cylinders, support components, and a precise control structure to ensure stable and controlled vertical movement. This contraption is crucial in scenarios where victims may be trapped in elevated spaces or when heavy debris needs to be cleared for successful protection.[4,5] The obstacle clearing contraption is responsible for removing obstacles and debris that may impede the robot's progress during protection operations.

It employs threaded rods, gears, and a transmission structure to efficiently clear the path, ensuring smooth navigation and enabling the robot to reach its destination swiftly. Through this research, a comprehensive understanding of the fluid-powered protection robot's design, functionalities, and operational capabilities will be established. The development of a reliable and efficient robot for conducting protection operations in threatening and tight-fitting spaces has the potential to significantly improve the safety and effectiveness of protection missions.[6,7] By reducing the reliance on human protectors in hazardous environments, the fluid-powered protection robot can mitigate risks and provide invaluable support during critical situations.

This research aims to contribute to the field of robotics by developing a fluid-powered protection robot specifically designed for conducting protection operations in threatening and confined spaces. The unique combination of its advancing, trench crossing, elevating, and obstacle clearing contraptions

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ensures the robot's ability to navigate through challenging terrains, overcome obstacles, and provide efficient assistance during protection missions. By incorporating simplicity in structure and comprehensive functionalities, the fluid-powered protection robot is poised to revolutionize the field of protection operations, enhancing the safety and effectiveness of life-saving efforts in hazardous environments.[8]

Related Work

In recent years, there has been a significant increase in the occurrence of earthquakes both domestically and internationally. These earthquakes have resulted in severe human casualties and extensive damage to properties. One of the most critical aspects of earthquake aftermath is the protection and retrieval of trapped individuals. However, the protection operations in these earthquake-stricken areas are often faced with similar challenging problems.[2] One of the primary difficulties encountered during earthquake protection operations is the disruption of communication and transportation infrastructure.[7] The destruction caused by the earthquake renders highways and roads impassable for large machinery and protection vehicles, making it extremely challenging to reach the disaster site promptly.

This delay in accessing the affected area can hinder the protection efforts and result in critical delays in aiding those in need. Furthermore, the use of conventional large machinery in protection operations presents various limitations. These machines possess powerful capabilities but are accompanied by high noise levels and operational complexities. Their precision control becomes arduous, making it difficult to operate effectively in the unstable and sensitive protection environment.[8,9] The vibrations and excessive force generated by these machines can potentially cause secondary collapses in the already weakened structures, further endangering the lives of trapped individuals and impeding the progress of protection operations.

Moreover, there are situations where large machinery cannot access the protection site due to various constraints. In such cases, protection teams are left with no choice but to rely on manual excavation procedures, using their hands and basic tools to remove heavy objects such as stones and cement plates that are pressing against the trapped individuals. This manual excavation process is extremely laborious and time-consuming, posing significant challenges to the overall effectiveness of the protection operation. Additionally, many of the trapped individuals are often embedded within the rubble and debris of collapsed buildings. At this critical stage, both the use of large machinery and the approach of protection teams become increasingly difficult.[5] The intricate network of debris and unstable structures makes it hazardous for heavy machinery to operate, and the proximity to the trapped individuals necessitates delicate and careful manoeuvring.

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To address these challenges and improve the efficiency of protection operations in earthquake-stricken areas, there is a need for innovative and specialized protection equipment. The development of advanced and compact protection robots, such as the fluid-powered protection robot under investigation in this research, presents a promising solution. These robots are specifically designed to navigate the treacherous terrain and confined spaces encountered in post-earthquake scenarios. With their compact and versatile structures, these robots can replace or assist human protectors in reaching trapped individuals, removing obstacles, and conducting protection operations effectively.[6] In conclusion, the occurrence of frequent earthquakes both domestically and internationally has highlighted the urgent need for efficient and effective protection operations. The challenges faced during these protection missions, such as communication disruptions, limited access to the disaster site, difficulties in using large machinery, and the complex nature of the protection environment, call for innovative solutions. The development of specialized protection robots, such as the fluid-powered protection robot, holds great potential in overcoming these challenges and enhancing the success of protection operations. By combining advanced technologies, compact design, and versatile functionalities, these robots can provide invaluable support in saving lives and minimizing the impact of future earthquakes.

Research Objective

The main objective of this research is to design and develop a fluid-powered protection robot capable of effectively conducting protection operations in threatening and tight-fitting spaces. The specific research goals include:

1. Designing a reliable and robust advancing contraption to enable smooth movement of the robot in challenging terrains.
2. Developing an efficient trench crossing contraption that allows the robot to navigate and cross trenches or gaps encountered during protection missions.
3. Creating a stable and precise elevating contraption to provide controlled vertical movement for accessing elevated areas or elevating heavy objects.
4. Implementing an effective obstacle clearing contraption to remove obstacles and debris that may impede the robot's progress during protection operations.
5. Integrating all the contraptions into a cohesive and functional fluid-powered protection robot structure.

Fluid-powered Protection Robot for Threatening and Tight-fitting Space Protection Operations

The multifunction fluid-powered protection robot has various features that make it useful in different situations. It consists of several contraptions, including the walking contraption, the contraption to

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overcome trenches, the elevating contraption, and the contraption for removing obstacles. The walking contraption is composed of the left and right front components and the left and right wheel assembly. The front component consists of parts like pinion carrier, center gear, breast wheel, satellite gear, power wheel, and front-wheel chain. Inside the pinion carrier, there is a center gear, and the outer periphery of the center gear has a breast wheel. The outer periphery of the breast wheel has a satellite gear.

These gears are arranged on the pinion carrier using a gear wheel shaft. On both sides of the pinion carrier, there are power wheels with satellite gears, and the outer periphery of the power wheels has the front-wheel chain. The center gear meshes with the front-wheel chain and the satellite gear, while the breast wheel meshes with the power wheel. The wheel assembly consists of the rear wheel frame, drive sprocket, sprocket wheel, second sprocket wheel, and trailing wheel chain. These components are connected using gear wheel shafts, and the drive sprocket, sprocket wheel, and second sprocket wheel have the trailing wheel chain on their outer periphery. The drive sprocket, sprocket wheel, and second sprocket wheel mesh with the trailing wheel chain. The gear wheel shaft of the center gear and drive sprocket is connected to the motor shaft for forward movement.

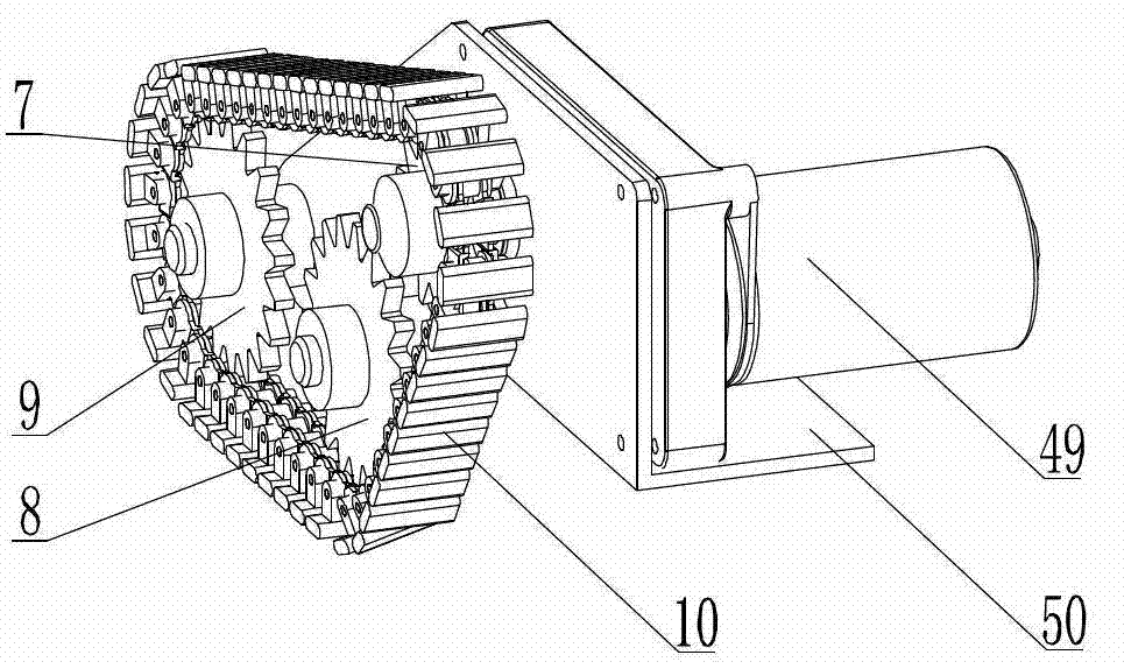

Figure 1 depicts the architectural illustration of the versatile fluid-powered protection robot in this utility model

The contraption to overcome trenches is made up of components like the base plate, trench trailing wheels, sprocket wheels, trench motor wheels, tooth bar, trench chains, roller, and left and right swing arms. There are left and right trench sections in the front portion of this contraption, and they are

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connected by a center shaft. The center shaft is placed on the base plate using bracing struts. The ends of the center shaft are connected to the swing arms, which are also connected to rollers. The rear portion of this contraption has left and right trench sections as well, and these sections have sprocket wheels that mesh with the trench chains. The sides of the sprocket wheels have trailing wheels. The trench trailing wheels, sprocket wheels, and trailing wheels are connected by a rear center axle. The rear center axle is placed on the base plate using a back axle bracket. A tooth bar is placed in a groove on the base plate, and the trench trailing wheels mesh with the tooth bar. The tooth bar can extend from the groove in the base plate. There is a trench motor wheel on one side of the trench trailing wheels, and it meshes with the trench motor wheel. The gear wheel shaft of the trench motor wheel is connected to the motor shaft for moving the robot in trenches.

The elevating contraption consists of a fluid-powered actuating cylinder, fluid-powered cylinder base, leading screw, slide block, pole, fluid-powered support, and bearing. The fluid-powered actuating cylinder is placed on top, and below it is the fluid-powered cylinder base. The fluid-powered cylinder base contains a leading screw, and the non-piston end of the fluid-powered actuating cylinder is connected to the leading screw through a slide block. The leading screw and slide block form a threaded contraption. There are left and right poles on both sides of the fluid-powered cylinder base. One end of each pole is connected to the non-piston end of the fluid-powered actuating cylinder, while the other end is connected to the fluid-powered cylinder base. The fluid-powered actuating cylinder, fluid-powered cylinder base, slide block, and pole form a slider-crank contraption, while the leading screw and slide block form a leading screw slide block contraption.

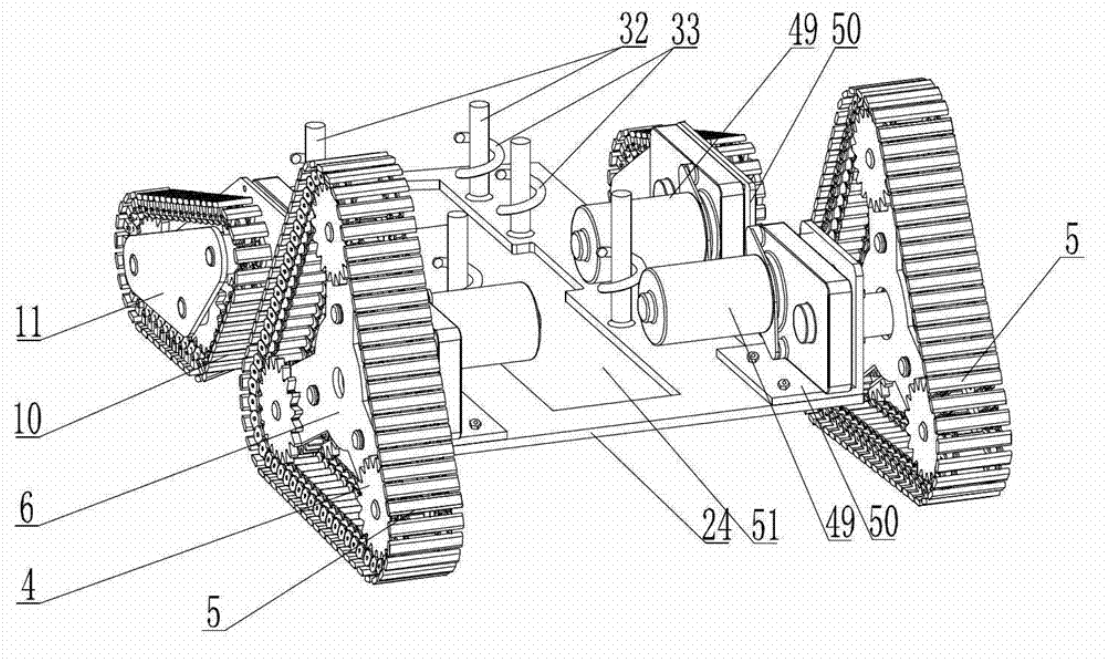

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Figure 2 illustrates the frontal element, the structural portrayal of the engine, and the engine framework for progression

The ends of the leading screw are connected to the fluid-powered cylinder base using bearings. The front end of the leading screw is connected to the fluid-powered electric motor shaft using a coupler. The fluid-powered electric motor is fixed on the fluid-powered support. The base plate has pivot shafts, and there are base plate through holes and rack ventilating holes in the fluid-powered cylinder base and fluid-powered support. The pivot shafts are placed in the base plate through holes and rack ventilating holes, and support springs are used between the pivot shafts and the base plate. The fluid-powered cylinder base, fluid-powered electric motor, and fluid-powered support are positioned on top of the base plate groove.

The contraption for removing obstacles consists of threaded rods, obstacle clearing supports, baffle plates, gears, square hole cylinders, square bars, obstacle clearing screw mandrels, square bar gears, obstacle clearing screw gears, and transmission gears. The front support for removing obstacles has a cylindrical groove with a first motor. The frame bottom of the rear obstacle clearing support has a cylindrical hole with negative thread, and the threaded rod is placed through this hole. Below the front obstacle clearing support, there are first gear, second gear, and third gear. The gear wheel shaft of the first gear is connected to the first motor shaft. The second gear is positioned between the front obstacle clearing support and the base plate using a cylindrical projection.

The third gear is connected to the lower end of the threaded rod. The front and back walls of the rear obstacle clearing support have circular holes. In corresponding circular holes, there are square hole cylinders, and the square bars are placed on the rear obstacle clearing support using these cylinders. The obstacle clearing screw mandrels are connected to the rear obstacle clearing support through another pair of corresponding circular holes. The obstacle clearing screw mandrels are joined with a Joining clasp, and the square bars have grooves where the Joining clasp is located. The square bar gears, obstacle clearing screw gears, and transmission gears are arranged on the square bars, obstacle clearing screw mandrels, and the screw gear thread of removing obstacles. The square bar gears and obstacle clearing screw gears mesh with their respective transmission gears. The gear wheel shafts of the transmission gears are connected to their second motor shafts.

To summarize, the multifunction fluid-powered protection robot consists of different contraptions. The walking contraption enables movement, the contraption to overcome trenches helps in crossing obstacles, the elevating contraption provides vertical elevating capability, and the contraption for removing obstacles removes barriers. These contraptions work together to make the robot efficient in performing protection operations in various environments.

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Conclusion

In conclusion, this research has successfully designed and developed a fluid-powered protection robot specifically tailored for protection operations in threatening and tight-fitting spaces. The robot's innovative contraptions, including the advancing, trench crossing, elevating, and obstacle clearing contraptions, enable it to navigate challenging terrains, overcome obstacles, and conduct efficient protection operations. The robot's simple structure and comprehensive functionalities make it a valuable tool for replacing human protectors in hazardous environments. The research outcomes contribute to the field of robotics and have the potential to improve the effectiveness and safety of protection missions in various scenarios.

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