関連報告

国際交流委員会特別企画「ARAHE2017講演概要」ーその２ー

Efforts based on clothing science to provide clothing life support for the elderly — Potential for linkage with robotics —

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In Japan, aging is already progressing at a rate unprecedented anywhere in the world, and a super aging society is coming into being.

When the elderly wear comfortable, functional clothes in daily life, it helps to improve their quality of life, and living support through clothing is indispensable.

However, previously the market potential for elderly clothing has been regarded as low, and thus at present there is little clothing which takes into account changes in body type and bodily function.

Improvements in elderly QOL (Quality Of Life) are needed in all fields. In an aging society with low birthrates, it will be essential to develop robots to get close to and assist people. Clothing is something which always accompanies people, and it can provide functionality by nestling close to the person. From this perspective, there is a dream of linking home economics with robotics.

Development of clothing-type robots is also expected. Possibilities for development in the first stage include: wearable body measurement clothing, clothing-type robots that can monitor health status, clothing-type robots to boost muscle strength, and tailor's dummies with variable size and posture. Some of these have already been developed, and some are in practical use, but as a person involved in clothing design, I would definitely like to develop variable tailor's dummies whose size and posture can be changed.

In the second stage, we expect to see development of excretion assistance robots and clothing-type robots with clothes-changing assistance functionality. Although they are still at the machine level, excretion assistance robots are already being developed. Today, I will report on some of the basic research for developing clothes-changing assistance robots.

As requirements for clothing of the elderly, we can mention: body type fit, motor/physiological function support, psychological effect, dynamic fit, anti-aging, and so forth, but today I would like to talk about examples of research relating to body type fit and motor/physiological function support.

The 3D silhouette for garments was created by using LookStailorX made by Digital Fashion Ltd., reading in the average shapes of both types of people captured with a body scanner into LookStailor, and taking the generated three-dimensional body shape (mannequin) to be a virtual tailor's dummy. For the 3D silhouette of the trunk part, a borderline was created using a princess line, and a comparative examination was done of the 2D tight fit patterns of the torso part up to the hip line in both cases, where the 3D body surface was expanded flat onto 2D pattern. (Fig. 1)

The solid line indicates an elderly person, but the front-back tilt of the body, which is a feature of the body type of elderly women, is indicated by the inclination from the front side panel waist to the shoulders, and the degree of fatness/thinness is apparent in the quantity of the center panel side of the front side panel. Also, the degree of curvature of the spine is apparent in the upper length from the waist line of the rear panel, and constriction of the waist of the rear side panel. (Fig. 2)

In the field of clothing, direct pattern making from 3D data is performed in this way, but we still cannot say that handling of all postures has been adequate. In particular, the situation is such that it is difficult to acquire 3D body data in a variety of postures.

I would like report on analysis results for the seated posture of elderly women.

In daily life, people spend a long time in a seated posture, engaged in activities such as eating, deskwork, computer operation, reading, and watching television, and the elderly in particular spend an inordinate amount of time seated.

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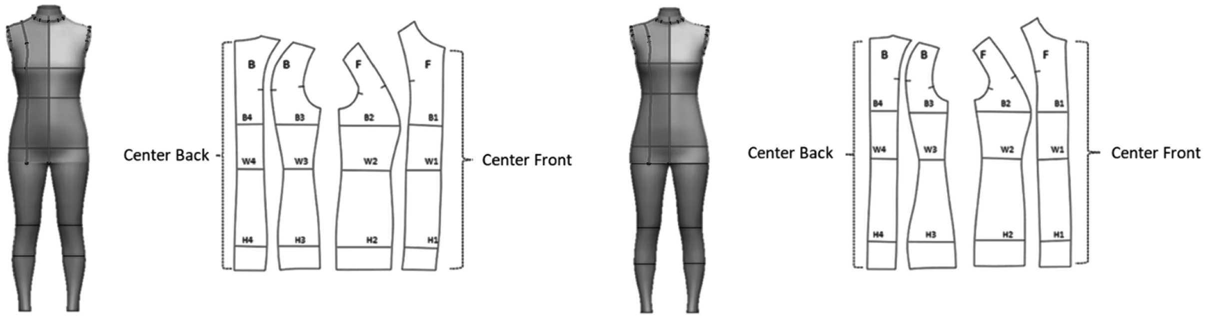

Fig. 1. The 3D body surface was expanded flat onto 2D pattern

(left: elderly, right: younger)

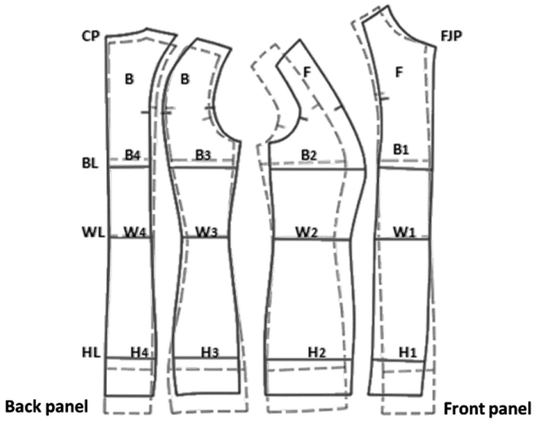

Fig. 2. The pattern overlay diagram for elderly and younger people

(Solid line: elderly, Dotted line: younger)

Nevertheless, almost no research has been done on the seated posture, and body size in the seated posture has not been clearly determined. (Fig. 3)

The 3D scan data was gathered for the seated posture, which are the main postures in daily life, and an analysis was conducted of the features of the body shape of the trunk of elderly women in the seated posture, based on a comparison of both postures. First, the average shapes in the seated posture were derived.

Body measurement using a body line scanner made by Hamamatsu Photonics corresponds to the 3D posture originally designated, and thus precision was first verified for the seated form as an object. As a result, it was confirmed that measurement can be done within the precision range of ISO, and therefore feet were placed the same as in the standing posture, the joint angle between the knee and ankle was set to 90°, the head was faced forward, and the upper limbs were opened at 20° from the body side.

Using 3D scan data for the measured seated posture, 29 anatomical feature points were selected, a homology model was created, and principal component analysis was carried out.

A homology model for the seated posture was created, and principal component analysis was carried out. In the results, the cumulative contribution rate up to the 4th principal component was 82.02%, and thus interpretation was carried out up to the 4th principal component.

For the 1st principal component, there is a major change in the shape of the back part, and therefore, this was interpreted as a factor indicating "degree of curvature of the spinal column."

For the 2nd principal component, there is a large change in the shape of the front face of the torso part, and thus this was interpreted as a factor indicating the "shape of the

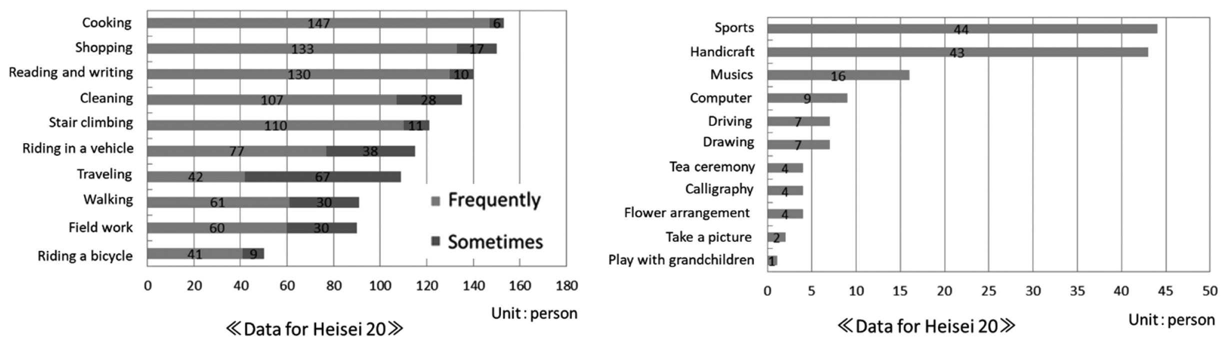

Fig. 3. Living behavior of elderly people

torso part front face." For the 3rd principal component, as the M +3SD shape is approached, the high diameter decreases, and the circumferential/width diameters increase, and as the M −3SD shape is approached, the high diameter increases, and the circumferential/width diameters decrease. Therefore, this was interpreted as a factor indicating the "balance of high diameter and circumferential/width diameters." For the 4th principal component, change in the high diameter item is small, but the shape of the circumferential diameter and width diameter is large, and thus this was interpreted as a factor indicating the "degree of fatness/thinness." (Fig. 4)

The figure 5 shows the average shape in the seated posture of an elderly woman. The protrusion of the stomach part, and the forward tilt and forward curve of the back face are striking, and it was shown that, in the design of seated tailor's dummies and lower body clothing for elderly women, increasing the degree of curvature of the spine, and the front and side faces at the stomach part are crucial elements which must be specially considered.

In this way, the situation is such that it is difficult to grasp the body type due to seated posture, and therefore it is indispensable to develop wearable body measurement sensors.

There are high expectations for the development of wearables enabling measurement under various body conditions, such as the elderly, the disabled, supine position, side supine position, and seated position. Therefore, research linked with robotics will be indispensable.

Next, I would like to mention about the problem of dressing and undressing by the elderly. For the elderly and disabled, changing clothes is a highly burdensome life activity.

Based on a field survey of dressing/undressing by 70-year-old women, it was found that as many as 46.7% have the experience of feeling that the actions of dressing and undressing are difficult. More specifically, 13% feel dressing and undressing are difficult with pullover designs, tight designs, and designs with rear fasteners.

As the dressing method, about 80% of the all subjects performed dressing actions using a method of raising the arms, spreading out the upper garment to the top side of the back face, and sliding the hands into the sleeves. (Fig. 6)

It is thought that, in the range where there is no strain in the person's own joint range of motion, putting precedence on joint motion from a direction in which movement is easy is important for carrying out smooth dressing and

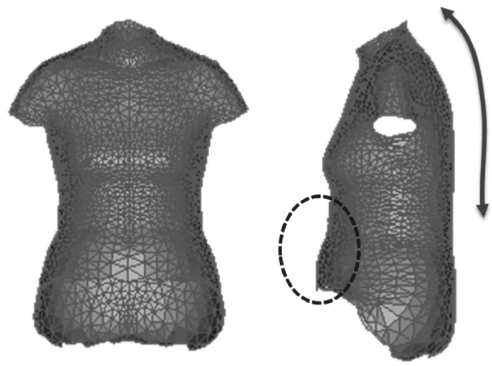

Fig. 5. The average shape in the seated posture of an elderly woman and size

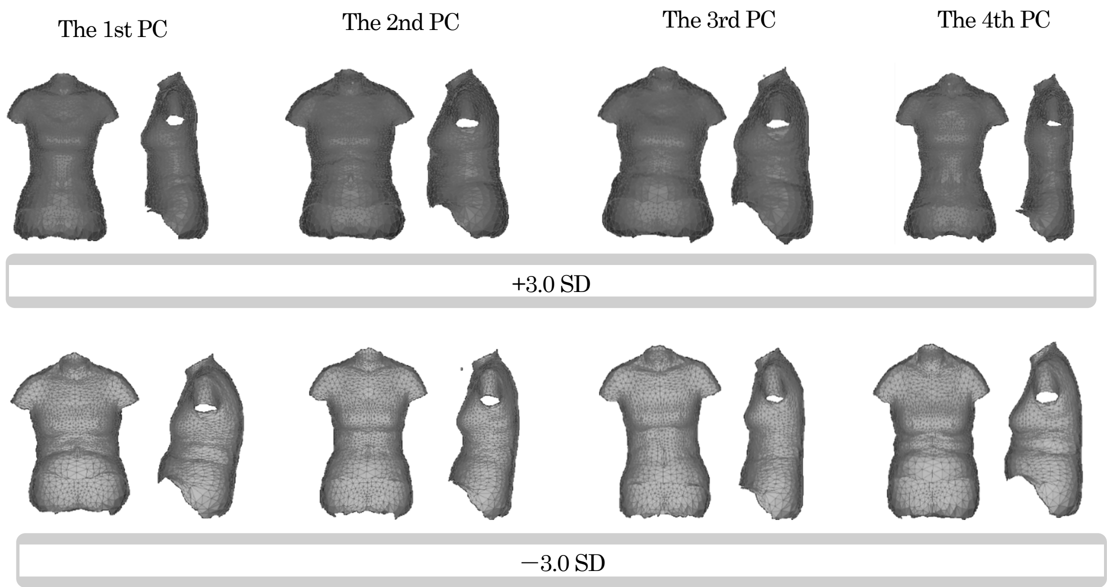

Fig. 4. Principal component analysis of seated postural homology model

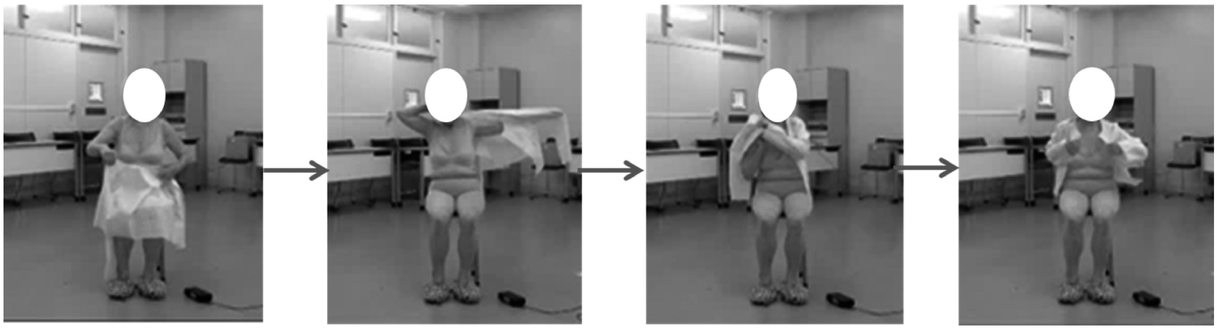

Fig. 6. A scene of the dressing action process of an actual subject

undressing actions.

Observation experiments were incidentally conducted on changes in the clothes morphology during dressing actions. The experiment was conducted in a 3D videography studio at Kyoto University. The scene of the dressing actions of a subject was captured with 12 periphery cameras and 2 top of the head cameras, for the multi-viewpoint simultaneous videography needed for generating 3D shape data. In addition, for the performed dressing actions, the method was taken to be raising the arms, spreading out the upper garment to the top side of the back face, and sliding the hands into the sleeves, a technique which appeared at a high rate in the previous experiment.

For the situation of clothing movements, it was decided to observe changes in the clothing shape in the process after the first action of passing the arms into the sleeves, through when the body part of the garment is passed to the shoulder of the opposite side, until completion of insertion into the sleeve of the subsequent arm.

The figure 7 shows the scene of passing through the

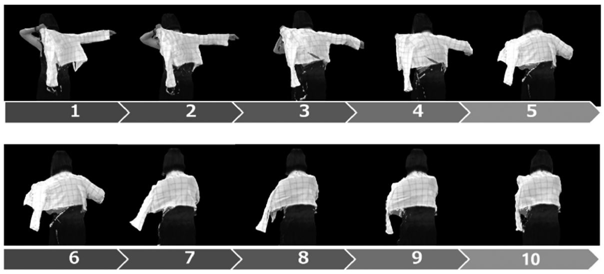

Fig. 7. The scene of passing through the subsequent arm

subsequent arm. There is large elongation of the back face in the scene of brining the sleeve to the top side, and the scene of putting hands into sleeves. The figure 8 shows the scene of dressing by a young person and elderly person. Elongation on the back surface is small compared to the elderly.

Based on 3D video analysis, it was shown that in dressing actions, the amount of elongation of the back part of clothes was large when passig the subsequent arm into the arm hole.

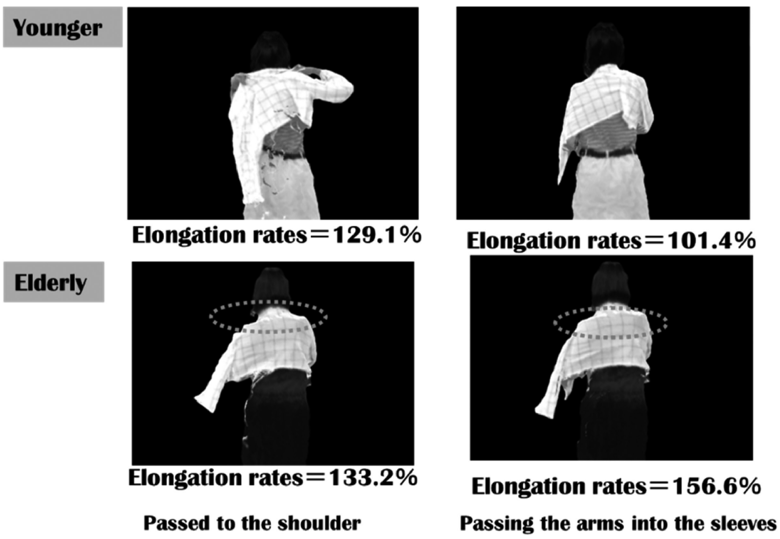

Fig. 8. The scene of putting later hands into sleeves

Fig. 9. Cape and bag made from optic fiber textile (Work by Ai Takizawa)

In this way, it is thought that, in the structure of upper garments for the elderly, there is need to increase the width of the back to make it easier to put arms into sleeves due to the abduction motion of the shoulder joint. Also, in the action of putting an arm into a sleeve cap, it was difficult to perform the action of catching the hand onto the sleeve cap at the top part of the side, from the state where the arm was bent, and thus it will likely be important to lengthen the sleeve cap curve, and increase the volume of the sleeve cap part, so the arm goes into the sleeve more easily.

One possible method for doing this is to make the amount of shirring at the sleeve cap part as large as possible.

I believe it is possible to accumulate information by conducting this sort of research with robotics researchers, who have high ability to analyze information, and it is not a dream to create robots through collaboration between the fields of robotics and clothing. In this case, experiments were carried out with a focus on healthy elderly people, but for disabled people and elderly people requiring care, it is likely that quality of life can be improved if there are robots not to perform all dressing, but to support changing clothes only during difficult actions.

I would like to list a number of possibilities for linkage between robotics and the clothing area:

1. If wearable sensors enabling body measurement can be realized, this will expand the possibilities of all product design for people.
2. Direct pattern design based on dynamic measurement is being realized, and improvements in precision are expected.
3. Today's robots are arriving at the framework level. Going forward, if it becomes possible to carry out high-precision muscle simulations, this will enable design of a diverse range of clothing.
4. My dream is to make variable tailor's dummies with the average shape of various body types. This will enable universal design of clothing. Recently, I've been thinking of creating average shapes for each sport for Olympic athletes, and a major challenge is the question of how to enlist subjects, but if this comes to fruition, I believe it will help improve results in the various events.
5. As mentioned in my presentation today, it is possible to develop robots to support clothes-changing by teaching the robots dressing and undressing actions.

The figure 9 is a cape and bag made from optic fiber textile to provide safety when elderly people are walking at night. I am also hoping for collaborations with wearables.

Finally, being healthy supports an aging society with low birthrates and a super aging society. There are more than a few things that clothing can do for that purpose. I believe that collaborative research with a broad perspective is essential for supporting the super aging society through clothing.

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