Development of the system to teach the bedsore prevention method for wheelchair users

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Abstract. In this study, we are developing the system to teach bedsores prevention method for wheelchair users. This system can measure the distribution of pressure by the sensor sheet when a wheelchair user sits on it, and show the measured result on the monitor by the color image. Therefore, wheelchair users are able to learn the bedsores prevention method under recognizing their distributions of pressure with the therapist. We measured pressure distribution and got differences between SCI people and AB people using this system, and we confirmed that it is important to measure pressure distributions and this system is useful to use when therapist teach the bedsore prevention method to wheelchair users.

1 Introduction

For constantly bedridden people and wheelchair users, bedsores is one of the most horrible diseases. The medical term used for bedsores is "decubitus ulcer". "decubitus" is the Latin word for "recline". Thus, bedsores are ulcers which break out when bodies are reclining. However, bedsores is also caused to wheelchair users by reason of the continuous sitting. Because sitting is the same condition to reclining in concerning of the pressure to the body. When those people are continuously lying or sitting in the same posture, pressure, which is the physical factor, is continuously maintained upon the same area of the body and closes the capillary vessels in that area, leading to the blockage of the circulation. As the result, tissues in that area undergo irreversible changes leading to death and bedsores break out.

It is usually said that prevention is the best strategy for bedsores. For example, restoration of healthy nutritional conditions or motive ability, keeping the area where bedsores often break out clean, reduction of the pressure, etc.. From a technical point of view, there are three ways to prevent bedsores, which are used singly or in combination.

- (1) Use of a mat or bedding designed to support the weight equally and to prevent pressure from centering upon one local area of the body.
- (2) To change the posture or to lift up the area under pressure at regular intervals by self-help or , if necessary, with the aid of helpers.
- (3) Reducing the pressure by moving the bedding, mat, etc. in stead of moving the patient's body directly.

Normally, wheelchair users learn the bedsores prevention method from the therapist

in hospital. For example, how to do the push-up, which is the best fit cushion etc.. However, there are no system and data to measure the distribution of the pressure, they teach it only by their experiences [1].

2 The aim of this study

In this study, we are developing the system to teach bedsores prevention method for wheelchair users. This system can measure the distribution of pressure by the sensor sheet when a wheelchair user sits on it, and show the measured result on the monitor by the color image. Therefore, wheelchair users are able to learn the bedsores prevention method under recognizing their distributions of pressure with the therapist. So this system belongs to the assist equipment when the therapist teach the bedsores prevention method.

3 System Configuration

3.1 The necessary conditions for System

In order to determine the mechanical relationship, measurement of the distribution of pressure between a body and a wheelchair seat is required. A number of methods have been suggested for it, such as pressure-sensitive films, load-cell matrix, pyramid-shaped matrix rubber sheets and switch arrays, but each method has its particular weak points to use this study. Most pressure distribution-detecting device are applied to flat surfaces only. If a device is applied to a flexible curved surface and each of the sensing transducers of that device is non flexible, the contact condition between a body and the transducer is poor. Also, as the sensors are placed at intervals of several centimeters, the spatial resolution of the device is fairly low. Moreover, since a large number of transducer necessitates many wires and amplifiers, the system is very bulky. Therefore, the measurement of pressure distribution between a body and a wheelchair seat has been impossible. The necessary conditions for measuring a moving body pressure distributions are as follows:

- (1) flexibility of sensors
- (2) availability of high-speed sampling
- (3) availability of high-density measurement
- (4) ease in processing detected data
- (5) ease in installing equipment

3.2 System outline

We have developed a tactile imaging system which meets above conditions. This system transforms 23×24 matrix pressure distributions, which are detected by pressure-sensitive conductive rubber sheets, into video signals. This enables various applications of the video signals by using a variety of video equipment. Using this system, you can not only see the pattern of image pressure distributions on a video monitor but you can also easily store images, restore and record by using a video tape recorder. You can also process the images with a computer.

Fig. 1 shows the components of the tactile imaging system. A tactile image sensor receives vertical and horizontal digital address signals from an imaging controller. It returns analog pressure distribution signals to the controller.

The imaging controller forms a video signal of the pressure distribution analog signals by adding vertical and horizontal synchronous signals. It sends the video signal of a monochromatic image of pressure distribution to an image processor or a video tape recorder.

The image processor connects with not only a monochromatic video monitor which shows images from the imaging controller, but also a pseudo-color video monitor which displays pressure distribution images as color contour lines.

A personal computer, NEC PC-9801, and an additional image input memory board are used as the image processor. This makes it possible to store 4 successive images in a 640kb memory.

Fig.1 Components of the Tactile Imaging System

Fig.2 Sensor sheet overview

Fig.3 Detecting point overview

3.3 Sensor Sheet

Fig. 2 shows the overview of the tactile image sensor sheet. This flexible sensor sheet consists of flexible print circuit comb-shaped electrodes and pressure-sensitive conductive rubber which changes the electric conductivity continuously corresponding to the applied pressure. Each detecting point is placed in a 23×24 matrix with an 16mm pitch. The size of the sensing area is $352\text{mm} \times 368\text{mm}$. The detecting point, a pair of 16mm square comb-shaped electrodes and a pressure-sensitive conductive rubber in 7.4mm diameter and 0.5mm thickness, are shown in Fig. 3.

Fig. 4 shows an example of data characteristics of the pressure-sensitive conductive rubber. When no pressure is applied on it, it shows very low conductivity or very high resistance over $M\Omega$, or it is almost isolated. Under a load of 30 Newton, the sheet becomes very highly conductive or has very low resistance. The resistance of the rubber sheet changes gradually and continuously, corresponding to the applied pressure. Fig. 4 also shows that hysteresis should be observed in the pressure-resistance characteristics, and therefore the tactile sensor is suitable for a relative pattern measurement, but is not recommendable for measurement seeking high accuracy of the absolute value [5].

Fig.4 Typical pressure-resistance characteristics of a sensor

3.4 Principle of Measurement for Pressure Distributions

A DC +5V current is put through a transistor and a current flows simultaneously into a row of inside electrodes, and then each outside electrode receives the current corresponding to the conductivity of the rubber sheet. At that time, a horizontal scanning circuit is transmitted to the outside electrodes through certain FET's, each in a 500ns time series. Subsequently, a time-serial signal of a horizontal row of the pressure distribution is given.

During this process, a DC +5V current is applied to the top row of inside electrodes for $64.5 \mu\text{s}$. Each gate of each FET connected to an outside electrode opens time serially from left to right during $0.5 \mu\text{s}$, driven by a horizontal address decoder and driver. A current corresponding to the row of the pressure distribution flows into an output line through each FET. Next, the 2nd line is indicated by the vertical address decoder-driver, and the time series current corresponding to the pressure distribution of the 2nd row is also transmitted to the output line. Successively, each row from the 3rd row down to the bottom row is time serially addressed by the vertical address decoder-driver, and a complete image of the pressure distribution is given on the output line in 16.7ms. Sixty images are produced per one second [2,3,4].

4 Experiments for Wheelchair Users

Using this system, we have measured pressure distributions of Spinal Cord Injured (SCI) people who use wheelchair and Able-body (AB) people when they sit on the wheelchair. Fig. 5 and Fig. 6 show examples of each data by the color image.

We got following results from this experiments.

- (1) AB people have wide area to support the body pressure and have almost same shape distributions (only the density and the size are different). However, SCI people have small area to support and the high pressure concentrate to one point. Furthermore, shapes of pressure distribution of SCI people are various.
- (2) Pressure distributions of AB people are changed little by little while they are sitting on the wheelchair. This is quite natural thing. However, pressure distributions of SCI people are not changed under same conditions.
- (3) When AB people slightly incline their upper body to right and left, the pressure distributions are changed according to their motion. In the other hand, pressure distributions of SCI people are not change even if they do same action.

From these results, it is important to measure the real-time pressure distribution of the wheelchair user when therapist teach the bed sore prevention method. Because their pressure distributions are variety and therapist must confirm that the prevention method, for example push-up etc., really release the high pressure or not.

Fig.5 An example of the pressure distribution of Able-Body person

Fig.6 An example of the pressure distribution of Spinal Cord Injured person

5 Conclusions

We have developed the tactile imaging system using the flexible sensor sheet to measure and show the pressure distribution of wheelchair users in real-time. We measured pressure distribution and got differences between SCI people and AB people using this system, and we confirmed that it is important to measure pressure distributions and this system is useful to use when therapist teach the bed sore prevention method to wheelchair users. And we also got good estimations from therapists who used this system.

Next stage, we will try to evaluate various cushions which are on the market from the point of the pressure dissolution ability.

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