Development and Field Test of a Nuclear Disaster Response Robot, Armstrong

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1. Introduction

In the wake of a nuclear accident, the environment surrounding the scene of the accident quickly becomes highly radioactive. Consequently, such an environment is extremely hazardous to any emergency response teams wishing to gain access to the scene of the accident. Accordingly, there has been much research recently on developing emergency response robotic technologies.

At the scene of a nuclear accident, an emergency response robot might be required to carry out a variety of tasks depending on the nature of the accident; for example, removal of debris, creation of an access road. Such tasks typically involve the handling of heavy payloads. Current human-sized robotic manipulators, however, are not capable of handling such tasks due to their relatively low payload limits. As such, there is a need to develop a small high-power robotic manipulator capable of handling a wide range of heavy-duty tasks in an emergency.

In this paper, we discuss the design of a small high-power robotic manipulator capable of handling heavy payloads in an initial response action to a nuclear accident.

2. Heavy-Duty Dual Arm Robot

In the design of a small high-power robotic manipulator for use at the scene of a nuclear accident, the size of the arm of the manipulator is an important factor to be considered.

Because most man-made structures are built for humans, it is necessary to build a high-power robotic manipulator of human proportions for freely maneuvering in and out of such structures and for handling tasks that would otherwise need to be performed by human emergency response workers.

In this paper, we propose a small high-power robotic manipulator of length 1 m capable of simulating the linkage structure of a human arm. The proposed manipulator should be able to perform tasks involving a heavy payload at the scene of a nuclear accident; for example, opening and closing doors, operating control valves, performing radioactive contamination treatments, and removing debris. Therefore, the proposed manipulator should be able to produce high power and large torque in a limited size. To realize the aforementioned size and output conditions, we used hydraulic actuators in the design of the proposed manipulator. The hydraulic actuators of the proposed manipulator can produce approximately 10 times more output compared to electric motors. In addition, they can generate large force and torque without the need for gear reduction; therefore, the structure of the proposed manipulator is made simpler. Hydraulic actuators are robust against external forces; thus, they are suitable for tasks involving a heavy payload.

In this study, we designed a dual-arm robotic manipulator of eight degrees of freedom named ARMstrong capable of handling objects weighing more than 100 kg.

The linkage structure of ARMstrong was designed by simulating the human body. For mobility, a caterpillar was adopted. A small, mobile hydraulic power pack was installed for the operation of ARMstrong. Fig. 1 shows the concept design of ARMstrong.

Fig. 1 ARMstrong: a heavy-duty dual-arm robotic manipulator

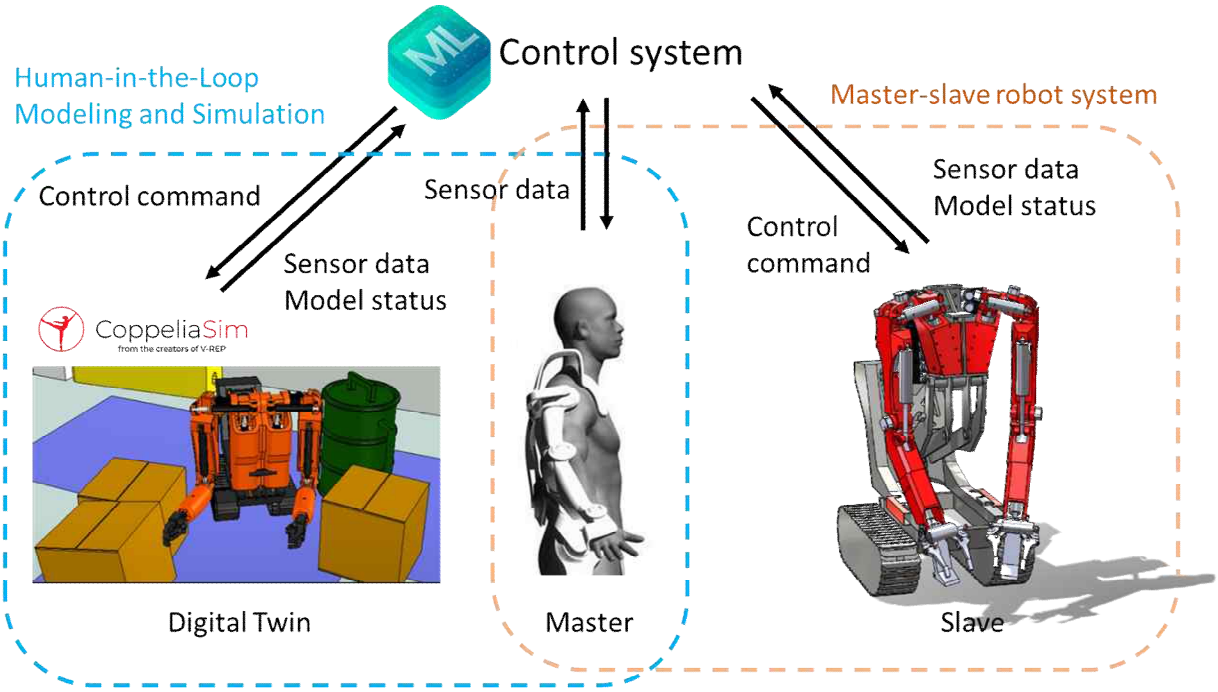

Fig. 2 ARMstrong simulation in a virtual accident environment

3. Simulation

A V-REP robot simulator was used to evaluate the characteristics of ARMstrong. In the simulator, ARMstrong's workspace, joint torque, and control performance were assessed. In addition, we constructed a virtual nuclear accident environment and conducted the detail work such as door opening and closing, valve operation, debris removal, hull movement, and transfer of radioactive materials. (Fig. 2)

4. Conclusion

In this paper, we discussed the design and simulation of our proposed heavy-duty dual-arm robotic manipulator for disaster response in the case of a nuclear accident. In the future, detailed design, manufacturing, and control system development of ARMstrong will be carried out.

REFERENCES

[1] Design of a High Power Robotic Manipulator for Emergency Response to the Nuclear Accidents, Jongwon Park, Yeong-Geol Bae, Myoung Ho Kim and Young Soo Choi, Proceedings of the KNS 2016 Autumn Meeting

ACKNOWLEDGMENT

This paper was supported by the Ministry of Science and ICT.