

Development of a door opening device for mobile robots

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***Keywords :** damped door, door hanging device, multi-stage linear actuator, door opening, mobile robot

1. Introduction

It is important to open a door automatically especially in robotic age. After the pandemic, non-face-to-face services from robots are in great demand. In the event of an indoor accident such as an operating nuclear power plant and chemical plant, robots need to perform tasks mitigating the situation. In many cases, the mobile robot should pass through the door.

But it is very difficult task to open a door, especially a damped door, for the mobile robot. Because it requires a articulated robot arm, the perception of a door handle and position, the complicated calculation of the trajectories of the robot arm and a mobile robot. Thus many researchers have studied the automatic door opening techniques of mobile robots for many years [1, 2].



Fig. 1. Mobile robots trying to open a door.

This paper presents a simple device opening a damped door for mobile robots. If a mobile robot attached the door opening device on the door, it opens the door remotely and maintains the door open. Then many mobile robots pass through the door without concerning the complicated door opening task. Fig. 2 shows the concept of the door opening device.

2. Methods and Results

In this section some modules of the door opening device are described. The door opening device includes a cling module, a door handle rotating module, a extension actuator including a hinge and a base including a controller.



Fig. 2. Concept of a door opening device.

2.1 Cling Module and door handle rotating module

The door opening device should be attached to the door near by the handle. The device is expected to weigh up to 3kg. We selected a suction cup of suitable cling force and motorized it which is called a cling module. Then another motor rotates the handle to open the door. Thus we designed a very simple 2DOF gripper, door handle rotating module. Fig. 3 shows the cling module which withstands a weight of about 5kg by adsorbing it to the door and the door handle rotating module.

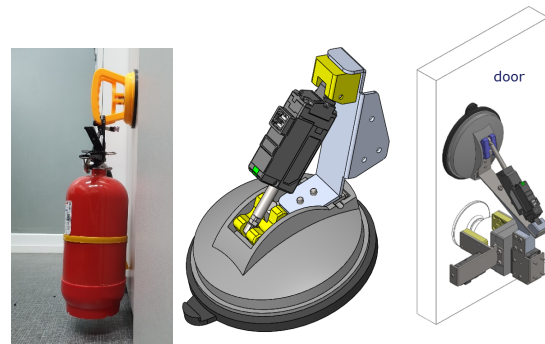


Fig. 3. Cling module and door rotating module.

2.2 Extension actuator

The extension actuator pushes or pulls the door to 900mm. The door rotates around the door hinge so that

the extension actuator rotates around the hinge of the extension actuator. The rotation is recovered by the spring when the door is closed. Fig. 4 shows the extension actuator.

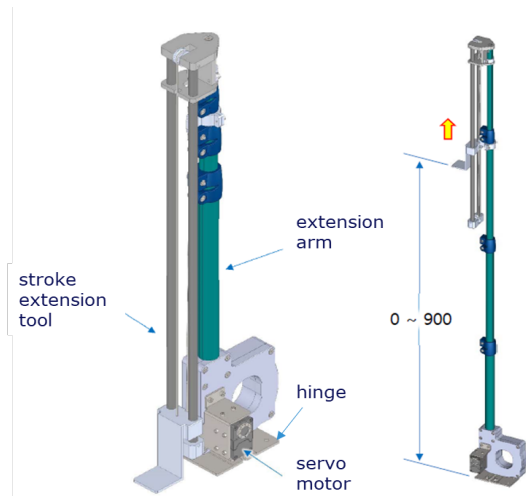


Fig. 4. Extension actuator.

To prevent the jamming of the extension arm when the door is opened and to increase the stroke distance, a stroke extension tool was made and installed. Fig.5 and fig. 6 shows the function of the stroke extension tool.

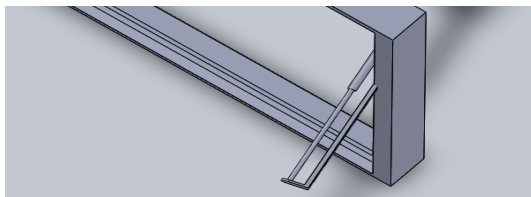


Fig. 5. Jamming without a stroke extension tool.

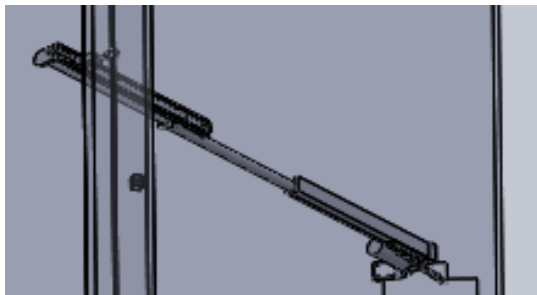


Fig. 6. Avoiding jamming with the stroke extension tool.

The tip of the extension arm should hang on the door frame for the extension arm to push the door so that a tip tool was manufactured and installed at the end of the stroke extension tool.

2.3 Base and Controller

The base connects the all modules and is equipped with a cam mechanism to prevent rattling when the extension arm rotates. The controller is attached on the base. Fig. 7 shows the base including the controller and the door opening device.

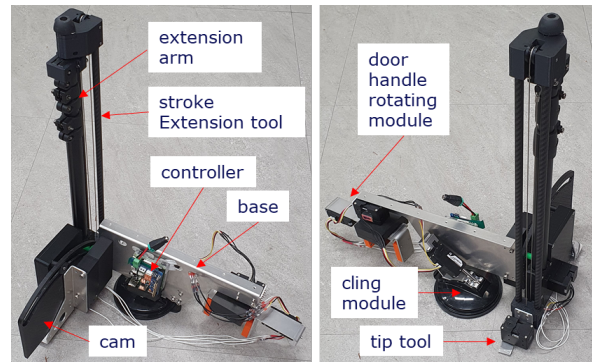


Fig. 7. Door opening device.

2.5 Door Opening Experiment

Fig. 6 shows the door opening device to open the door. The device clings to the door, grips the handle of the door, rotates the handle of the door, hangs the door frame with the tip tool, and expands the extension actuator. Then the door is opened. The power of the device was supplied by the tether yet.

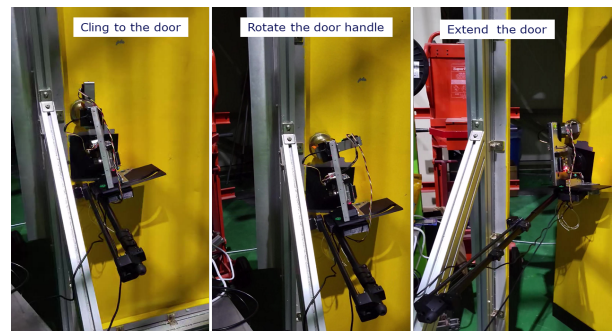


Fig. 6. Opening a door.

3. Conclusions

The door opening device was developed for the mobile robot which will play many roles in the future, including non-face-to-face services and emergency responding mitigation tasks. The door opening device successfully opens the door. It will be an important device for the mobile robots. The door opening device needs more cling force, self power pack and wireless communication. We will study the technique to place the device remotely with mobile manipulator.

REFERENCES

- [1] M. Stuede, K. Nuelle, S. Tappe, and T. Ortmaier, "Door opening and traversal with an industrial cartesian impedance controlled mobile robot", ICRA 2019, 2019.
- [2] D. Hyun and H. Shin, "A study of the teleautonomy approach to the door opening task of a mobile robot for accident response at operating nuclear power plants", Transactions of the Korean Nuclear Society Spring Meeting, May 18-19, 2023, Jeju, Korea.