COMPUTER AIDED PRESCRIPTION OF SPECIALIZED SEATS FOR WHEELCHAIRS

S. Reger, D. Neth, T. McGovern
The Cleveland Clinic Foundation

Introduction:

Many disabled individuals require specialized seating systems in their wheelchairs. The interface between the person and the wheelchair in crucial. Without an accurate fit of the support, pressure sores and postural deformity results. The cost of treatment of pressure sores and deformities are extremely high and are increasing. Currently, the prescription and fabrication of personal support systems is a highly subjective process that creates long delay and much expense before delivery of the seat and wheelchair.

To overcome some of the costs and delays, a new concept in clinical data collection is proposed through the use of an innovative computer aided prescription seat (CAP-seat). Interactive adjustments will be made by the clinical personnel using the pressure and contour information displayed by the instrument. The actual shape adjustments will be made by an array of low pressure pneumatic cylinders acting under either closed loop control to deform the foam seat and trunk support surfaces while the subject is sitting on it. The digitized shape data will then be available for computer aided manufacturing of the custom body supports. Using numerically controlled machinery such fabrication techniques are possible and will be developed in this project.

Previous Work

A positioning seat has been built for the passive measurement and quantification of body contours and pressure distributions. This work is a modification of the contour measurement seat developed at the University of Virginia(14). The device consists of a chair with an array of contour gauges in both the seat and back for measuring displacement, as well as a Texas Institute of Rehabilitation Research (TIRR) pressure evaluation pad for measuring pressure. An IBM PC/AT is used to process the data generated by the contour gauges and the pressure evaluation pad. The PC/AT is configured with 512 K Bytes of memory as well as an Analog-to-Digital Converter Card and an I/O Card. The hardware configuration is depicted in Figure 1.

The contour gauge arrays are each made up of 64 detectors. The individual detectors are simple in design, consisting of an aluminum shaft which descends through the supportive cushion and is attached to a linear potentiometer. The contour gauges have been built in modules of eight detectors, providing interchangeability and easy replacement. The detector output is a voltage level which corresponds to a given displacement of the supportive cushion. The output of each detector is connected to one of eight analog multiplexors. The multiplexors are controlled by the computer I/O port. Each of the multiplexors is accessed individually and the respective voltage levels are digitized by the Analog-to-Digital Converter. The digitized voltage level is then converted to displacement by a software routine which

utilizes a statistically derived linear equation. This equation. was derived by measuring the displacement of several detectors at a number of specified voltages. A linear regression was performed on the collected data resulting in the final equation

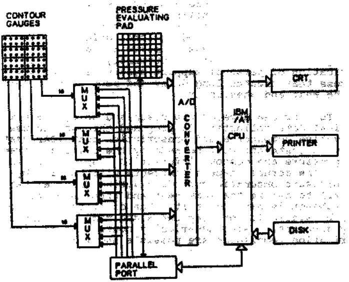

Figure 1: System Configuration for Existing Positioning Seat

which, when compared to the empirical data, **yielded an accuracy** of ± 1.10 mm. Once the data collection and conversion are **complete,** the results are used to create and display contour slices on the computer terminal. The data is also written **to a** which is automatically saved on disk. This data file **can** be used by a resident Computer-Aided-Design (CAD) package to generate three-dimensional models of the body contours. **An** a three-dimensional **model of** a seating contour is

The TIRR pressure evaluation pad consists of a **12 X 12** array of electro-pneumatic sensors. Each sensor consists of **a** pair of electrical contacts which are scanned by the computer for closure. The pad is initially inflated to a pressure at which all of the contact pairs are open. The internal pressure of the pad is measured with a manometer and is entered into the computer by the user. The internal pressure is then lowered to a specified point and the contacts are again scanned for **closure.** The internal pressure at which a contact pair **at a given point** is first closed is equal to the external pressure placed **on the pad at that point.** The internal pressure of the pad is **continually lowered until all** pairs of **contactors** are closed

This provides a means of measuring the pressure interface between the supportive cushion and the patient's body.

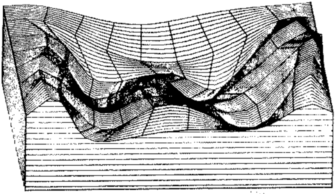

Figure 2: Three-dimensional Model of Seat Contour

Collectively these systems work well to record shape and pressure distributions at the patient-support interface. However, the present system does not allow the interactive modification of the shape and pressure distributions. The proposed system will overcome this by providing closed-loop feedback control to modify the shape and pressure distributions.

Proposed Work

The proposed system will provide closed-loop feedback control of displacement to actively modify the shape and pressure distributions. This will be accomplished through the use of low-pressure pneumatic actuators coupled to the existing system. A block diagram of the proposed system is shown in Figure 3.

Each of the aluminum shafts used in the contour gauges will **be** connected to a pneumatic cylinder. The displacement of the shaft is controlled by increasing or decreasing the pressure supplied to that particular pneumatic cylinder.

The CAP seat system will be tested on patients with cerebral palsy or multiple sclerosis at the Rehabilitation Engineer**ing Clinic of the Department** of Musculoskeletal Research. The **results will be evaluated by** comparison to the current method **using dilatancy casting of the same client. The digitized shape of the cast will be used as the control data. The digitized mold shape will be correlated with the shape data obtained from the clients in the CAP seat. For both control and experimental data, the clients will be positioned by the clinic team in a**

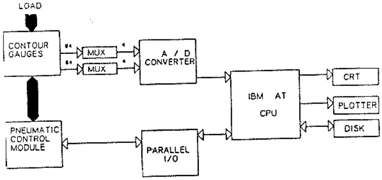

Figure 3: System Configuration for Proposed CAP Seat

subjectively good posture. The results of the comparison will be used to show that the computer aided prescription yields shape data as reliable and effective as the hand cast technique. The potential improvement in cost effectiveness and speed of delivery will then be of great benefit to the patients.

ABSTRACT

Many disabled individuals require specialized seating systems in their wheelchairs. The prescription and fabrication of specialized seating is a highly subjective process that creates long delay and much expense before delivery of the seat and wheelchair. To overcome some of the costs and delays, a new concept in clinical data collection is proposed through the use of an innovative computer aided prescription seat (CAP-seat). A positioning seat has been built for the passive measurement and quantification of body contours and pressure distributions. The device consists of a chair with an array of contour gauges in both the seat and back for measuring displacement, as well as a Texas Institute of Rehabilitation Research (TIRR) pressure evaluation pad for measuring pressure. The proposed system will provide closed-loop feedback control of displacement to actively modify the shape and pressure distributions. This will be accomplished through the use of low-pressure pneumatic actuators coupled to the existing system.

KEY WORDS: CAT-CAM Seat, Pressure, Wheelchair, Contour