RESCUE ROBOT “T-52 ENRYU”

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Abstract: “T-52 Enryu” was developed for the purpose of the heavy duty works in disaster spots. It was aimed for heavy labor of a first aid rescue operation in disaster spot and developed large-scale rescue robot “T-52 Enryu” in corporation with Kitakyushu City Fire And Disaster Management Department, National Research Institute of Fire and Disaster, Kyoto University etc. of a member of “Rescue Robot Development Meeting”.
This paper describes the activity by the development circumstances of "T-52 ENRYU", and the present, and future development.
Keywords: Rescue robot, remote control, disaster relief, the measure against snow damage

1. Introduction

A rescue robot is a robot that can play an active role in areas struck by natural and man-made disasters including earthquakes, fires, and accidents. Natural disasters caused by earthquakes, rainfalls, etc., have frequently occurred worldwide in recent years, resulting in a large number of casualties. Many rescue robot engineers have therefore been struggling every day to develop a model that would reduce such victims of disasters to the extent that is possible.

Making the most of their characteristics, rescue robots exert strength beyond the capabilities of humans in their rescue work while reducing the risk of secondary disasters. Wireless remote operation of these robots enables safe search and rescue of victims. They can also remove debris to ensure safe access to rescuees.

This paper reports on the background of the development of rescue robot “T-52 Enryu” by Tmsuk Co., Ltd., experiments conducted so far using Enryu, and future development plans by Tmsuk.

2. Background

Tmsuk developed a large-scale rescue robot for use at disaster sites “T-52 Enryu” in cooperation with Kitakyushu City Fire and Disaster Management Department, National Research Institute of Fire and Disaster (NRIFD), and Kyoto University, which are members of the Rescue Robot Development Meeting. This robot was made public at NRIFD in Mitaka, Tokyo, on March 25, 2004.

“T-52,” which follows a large hydraulic remote-controlled robot “T-5”(Figure 2) made public in 2000, was developed to quickly and adequately remove rubble of wrecked buildings containing steel, wood, and concrete lumps on disaster sites struck by an earthquake, etc., so as to rescue victims trapped under it.

Figure 1: T-52 Enryu

Figure 2: T-5

3. Characteristics of "T-52 Enryu"

"T-52 Enryu," one of the world's largest rescue robots, measures approximately 3.45 m in height and 2.4 m in width and weighs 5 ton. It is characterized by its two 6-m long arms, with which it can carry out work as humans do.

Each arm having eight joints can lift 500 kg (1 ton with both arms). This robot runs on diesel, which also powers the operation of each moving part. It can move on crawlers at a maximum speed of approximately 3 km/h. Similarly to most construction machines, the two arms and crawlers are activated by oil pressure.

Enryu is operated in two modes: one by an operator riding in the robot and the other by remote operation by master-slave control (Figure 3) and joystick control (Figure 4) for perilous situations in which rescuers cannot gain access to victims because of the risk of secondary disaster.

The master-slave control directly transmits the motion of the arms of the operator to the robot, enabling more human-like motions. The remote control device with a height, width, and length of approximately 1 m, 1.2 m, and 1.8 m, respectively, weighing approximately 120 kg in total, can be carried on the back of a small truck. Brakes using air cylinders are also mounted on the control to relieve the operator of the weight of the arms of the device. The loads on the operator are mitigated by fixing the parts that do not have to be moved.

Remote control using a joystick, which enables the motion of a single joint of the robot arms, is effective when a more precise motion than master-slave control is required. The use of armrests also has the advantage of reducing the burden on the operator during rescue work over a long time.

It is essential for remote control to grasp the situation of the site on a real time basis. Enryu is furnished with CCD cameras at 9 locations including the head, body, arms, etc., through which the operator can watch the image of each point on the monitor during working. The communication between the remote control device and the robot is provided by wireless LAN (2.4 GHz and 5 GHz) and PHS. Wireless LAN is used when the distance is within 150 m, whereas PHS provides remote control from anywhere in Japan.

Figure 3: Remote control device (master-slave)

Figure 4: Remote control device (joystick)

4. Joint training exercise with the Fire Department rescue team

Tmsuk has been carrying out the improvement of Enryu in cooperation with the Fire and Disaster Management Department (FDMD) of Kitakyushu City. Performance testing and rescue training using Enryu were conducted on December 9 and 10, 2004, during the rescue drill of the international fire rescue team held by the FDMD of Kitakyushu City (Figure 5). During this training, a building demolition site in Kitakyushu, Fukuoka Pref., was assumed to be an earthquake-struck ground, where the rescue team

worked for 24 consecutive hours to rescue the assumed victims.

Figure 5: Rescue training using Enryu

The following three improvements were made to Enryu for this drill:

(1)The attachments to both arms were changed to the grapple type to remove rubble more effectively.
(2)A joystick system was added to the remote control device to make the operation more precise.
(3)A night-vision camera with a zoom function was mounted to the head to facilitate work during the night.

The operation of these improvements was checked and performance tests were conducted during the drill to collect data for further improvement.

During the drill for rescuing victims out of a vehicle embedded in rubble, rescue dogs identified the victims, Enryu removed the obstacles including steel framing and rubble, and the rescue team carried out the rescue work.

Actual cooperation with the rescue team in a situation simulating a real disaster site provided useful data for Enryu, such as the strength required for each part and the size suitable for actual work.

5. Tests against snow disaster

Accidents related to snow have been frequently reported in Japan in recent years. There have been a large number of casualties due to avalanches and snow falling from roofs particularly in northern Japan. Snow removal has been carried out by hand even in hazardous areas, since no new technology has been developed for this task over the past 40 years. With this as a background, experiments were conducted using Enryu at Nagaoka University of Technology in Nagaoka, Niigata Pref., in a week in February 2006 to explore the possibilities of snow disaster prevention and rescue by a remote-controlled robot.

Two types of experiments were conducted: removal of snow eaves and rescue of victims from vehicles buried under the snow after an avalanche (Figure 6). Snow eaves are protrusions of snow masses from the edges of cliffs and building roofs. Leaving snow eaves as they are is hazardous, as they can fall down in great masses.

In the experiment to remove snow eaves, “T-52 Enryu” removed the snow eaves at a height of 3.5 m from the ground with their two arms. Snow eaves are normally removed by hand, but many people have been injured or buried while removing snow year after year. The experiment has proven the effectiveness of snow eaves removal from within the safe robot or by remote control from a distance.

In the experiment to rescue victims from a vehicle buried under the snow after an avalanche, a car was placed under snow at the bottom of a cliff to assume the conditions after an avalanche. Enryu pulled out the car from under the snow and moved it to a safe place. The primary concern for the rescue work at an avalanche site is the risk of a secondary disaster. Though no time should be lost in rescuing victims, safety of the rescuers must also be ensured. A robot like “T-52 Enryu” is most useful under these circumstances, as it can be remote-controlled and can realize human-like precise motions with superhuman power. The weight of the car loaded with snow was very large in this experiment, but Enryu succeeded in moving it to a safe place using their two arms.

Figure 6: The rescue experiment from burial vehicles

6. Soil surveying by remote control

There is no guarantee that the ground is stiff in disaster areas. It is therefore necessary to conduct a ground survey before carrying out rescue work. However, because of the danger associated with such a survey, it is desired that a remote-controlled robot also conduct a ground survey.

In this experiment, a ground survey was conducted using a portable cone penetration test apparatus attached to the tip of the arm of “T-52 Enryu” by utilizing its hydrodynamic drive (Figure 7). This function of Enryu was proven useful, as the results of this remote survey agreed with those of direct survey by hand. Whereas it was difficult for testing by hand to achieve the required constant rate of penetration, it was easily maintained by robot testing utilizing its oil pressure, providing more accurate data of the ground.

Figure 7: Soil surveying

7. Future development plans

Being a prototype, “T-52 Enryu” is still in the process of improvement through a wide variety of experiments. However, it has already achieved a practically feasible level in regard to moving of heavy objects and assessing the situation at hazardous areas where the risk of a secondary disaster is high. The authors intend to make further improvement in such aspects as safety, durability, and user interface to develop a practical model, as well as variations with different sizes, so as to cope with various kinds of disasters.

“T-52 Enryu” is capable of carrying out fine manipulation from a remote place assuming rescue work in hazardous areas. For this reason, it can also be effective for use in hazardous fields of construction, civil work, and waste recycling. Jobs that have been done by two backhoes can be done by a single “T-52 Enryu” having two arms. The authors therefore plan to make it practically feasible for uses other than rescue activities by accumulating experiment data.

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