Development of the Laundry Folding System with Removing Hanger Function

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Abstract: In this paper, we discuss the laundry folding system that we have developed. Folding laundry in automatically has been studied by some researcher. However, they use laundry dryer for drying the laundry process. Therefore, hanging the laundry to dry process is ignored in previous studies. Thus, folding laundry that state is hung the hanger is not much studied. However, we often use the hanger to dry the laundry. Further, some clothes can't be dried in the laundry dryer because they shrink in the heat of the dryer. Thus, we have developed the system it has the ability to fold the laundry that state is hung the hanger in automatically. Also, this system could remove the hanger from the laundry. Further, this system could check whether the laundry is dry or not. If the user wants to fold laundry with this system, all he has to do is hang the laundry with the hanger on the hanger rack in this system. This system folds that laundry by controlling each device in the system. With this system, the burden of housework will be reduced.

Keywords: Folding the Laundry, Folding System, Motor, Arduino

1. Introduction

Housework is one of tough jobs. Not only that, we must do it every day. We can't live comfortably without doing housework. In the case of a single life, you have to do that as well as your work. On the other hand, if you have a large family, amount of housework becomes enormous. There are a great number of household tasks such as cleaning the room, washing the dishes, and doing the washing [1][2]. Previously, housework has been done manually. However, as a result of the appearance of a dishwasher, a vacuum cleaner, and a washing machine, we can conveniently save trouble. Nevertheless, the machine which folds the laundry automatically has not prevailed among the ordinary homes. Even today, folding the laundry is a manual labor.

In 2015, the laundry folding robot: "Laundroid" was developed by Seven Dreamers Laboratories, Inc., Panasonic Corporation, and Daiwa House Industry Co.,Ltd.. Though the robot has ability to fold many kind of clothes, it takes approximately 10 minutes to fold one T-shirt, and it doesn't consider whether the laundry has already dried or not. Due to that, user should check whether the laundry is dry when he takes the laundry in. Folding laundry automatically has been studied by some researcher [3][4]. However, the laundry is dried in the laundry dryer, so there have not the step to hang the laundry on the hanger in previous studies. When we take in account the percentage of households owning a laundry dryer, hanging out the laundry to dry is still main

means to dry the laundry [5][6]. Addition to this, some clothes can't be dried in the laundry dryer because they do shrink in the heat of the dryer. Also there are some attempts to keep a proper humidity of the room by hanging out the laundry to dry in the room to prevent the room from drying [7][8]. If we hanged the laundry out, we have to detect whether the laundry is dried or not when we take the laundry in. After that, we have to remove the hanger from laundry to fold laundry. However, these processes of folding laundry are not much studied.

From such a background, we had developed the system to fold T-shirt from the hanged out state. [9]~[12]. The previously developed system could detect whether the T-shirt is dry or not. If the T-shirt is already dry, the system removes the hanger from the T-shirt and folds the T-shirt. It took about 1 minute and 30 seconds to fold a T-shirt. However, the prototype of the previous system could fold only a T-shirt.

Therefore, we developed the laundry folding device to deal with more kinds of laundry. This system can fold the shirt, towel, skirt, and trousers. Furthermore, after folding the laundry, proposed system can sorts the laundry according to the kind of it.

2. Construction of the System

2.1 System overall view The overall view of the system is shown in Fig. 1. The rotary hanger rack part is shown in right side in the Fig. 1. The user hangs laundry on the rotary hanger rack. We use the clothes pin (NSA-37 by NAITO-KOGYOSHO, INC.) and hanger (DFQ011 by DAISAKU-SHOJI, INC) to hang laundry. We pinch the

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Figure 1: Overall view of the system

Figure 2: The outline of the system

Figure 3: The hanger and clothespins

laundry to clothespins of the hanger. If the laundry has a sleeve such as a shirt, we hang the laundry to the hanger in normally. So, the sleeve is put through by the wings of the hanger. Folding laundry device part is shown the left side in

Figure 4: The hanger transport device

the Fig. 1. This device is the main part of the system. It detects dryness of laundry, removes hanger from laundry, and folds laundry. The behavior outline of the system is shown in Fig. 2. The behavior of the system can roughly divide into two parts: carrying laundry process and folding laundry process. In carrying hanger process, the system makes the laundry moves from rotary hanger rack. Thereafter, the system removes hanger from laundry. Finally in this process, the laundry placed on the laundry folding device. After that, the system runs the folding process and controls laundry folding device. In the folding laundry process, the system folds the laundry using laundry folding device. After the system folding laundry, the system sorts the laundry with kind of the laundry. By using motors and operating the respective device, these operations are realized. Also state of each device is detected by sensors and motors, and they are controlled by microcomputer. AC100V is used for the power supply of the system. It is converted to DC5V and DC12V by the power strip. The converted voltage is supplied to each device.

2.2 Carry the laundry with hanger We use the rotary hanger rack as the place of putting laundry with hanger. The user can hang a lot of laundry here. The system moves the laundry that is placed here to fold the laundry. The system uses the lift for carrying laundry to folding laundry device part. In initial state, the lift is standing by above the rotary hanger rack. If the rotary hanger rack is rotated by the system, the laundry is moved on the lift arm. Then, the lift detects the hanger hook and catches the hanger using its arm. Thereafter, the lift moves to the above folding laundry device part. Finally, the lift releases the hanger and backs to the initial state.

2.3 Remove the hanger from laundry We use special clothes pin and hanger as shown in Fig. 3. The system removes the hanger using their structure. The tip of the clothes pin is roller-like shape. The laundry that is pinched by the clothes pin can be taken easily by pulling the laundry or hanger. Also the hanger has special structure. Wings of the hanger are bent if the button of the hanger handle is pushed. Therefore, we can remove the hanger from laundry neckline. The system using hanger mobile device to remove the hanger as shown in Fig. 4. This device has abilities to

Figure 5: The laundry is fixed and stretched

Figure 6: The folding laundry device

move the laundry with hanger and push the button of the hanger handle. When the hanger is removed, the laundry is fixed by the arm of folding laundry device and stretched by the hanger mobile device as shown in Fig. 5. When folding laundry device fix the laundry, it also detect the laundry is already dry or not. If the laundry is pinched by clothes pins, the laundry is pulled away from clothes pins. As a result, the laundry is put on the laundry folding device. If the laundry is not pinched by clothes pins, the hanger mobile device pushes the button of the hanger handle. As a result, the laundry is dropped from hanger and put on the laundry folding device.

2.4 Fold the laundry The system folds the laundry using folding laundry device. The device is shown in Fig. 6. It can fold laundry using own panel. The panel is moved by servo motors. In this device, the laundry that has sleeve like a T-shirt is folded as shown in Fig. 7. The laundry that has no sleeve is folded as shown in Fig. 8.

2.5 After folding the laundry When the folding has finished, the laundry is put to the storage place. The system moves the laundry with folding laundry device in a horizontal direction. Then the board of the behind part of the folding device is opened by servo motor. Thus, the laundry is put in the storage place. The user can collect easily the laundry that has folded. The system has two storage places. The laundry is sorted each kind of the laundry and put on storage places.

Figure 7: Step of folding instrument about laundry that has sleeve

Figure 8: Step of folding instrument about laundry that has no sleeve

3. Devices used in this System

3.1 Devices which are operated by the system in carrying laundry process

In the carrying laundry process, three devices are driven by the system. First one is rotary hanger rack. It is rotated by the DC motor to move the laundry on the hanger rack. As a result, the laundry is moved to the lift as shown in Fig. 9. We use this lift to carry the laundry with the hanger. The sensor attached lift and measures the distance between the arm of lift and the sensor. When

Figure 9: Laundry to lift moving part

Figure 10: Inside of the folding device panel

Figure 11: The arm and distance measuring sensor are attached in the folding device

the laundry moved there by the rotary hanger rack, the lift catches the hanger using the arm. There after the lift carry the laundry to folding laundry device part. In the middle of this process, the system captures the image of laundry using a web camera. After that, the system distinguishes whether the laundry has sleeve or not. We used raspberry pi and OpenCV library to distinguish laundry. After the lift carrying the laundry, the hanger mobile device is operated. We use this device to move the laundry above the folding laundry device. When the laundry is carried by the lift, hanger mobile device catches the hanger using the arm and moves

Table 1: The size of laundry

Clothes	Size(Japan)
Short-sleeved shirt	L
Long-sleeved shirt	L
Skirt	S
Trouser	M

along the rail. The rail is laid above folding laundry device. In other words, the laundry is moved above folding laundry device to place on it. After that, the system runs the folding laundry process.

3.2 Devices which are operated by the system in folding laundry process

In folding laundry process, the system controls folding laundry device behavior and it position. The folding laundry device consists of eight servo motor, one distance measuring sensor and Arduino. The size of the device is 1.2 meter length and 0.75 meter width. The servo motor is attached in panel of folding device as shown in Fig. 10. Panels can fold laundry by rotating servo motor that attached each panel. Also the arm and distance measuring sensor are attached in the panel as shown in Fig. 11. The sensor detects laundry that is moved by hanger transport device. In Fig. 11, when the laundry moved in the position that between the aluminum bar and the aluminum plate, the sensor detects the laundry. Thereafter, the arm of device is closed to fix laundry. The laundry is sandwiched between the aluminum bar and aluminum plate. After that, the laundry is stretched above the folding device. Thereafter, the hanger transport device removes the hanger from laundry. As a result, the laundry is placed on folding device. The horizontal position of device is controlled by servo motor.

4. Experiment

We checked the performance of the laundry folding system that we have developed. We have made the system fold short-sleeved shirt, long-sleeved shirt, skirt, and trouser. The size of clothes is shown as Table 1.

As a result of experiment, the system fold each of the prepared laundry successfully. The folded laundry is shown in Fig. 12.

5. Conclusions

We have developed the laundry folding system with removing hanger function. This system developed for the case of using a hanger to dry the laundry. The developed system could deal with laundry that state is hung the hanger by controlling each device in the system. This system could remove the hanger from the laundry in automatically by using special structure of the hanger. Also, it could fold the laundry. Further, we checked the performance of the developed system whether it can fold some kind of the laundry for the experiment. As a result of the experiment, this system could fold a short-sleeved shirt, long-sleeved shirt, skirt, and trouser.

However, we still have problems. The future issue of our study is folding the small size laundry, for example, socks, handkerchief, and so on.

(a) Step 1

(b) Step 2

(c) Step 3

(d) Step 4

Figure 12: The system folds laundry

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