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Development of Rescue Manipulator to Search Narrow Space for Victims

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Abstract: Recently, disasters such as earthquakes and so on occur at various places, and rescue operation using robots has attracted much attention. In this paper, we propose a new rescue robot with duplex mechanism that is realized by connecting two manipulators in parallel. We have demonstrated the validity and effectiveness of the proposed system by developing a prototype system.

Keywords: Rescue manipulator, narrow space, Searching survivors

I. INTRODUCTION

Recently, disasters such as earthquakes occur at various places. In the disaster site, rescue operation with robots has attracted much attention because they can search dangerous place for survivors [1]-[4].

However, those rescue robots have serious problems. First problem is size of its body. In an actual disaster site, the main size of the space of collapsed Japanese house is about ten centimeters. So, it is difficult for conventional robots to go through in its space.

Second is electric power supply. We cannot supply enough electric power, because of blackout in disaster site.

On the other hand, an industrial endoscope is used in such situation. An industrial endoscope does not have the above problems because the size is small enough, and we do not require power supply for moving it. However, the industrial endoscope has another problem. The problem is not to proceed to desired direction.

In this paper, to solve these problems, we propose new rescue system that has both advantage of the rescue robot and that of the industrial endoscope. Our proposed system has duplex mechanism that is composed of two manipulators, and all joints of the manipulators are passive and have lock mechanism. By pushing the manipulator alternately with locking the joint suitably, we can move the manipulators to desired direction.

To demonstrate the effectiveness of the proposed system, we develop a prototype and conduct experiments.

II. PROBLEM

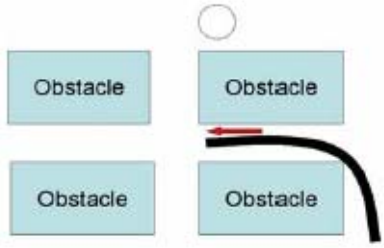
1. PROBLEM OF CONVENTIONAL ROBOTS

There are two problems. First problem is size of body. Fig. 1 shows movement of conventional robots in narrow space. Conventional robots have crawlers to proceed and motors to drive the joints. And they have sensors and controllers to control the motors. Therefore, the space to load with these parts in the robot is needed. Therefore, body becomes large. Therefore, it is difficult for them to search narrow space.

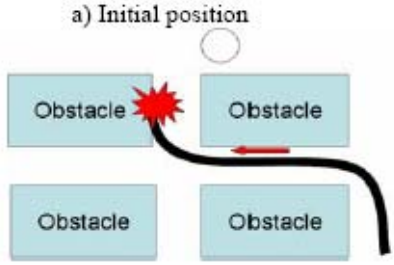
Second problem is electric power supply. To operate a conventional robot, we must supply the electric power. However, in an actual disaster sites, it is difficult to supply the electric power.

2. PROBLEM OF INDUSTRIAL ENDOSCOPE

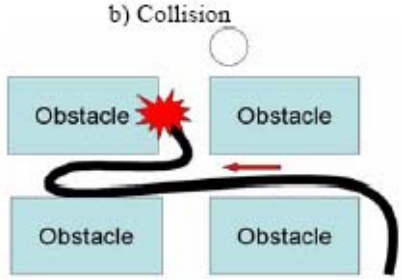
Fig. 2 shows movements of an industrial endoscope in narrow space. The white circle is target. In changing moving direction, conventional industrial endoscope has a problem. When, the head of the endoscope contacts an obstacle, the force for moving the endoscope is deflected and the endoscope is blocked (Fig. 2a)). Therefore, even if we keep pushing the rear side, the industrial endoscope cannot be moved (Fig. 2c)).



a) Initial position



b) Collision



c) Blocking

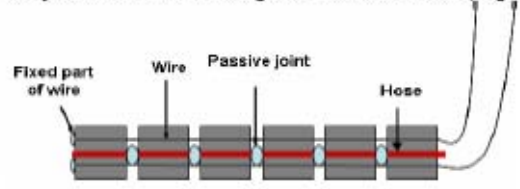
Fig. 2 Movement of industrial endoscope

III. PROPOSED MECHANISM

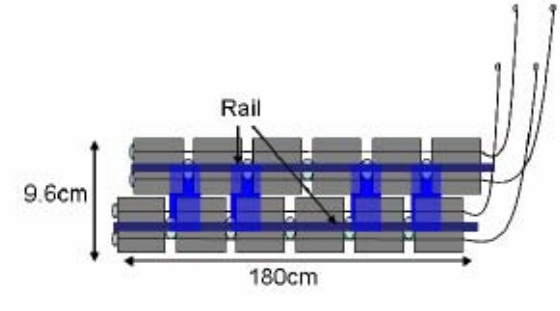
1. STRUCTURE

In this paper, to solve the problem written in section II, we propose new manipulator that has duplication system Fig. 3 shows mechanism of the proposed manipulator.

The manipulator has many passive joints that have lock mechanism. Two wires are installed around both sides of the manipulator, and a hose is installed in its center (Fig. 3a)). A rail is installed on a side of the manipulator. Two manipulators are connected by the rail. They can be moved along the rail each other (Fig. 3b)).



a) Manipulator



b) Duplex mechanism

Fig. 3 Proposed manipulator

2. MECHANISM OF CHANGING DIRECTION

By pulling the wire, we can change head direction, and then lock the joints at the state (Fig. 4).

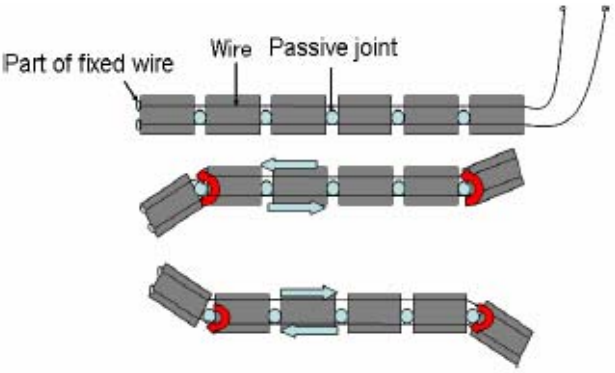


Fig. 4 Control of direction

3. LOCK MECHANISM

Fig. 5 shows structure of each joint. Each joint have two frictional materials (Fig. 5).And, hose passed through the center.

By putting water into the hose, the hose expands, and the expanded hose pushes inside friction materials, then, inside friction materials engages with outside friction materials. As a result, the joint is locked to the position (Fig. 6).

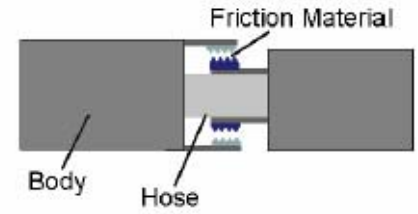


Fig. 5 Structure of joint

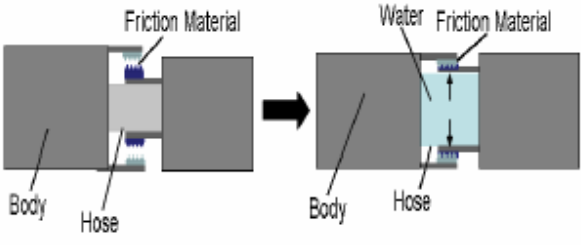


Fig. 6 Lock mechanism

The amount of the injected water into the hose is adjusted with the piston that is installed to the end part (Fig. 7).

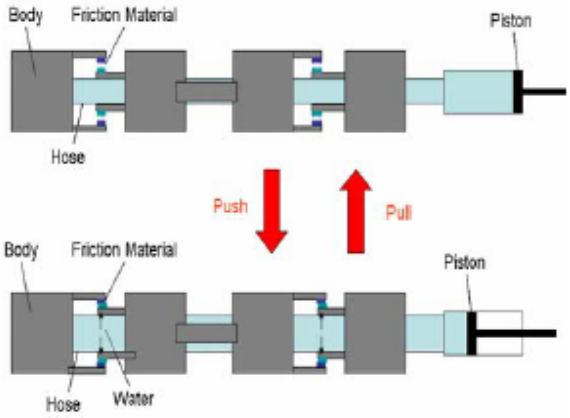


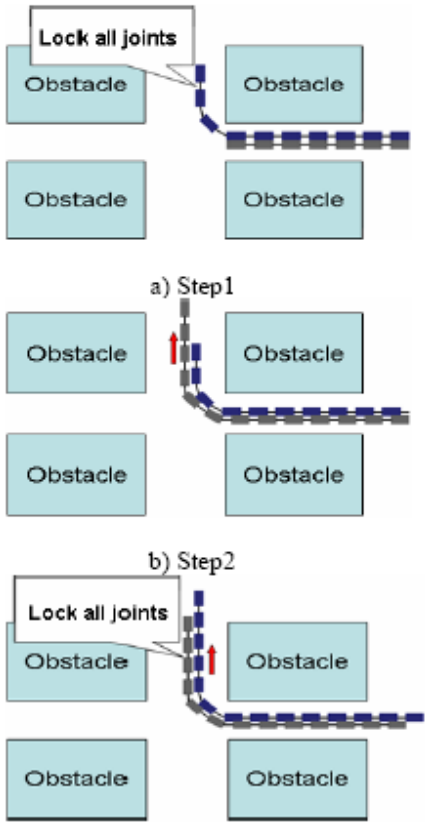
Fig.7 Adjustment of amount of water

As described in subsection II-1, conventional robots have motors, sensors and controllers to operate the robot, and, require space for loading with them. However, proposed manipulator does not need them. Thus, we can down the size of the robot. Furthermore, proposed manipulator does not require electric power supply because, it is operated by manual. And we can solve problem that was described in subsection II-1.

4. OPERATION METHOD

The proposed duplex mechanism enables the following movements (Fig. 8). At curved place, first, we move one manipulator forward. Next, we change direction of the head of the manipulator by pulling the wire. Next, we lock all joints of the manipulator by putting water into the hose (Fig. 8a)). Next, we move the other manipulator forward along the locked manipulator by pushing the rear side (Fig. 8b)).

Thereafter, this operation is repeated to the target (Fig. 8c)). In the proposed mechanism, it becomes possible to move the manipulator to desired direction by using the locked manipulator as a guide each other.



c) Step3

Fig. 8 Movement of proposed manipulator

By this method, we can solve problem that was described in subsection II-2.

IV EXPERIMENTS

Fig. 9 shows prototype of the proposed manipulator. We conduct two experiments.

First is to confirm ability of the lock mechanism. We adjust the amount of water with the piston, and we measure the maximum torque that lock of the joint is maintained (Fig. 10).

Second is to verify the movable range of manipulator. Fig. 11 shows environment of the experiment. We operate the manipulator to the target. Black circle is starting point, and, white circles are target.

Fig. 9 Duplex manipulator

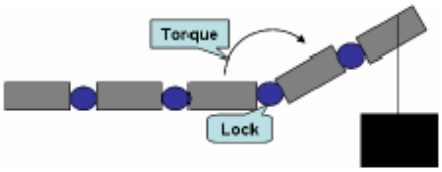


Fig. 10 Measurement of max torque

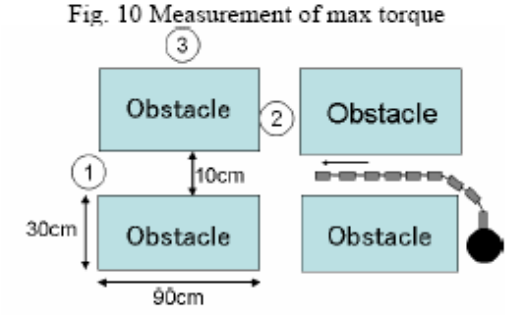


Fig. 11 Environment

1. RESULT OF EXPERIMENT

The maximum torque that lock is maintained is 2.4N·m. And, then, amount of water into the hose is 2ℓ. In the experiment to verify the movable range, prototype has reached at all targets in Fig. 12 .

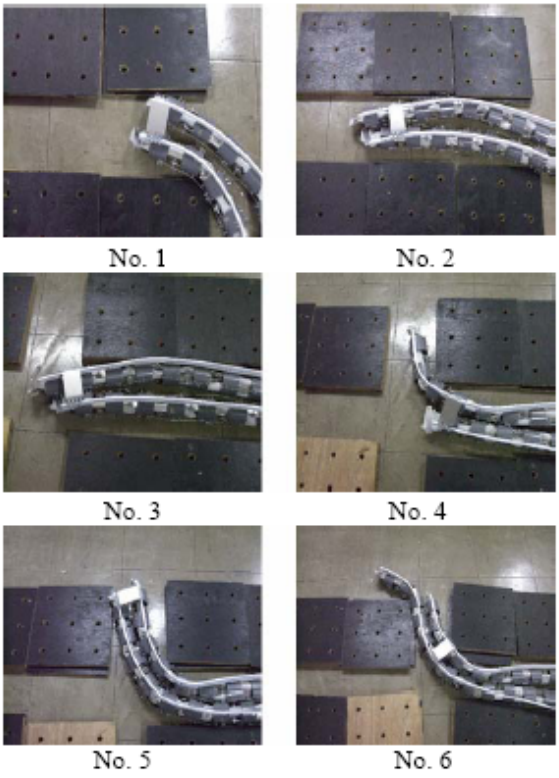


Fig. 12 Experiment of movement

V. CONCLUSION

In this paper, we have paid attention to two problems of conventional robots that are size of its body and electric power supply. And we have also paid attention to a problem of industrial endoscope that can not proceed to desired direction.

To solve these problems, we have proposed new rescue system that has both advantage of the rescue robot and that of the industrial endoscope. By connecting two manipulators that are composed of passive joints with lock mechanism, we make it possible move the manipulator to desired direction by manual control.

We have developed prototype, and conducted experiments to demonstrate the effectiveness of the proposed duplex manipulator. We can conclude that proposed manipulator is useful for searching narrow space for survivors.

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