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3D Mapping Method for Non-Spherical Objects

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ABSTRACT

The most prevalent 3D mapping system for any non-spherical or round objects is laser scanning. But there are some applications where we need to map certain main object which is covered with other unwanted objects, which hinders the mapping of the main object. For example, in the mapping of human scalp, hairs are the unwanted objects and hinder the mapping of the scalp. The laser scanner is not capable to scan only the scalp portion of the head it scans the human head along with the hairs. It requires other approaches to solve this problem. In this paper, we propose a new approach to scan the non-spherical objects with the help of contact sensors like LVDT.

Keywords: Sensing Technology, LVDT application, scanning of human head.

I. INTRODUCTION

The 3D mapping system like laser scanning and CMM scanning are the most widely used 3D modeling systems. There are few applications where a customized approach is required to map the object. The new customized approach proposed in this paper was specifically designed to scan a non-spherical or round objects like human scalp. The human scalp can also be scanned by CMM and laser scanning systems but there is a constraint to it. The human scalp is covered with human hairs. While scanning with the conventional methods the mapped model includes the human hair in it. If we want to scan only the scalp portion of the human head then it is not possible with the conventional approach. This paper proposes a new approach to scan the non-spherical and round objects like human scalp by eliminating the unwanted objects like hairs. The new system uses spring-loaded Linear Voltage Differential Transducer (LVDT) as a sensor with a Roller tip attached to its end. The Roller tip is pushed towards the object with the help of the spring in the sensor. Consequently, the roller tip compresses the hairs and rolls on the rigid scalp of the human head with reference to a fixed frame. This contact sensing approach makes the system capable to map and scan only the rigid scalp section of the human head eliminating the hairs on it.

II. EXISTING APPROACHES

CMM: The Computer Measuring Machine (CMM) is a measuring device which measures the physical geometrical characteristics of an object. Measurements are defined by the probe attached to the moving axis of this machine. Several types of probes are available like mechanical, optical, laser, or white light. These machine takes readings in six degrees of freedom and displays these readings in mathematical form. This machine gives a high precision measurement values and widely used on metallic surfaces. Several configurations are available based on the applications like Bridge, Cantilever, Gantry, and Horizontal Arm. These are applicable to flat surfaces with some slopes. But fails in applications having non-rigid and plastic surfaces.

Laser Scanning: The laser scanning combines controlled steering of laser beams and a laser rangefinder. It takes the distance measurements from every direction and the scanner rapidly captures the surface shape of objects, buildings, and landscapes. Construction of a full 3D model involves combining multiple surface models obtained from different viewing angles, or the admixing of other known constraints. Scanned laser beams are used in 3-D printers, in laser engraving and barcode scanners. This scanning method gives the precise 2-D image and 3-D image of objects but in the specific application of scanning the human head the laser scans the physical geometric shape of the hair.

CT Scanning: Computer Tomography scan, makes the use of a Computer-processed combination of many X-ray measurements taken from different angles to produce cross-sectional tomographic images (which can be said as virtual slices) of specific areas of a scanned object, allowing the user to see inside the object without cutting. Digital geometric processing is used to further generate a 3-D model of the object from a large series of two-dimensional radiographic images taken around a single axis of rotation. But this has some disadvantages if the scanning is done repeatedly it is hazardous to the human body. The setup of the CT scanner is very huge and expensive which makes this system unfavorable to use it on the human body.

III. PROPOSED SYSTEM

The only inputs to the System are the linear voltage differential transducer (LVDT) sensors and the stepper motor angles. The stepper motor is coupled to the circular frame and it moves the circular frame to a certain angular position on its axis. The array of LVDT sensors are arranged on the circular shaped frame in such a way that the axis of all the sensor is aligned exactly at the center of the circular shaped frame as shown in the figure.1

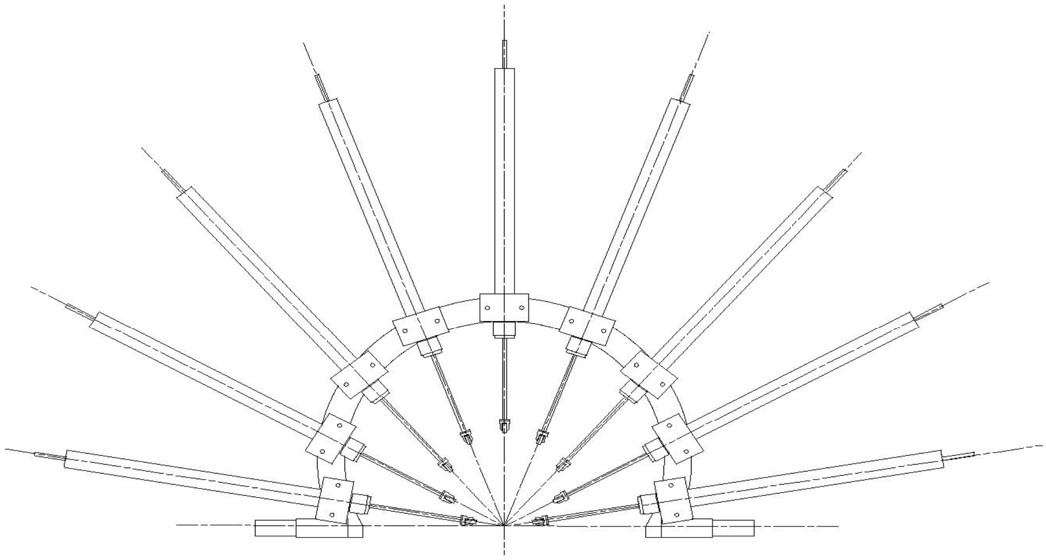

Fig.1 The arrangement of sensors on the circular frames.

The human head or any object to be sensed requires to being held fixed with respect to the system so that the values received will be precise and helps to maintain the repeatability of the system. After the head or the object to be sensed is held fixed the circular frame is moved from the initial position to the end position. The angles from the stepper motors are taken as a reference for the values of LVDT. The following figure.2a, 2b shows the initial and the end position of the movement of the circular frame.

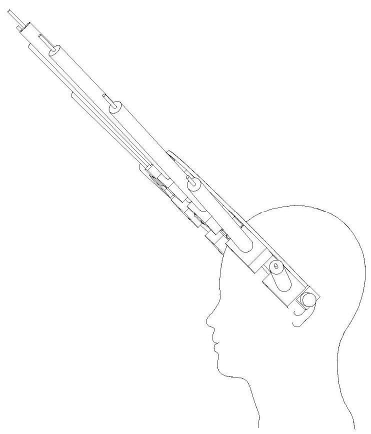

Fig.2a The starting position of the Circular frame.

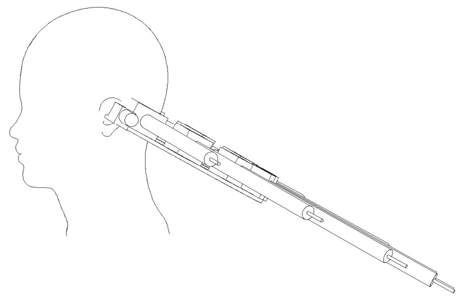

Fig.2b The End position of the Circular frame.

Each LVDT has a roller tip at the end. This roller tip rolls smoothly on the surface of the scalp. The roller tip is attached to the spring portion of the sensor. This spring pushes the roller tip against the object or towards the center of the circular frame. Consequently, the roller tip compresses the human hair placed on the head and rolls on the rigid portion of the human scalp. The hairs will surely create an error in the scanned values as compared to the real model values. But the error is very minute because the diameter of the human hair is around 0.1mm or 180 microns thick. This error is very minute and can be compensated in the software modeling of the system.

The values of 9 LVDT's are taken an each increment in the increase of stepper motor angle. These values from stepper motor is in the form of voltages and the precision is very high. The position of each LVDT with respect to the frame is known and the position of its roller tip with respect to the body of LVDT sensor is known for each value of the voltage in the LVDT. The voltage value of each LVDT is converted to the Cartesian coordinates of the system. For each position of the stepper motor, we get a set of 9 voltage values form 9 sensors. At each step increase in the stepper motor angle, there will be a new set of voltage values. The sensor values are then converted to Cartesian coordinates with respect to the circular frame and then they are converted to the Cartesian coordinates with respect to the system's frame of reference. Then this all values are provided to the Computer modeling software. Then the 3D Model of the object to be scanned is achieved.

Further equipment's required are a microcontroller to take the input, a power source to provide power, a power board to distribute power, a stepper motor, a stepper motor driver and a computer to input the coordinate values. The mechanical apparatus includes a circular frame, two numbers of bearings and few miscellaneous components like fasteners.

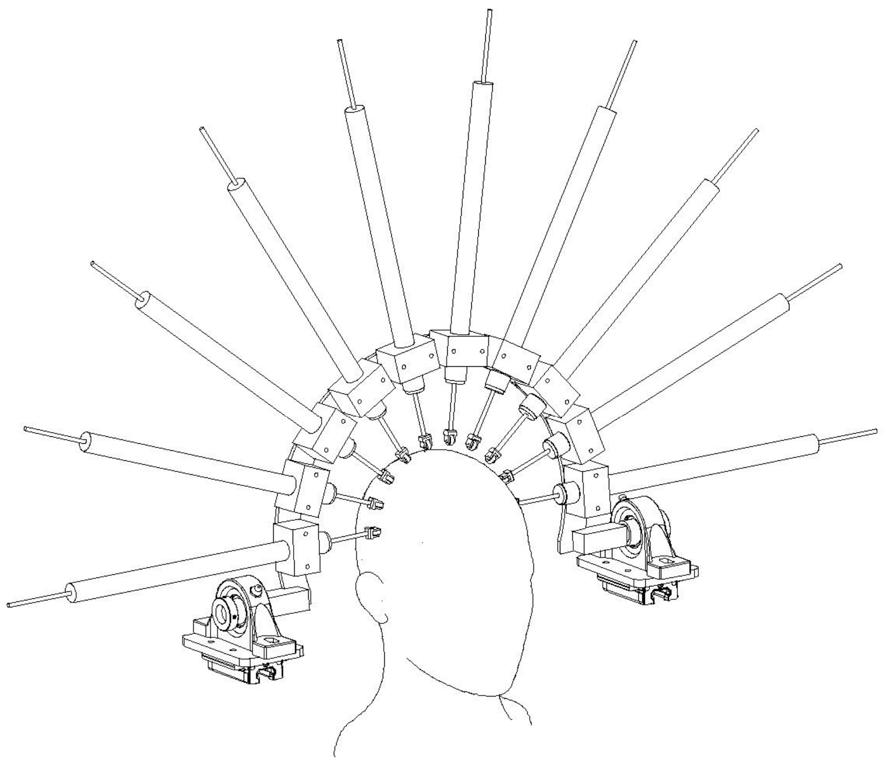

Fig.3 Arrangement of the object to be scanned and the sensing system.

IV. EXPERIMENTAL RESULTS

The Sensor values at a particular position of circular frame are taken and the position of the sensor with respect to the frame is noted and the coordinate values of the Roller tip with respect to the circular frame is computed as (X1, Y1)

Sensor Number	Sensor values(V)	Displacement	Polar(r)	Polar(Θ)	X1	Y1
1	18.7	117.4	82.6	330	71.5	-41.3
2	19.2	118.4	81.6	340	76.6	-27.9
3	19.7	119.4	80.6	350	79.3	-13.9
4	19.4	118.8	81.2	360/0	81.2	0
5	19.2	118.4	81.6	10	80.3	14.16
6	18	116	84	20	78.9	28.7
7	16.3	112.6	87.4	30	75.6	43.7
8	14.7	109.4	90.6	40	69.4	58.2
9	12.8	109.6	90.4	50	58.1	69.2
10	12.9	105.8	94.2	60	47.1	81.9

11	14.7	109.4	90.6	70	30.9	85.13
12	17	114	86	80	14.9	84.6
13	16.8	113.6	86.4	90	0	86.4

Table1. The Coordinate values are computed with respect to the circular frame of reference.

V. ADVANTAGES OF THIS APPROACH

Features:

- The system can eliminate the unwanted objects which are on the object to be scanned while scanning.
- Can scan in less time due to more number of sensors.
- Can scan non-spherical, spherical, and round objects.

VI. CONCLUSION

This paper has touched on the key points of the various scanning systems available and focusses on proposing and explaining a new approach of the scanning system for specific application of scanning human head. The new approach is equally precise as compared with other systems and gives repeatable values.

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