Development of A Device for Examining Body Surface Inspection While Clothed

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***Abstract*— This study presents a novel device designed to be worn over clothing for examining the body surface that attach over clothing to inspect the body surface. The device consists of a camera unit equipped with a camera for observing the body surface and a mobility unit for moving the camera unit. The camera unit is placed inside the clothing, and the mobility unit on top of the clothing, with the camera unit attached to the mobility unit using magnets. By moving the mobility unit through a ladder chain with a motor, the camera unit inside the clothing can be maneuvered while the clothing is worn. Potential applications include checking the condition of the body surface of people who cannot change their clothes frequently.**

I. INTRODUCTION

This paper presents a novel device for inspecting body surfaces while wearing clothing. Currently, the healthcare sector is facing a serious global shortage of medical professionals [1]. If this situation persists, a limited number of healthcare workers will be required to treat an increasing number of patients, significantly increasing their workload. One solution to this issue is the simplification of healthcare tasks through the use of devices. This study focuses on examining the body surface within healthcare tasks, particularly concerning bedridden individuals prone to developing pressure ulcers, which are essentially skin damage. Early detection allows for quicker recovery and reduces the workload of healthcare tasks. For individuals who are bedridden, changing clothes frequently is not feasible. Therefore, the development of a device that can observe body surfaces without removing clothing was initiated. Although robots that move on clothing have been developed [2] recently, to our knowledge, no devices exist that can observe the body surface inside clothing by moving an object on the clothing. This study places a camera unit equipped with a camera inside the clothing and attached this camera unit to a mobility unit on the clothing using magnets. While it would be easy to move the camera unit if the clothing were a rigid flat surface [3], [4], clothing is soft and easily deforms, creating a surface full of irregularities. The challenge lies in moving the camera unit over this soft, uneven surface while keeping it connected to the mobility unit. The solution involves equipping the device with multiple small wheels to adapt to the unevenness of the clothing and move accordingly, while also mounting magnets near the wheels to facilitate movement while maintaining connection. Additionally, to lighten the mobility unit, a device that moves it through a motor-driven ladder chain is simultaneously developed.

II. FUNCTIONAL REQUIREMENTS AND KEY MECHANISMS

A. Functional requirements

The functional requirements of the device are as follows:

1) Moving unit can move on clothing.
2) Camera unit equips with camera and can observe body surface through the camera.
3) Camera unit inside clothing can be maneuvered by moving the moving unit on clothing.

B. Device design

Fig. 1 shows the overview of the whole system. The device primarily consists of three parts: the ladder chain driving part (part enclosed by red dashed line), the inspection part (part enclosed by blue dashed line), and the ladder chain support part (part enclosed by orange dashed line). The ladder chain driving part is attached to the shoulder using a belt and mainly comprises a motor (DYNAMIXEL, XM430-W210-R) and a sprocket that feeds the ladder chain. The rotation of the motor drives the ladder chain, which in turn moves the inspection part. The ladder chain support part plays a role in tensioning the fed-out ladder chain. Rollers are placed at the entry and exit of the support part, and a sprocket is installed inside to prevent the ladder chain from jamming. Velcro is threaded through holes in the bottom and attached to the wrist like a watch. The inspection part consists of a moving unit that travels over the clothing and a camera unit that moves inside the clothing to observe the body surface. Six neodymium magnets are attached to the bottom surfaces of both the moving unit and the camera unit, allowing the inspection part to continue operating without falling by sandwiching the clothing between the outer moving unit and the inner camera unit. Additionally, elongated rollers are installed near the magnets to reduce friction during movement and enable smooth motion. A camera (KEENSO, HBV-1466FF) is mounted on the camera unit to take images of the body surface. The ladder chain driving part, the ladder chain support part, and the inspection part are each made of PLA, while the ladder chain is made of polyurethane.

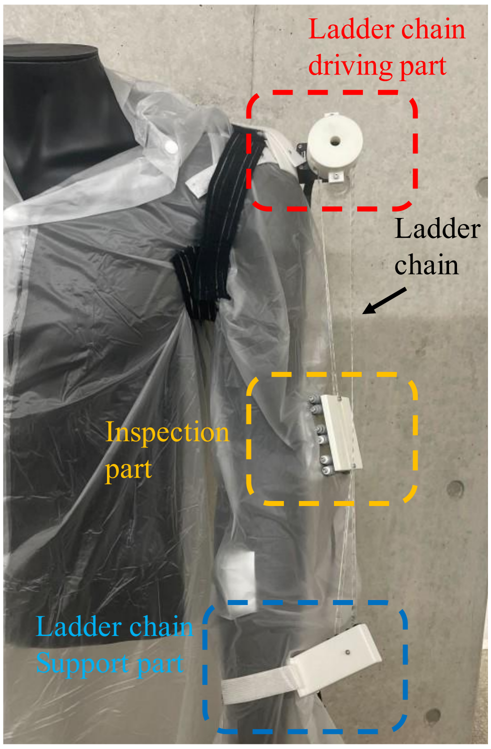

Fig.1 Overall view of the system

C. Driving mechanism and key components

The schematic of the drive mechanism and the 3D-CAD diagrams of the key components are shown in Fig. 2. The motor mounted on the shoulder rotates, driving the ladder chain, which in turn drives the attached moving unit. The camera unit and the moving unit are positioned such that the rollers of the camera unit and the rollers of the moving unit come into contact with each other, and they are attached to the clothing with magnets. This arrangement allows the camera unit to move in accordance with the movement of the moving unit. In this study, as a first step, it is assumed to be mounted on the arm to observe the surface of the arm. By changing the position and orientation of the fixed parts, it is possible to observe other parts, but the details will be addressed in future work.

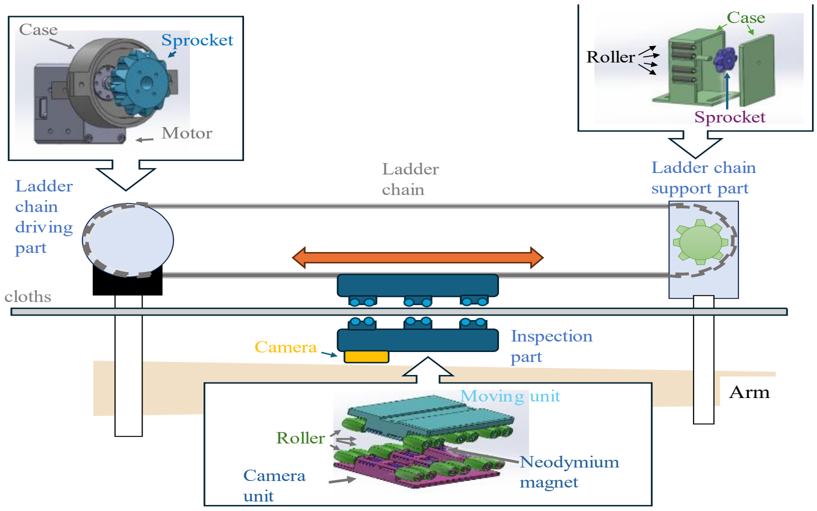

Fig.2 Schematic of the drive mechanism and the 3D-CAD diagrams of the key components

III. OPERATION TEST

To evaluate the effectiveness of the developed system, operation and camera tests were performed by attaching the device to a mannequin. The functionality of the inspection part was assessed by driving it from the shoulder to the wrist, ensuring that the camera and moving units remained connected throughout the movement. The results are shown in Fig. 3. The test confirmed that the inspection part operated normally from the shoulder to the wrist and that the moving and camera units functioned without detaching. During this movement, images of the mannequin's arm surface were captured using the camera mounted on the camera unit. The device's ability to observe the body surface was evaluated by checking if it could capture markers placed on the arm. White tape with the letter 'A' and yellow tape with the letter 'B' were affixed to the arm to see if the letters or parts thereof could be detected. Observations of the mannequin's surface itself were also conducted. The results are presented in Fig. 4. Parts of both letters 'A' and 'B' were clearly captured, and detailed images of the mannequin's surface were also obtained. These findings demonstrate the system's capability to observe the body surface.

Fig.3 Operation test

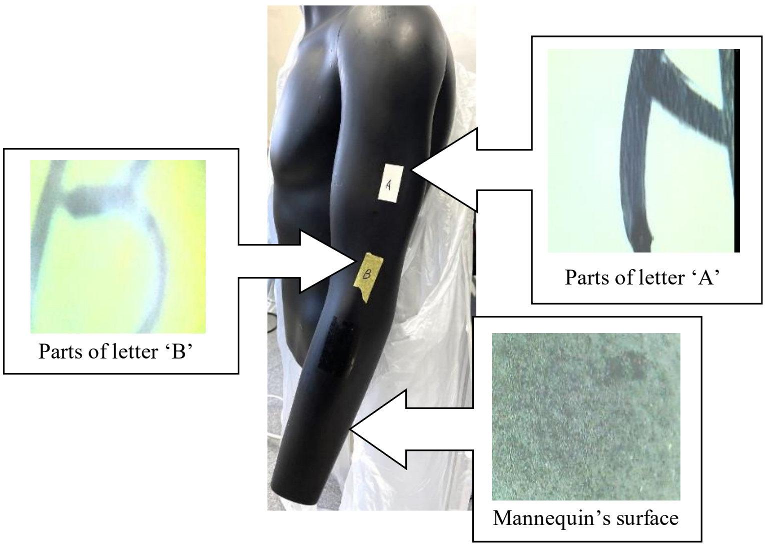

Fig.4 Camera test

IV. CONCLUSION

This study developed a device that can be attached over clothing and moved to observe the surface of the body. The device is composed of a moving unit that travels over the clothing and a camera unit that moves inside the clothing in coordination with the moving unit, using an onboard camera to observe the body surface. The moving unit and camera unit are connected through the clothing using magnets. The presence of multiple wheels at the connection points allows for movement over soft and uneven clothing surfaces. The moving unit operates via a motor through a ladder chain mechanism. As a first step in this research, the device was mounted on a mannequin's arm and moved from the shoulder to the wrist to verify its effectiveness. The moving and camera units were able to move without detaching. Additionally, the images captured by the camera clearly reflected the condition of the arm's surface. Future work will aim to measure the surfaces of other body parts and strive for miniaturization and slimming of the entire device.

V. ACKNOWLEDGEMENT

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VI. REFERENCES

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