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SIGNAL PROCESSING OF ANTHROPOMETRIC DATA

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ABSTRACT

The Anthropometric Measurements Laboratory has accumulated
a large body of data from a number of previous experiments. The
data is very noisy, therefore it requires the application of
some signal processing schemes. Moreover, it was not regarded
as time series measurements but as positional information; hence,
the data is stored as coordinate points as defined by the motion
of the human body.

The accumulated data defines two groups or classes. Some
of the data was collected from an experiment designed to measure
the flexibility of the limbs, referred to as radial movement.
The remaining data was collected from experiments designed to
determine the surface of the reach envelope.

The purpose of this project is to design and implement an
interactive signal processing package. Since the data does not
include time this package does not include a time series element.
Presently the results is restricted to processing data obtained
from those experiments designed to measure flexibility.

Center Research Advisor: Barbara Woolford

INTRODUCTION

An accurate analysis of human motion is required if substantial improvements in suit and control panel design are to be obtained. In [1] it has been indicated that efficient well designed workstations must take into consideration the interactive role of the human operator. Garg and Kohli, [2], indicate that complex equipment produced during the second world war operating as high speed generally required unusual capabilities beyond the operator. They further indicate that the design of equipment must take into account human capacities and limitations. This requires the acquisition, processing, and interpretation of large amounts of data.

At NASA/JSC the acquisition is accomplished by the use of a modified SELSPOT system as illustrated in Figure 1. The system consist of four cameras used to measure position, a monitor to view the experiment and data transfer, a pair of 6502 microprocessors for handling the data and controlling the hardware, and a video tape recorder. This system can provide for the acquisition of three dimensional data with time and LED identification numbers. Thus each point can be defined by the five-tuple: (x,y,z,t,i). The VRA (Video Recording Adapter) records not only visual image but data. Positional data from, up to thirty, LEDs which emit IR radiation are measured and digitized by the cameras. The acquired data which is stored on the video tape is then processed by the HP-21MX system. Bixon, [3], provides a functional description of the acquisition system.

The processing consist of several programs designed to format and plot the data. This project provided some statistical processing

capability. The software system consist of the following program

&MPIN1 A package designed to transfer the data from the
VCR to the HP disk on the HP-21MX system.

&CHKFL A package to rearrange the packed bits thereby
reconstructing the actual data.

&FRI'01 A package to determine the frequency, range, median
and mean of the data associated with each LED.

&SELVC A package which computes the coordinates of each
LED.

&CAL*L A package which computes calibration points.

&XYZTP A package used to generate a tape containing the
XYZ coordinates for transferring to the VAX-780.
At present the time is not tra   rred.

PLAID   A package used to generate some graphic displays.
Is implemented on the VAX. An interactive package.

PROJCRT A package used to aid in filtering the data main-
tained on the VAX. The package is interactive.

The interpretation segment will involve two primary segments:
formulation of mathematical models for various limbs and imple-
mentation of these models for simulation. There are numberous papers
on the subject, see [4], [5] and [6]. The initial stage is to acquire
a data bank of statistical information related to human motion.
This data bank must include data related to the design of seats,
control panels, control modules, and operational procedures. With
such a data bank a system can then be devised which will permit
the designer to use a graphics terminal for designing a particular
interface, then test the design for general use by allowing a bubble-
man, Refs.[7] and [8], to work through the various operations.
Such a project will require many new techniques: pattern recognition,
artifical intelligence, computer graphics, data base methodology,
and the like. At present work is just beginning and the project
consist primarily of data acquisition.

A SIGNAL PROCESS SYSTEM

It has been indicated that there are two problems. One related to radial movement, the other related to reach envelopes. This section considers only the first. Since the radial movement involves a limb moving through a fixed pattern the data will closely approximate a circle as seen in Figure 2. Hence this geometrical structure is implemented in the system.

In looking for existing technique some variations of a number of time series models were tried. See [9], [10], [11], and [12]. A design of one of these methods will be included later, but the process presently consist of employing manual selection, moving averages, and some statistical methods for removing the noise. These techniques are designed to use the best fitting circle.

In quickly reviewing the package, we note that the system begins by asking which file is to be processed. The data is read. Initially it contains the coordinates for all LEDs in a multiplexed form. If we select a single LED the data is demultiplexed and the corresponding data is retained. Then we may select to display or not to display this data on the terminal, a Digital VT125 or equivalent. This should be done since it provides us with the opportunity to judge which data is valid and which is noise. In addition, the plotting gives us a feeling for the particular motion envolved. We then estimate the center and radius of the best circle. Next, the system applies a moving average for the purpose of removing isolated spikes. On completion of these smoothing processes we are asked if we wish to manually remove any data we view as noise. Again we are queried with regard to plotting. We may estimate the parameters for the best circle again, after which the system determines the parameters for the best circle and prompts for replacing the

generated value or leaving them as calculated. Once the parameters
are determined the circle is used to remove any data not lying withing
a specified band defined by the circle. The remaining data is then
used to generate the parameters of the best circle. The center of
this best circle is then used to partition the plane into a number of
wedges. The data lying within a wedge is then used to define a new
set of values, namely the distance from the center of the best circle
to the data point. These distances are then ordered, smallest to
largest. Next, a set of differences, $DIST(J+1)-DIST(J)$, are formed.
This last set of values is used to define a cluster measure which
is the standard deviation of these difference. This cluster measure
is then used to cluster the set of distances. See Figure 3. The mean
and the standard deviation of each cluster is then determined and
retained. These averages and standard deviation are converted to
plane coordinates using the angle which bisects the wedge. If there
are too few data points the system assumes that the wedge does not
contain any data. Using the wedges a set of expected values for
the angles is determine along with the number of data points in
the wedge, and the associated standard deviation. This information
is made available for writing to a disk file. Clearly, small sample
statistics must be employed. Finally, the user is queried on
whether he desire to write the results to the file or simply quit.

FUTURE

In closing a number of future directions should be pointed
out. Some are related to the area of signal processing, others
are related to the use of the computer as a designing tool in the
area of human factors. These include:

* Implement a time series approach, i.e., use an FFT.
* Modify the system to permit hardcopy of all graphics.

* Modify the read file subroutine to read new data
  files containing time and LED numbers.

* Develop and implement an algorithm for processing
  reach data and thereby determine a reach envelope.

* Increase the intelligence of the system by providing
  it with the ability to remove any data which is not
  within reach.

* Implement Ted Kall's subroutine to permit unsolicited
  input.

* Begin the task of designing a data base for the over-
  all problem of computerized control panel design.

* Try to develope a statistical theory for convex
  combinations of normal distributions.

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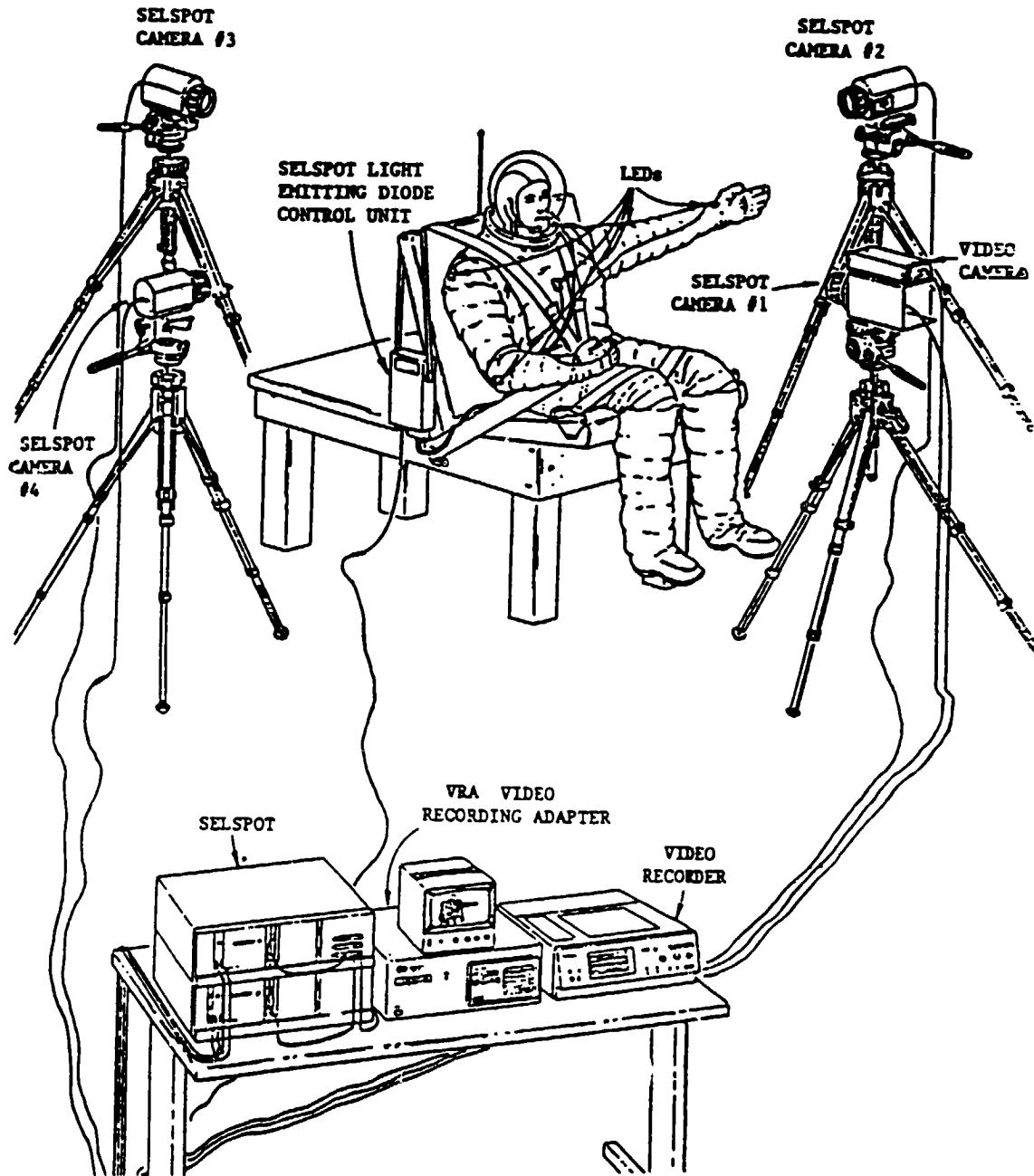
Figure 1. Anthropometric Measuring Setup

ANTHROPOMETRIC
MEASURING LABORATORY

DATE/TIME:14-JUL-83

FILE NAME: X4061S.DAT

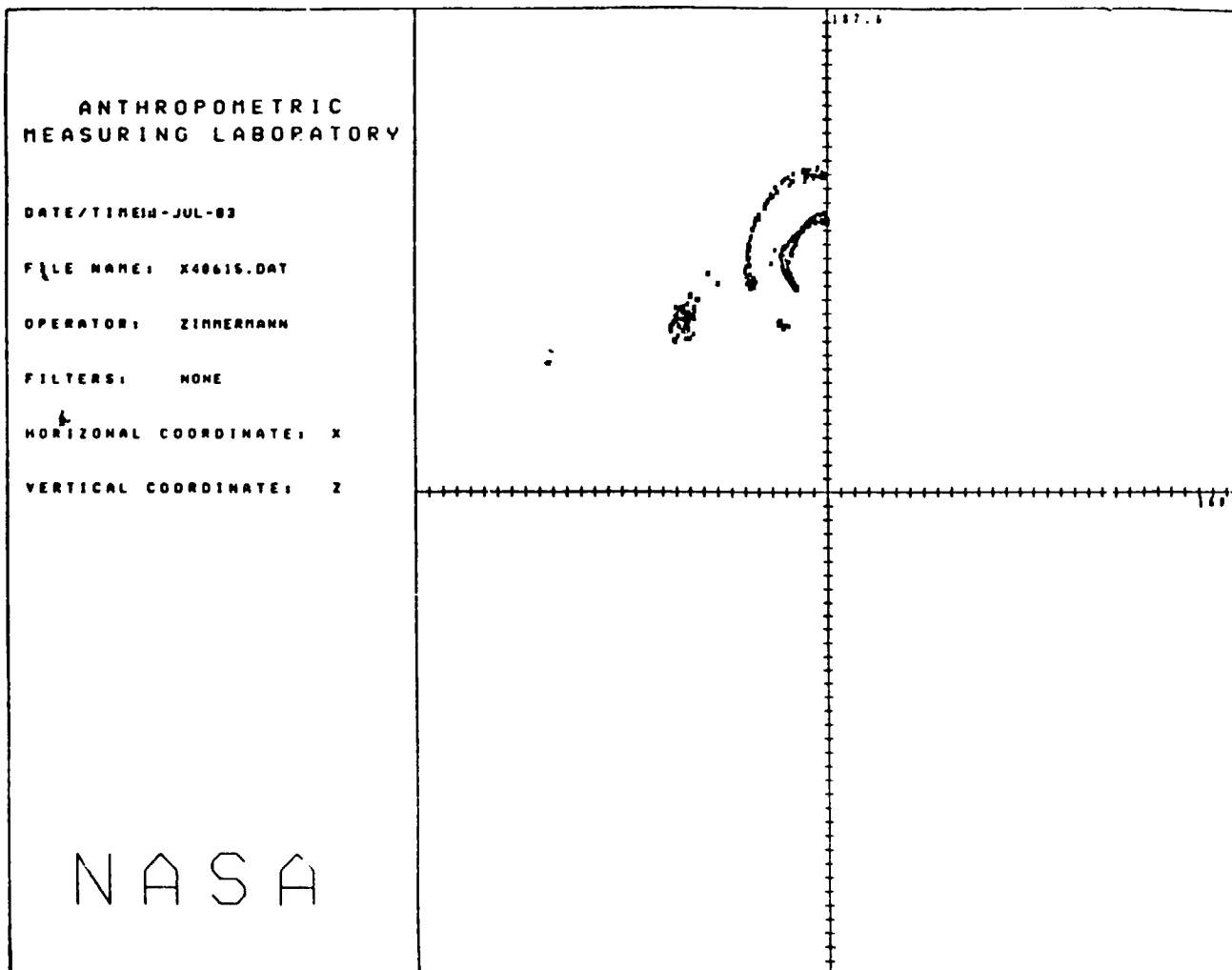OPERATOR: ZIMMERMANN

FILTERS: NONE

HORIZONAL COORDINATE: X

VERTICAL COORDINATE: Z

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Figure 2. Radial Motion Data