Volume : 5 | Issue : 1 | January 2016 ISSN - 2250-1991

Research Paper Engineering

A TACTILE SENSORS SYSTEM

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ABSTRACT

The proposed sensor system is a complex electromechanical system, which sends information as a result of the physical interaction with an object. The tactile sensors are modelled after the human model. The tactile sensor system is important because it can offer information about the shape of objects. The proposed sensor is made out of a sensible elements matrix in the form of tactile cells. This matrix system can give information about a 2D image as a consequence of a contact pressure between sensor and object. The determination of the object's third dimension is obtained by the deformation of an elastic object, on which electro resistive transducers are applied, as a result of touching the object in question. This third dimension is given by the overlap between the sampling planes obtained after the multiplexing of the measurement points of the tactile cells. The tactile sensible system is defined by sensory technique, which incorporates the total software and hardware operations.

KEYWORDS sensors, tactile, cell, transducers, interfacing

INTRODUCTION

Tactile sensors can be used for different applications. In the domain of robotics, tactile sensor systems are designed to interact with objects of different shapes, which need handling. These systems can offer visual information when the robot starts to touch an object. The robot must work with the objects by handling them directly and to interact with them safely. In robotics the tactile sensor is formed from a matrix of elements, ensuring the determination of the contact pressure distribution. The tactile sensor system is based on tactile cells arranged under a matrix form of elements. By dividing the contact surface into measurements point matrices, a 2D imagine can be obtained. For determining the third dimension a displacement sensor is used. The correlation of the information given by the overlap between the 2D images with the information coming from the displacement sensor gives the 3D image of the handled object. The tactile sense is important within this context, due to the fact that it helps in determining the estimated dimensions, such as the shape of objects [1], [3], [7].

SENSOR CONSTRUCTION

The binary three - dimensional matrix sensor, that is proposed in this paper, is obtained from the tactile cells, which use for displacement detection sensing needles, as part of the sensor [5].

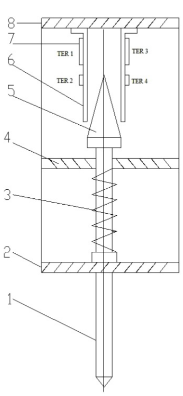

Figure 1: The tactile cell

The tactile cell with detection transducers is presented in Figure 1 and composed out of the following elements:

1- the sensing needle;
2 - the inferior plate;
3 - the compression spring;
4 - the intermediate plate, that constitutes the reference element;
5 - the cone made out of electrical material;
6 - the elastic lamellas;
7 - electro resistive transducers, TER;
8- the superior plate (electrical insulation).

WORKING PRINCIPALE OF THE CELL

Under a pressure (force) the sensing needle 1 is displaced, achieving an elastic contact between the lamellas 6 by means of the cone 5. In this way the achieved electric contact corresponds to the "1" logical level, which further corresponds to the state change of tactile cell from the sensory elements' matrix [3], [5].

The state change of the tactile cell can also be emphasized by means of the assembly constituted from the elements 6 and 7 that represent a sensor with detection transducers. The electro resistive transducers (TER) are connected in a circuit, achieving a Wheatstone bridge. This bridges is in equilibrium, according to the '0' logical level, as long as no force acts on the sensing needle.

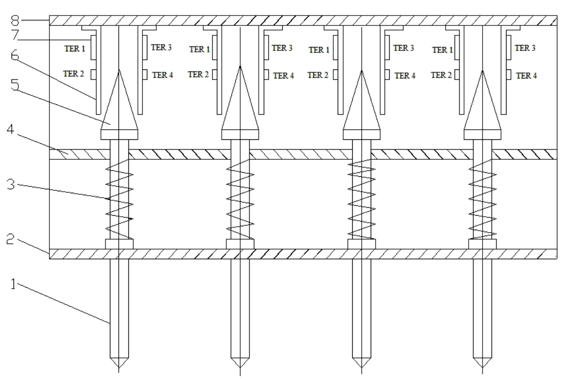

Figure 2: The tactile sensors - 3D cell

The displacement of the sensing needle, caused by a force acting on it, involves the deformation of the lamellas and in the same time the unbalance of the Wheatstone bridge, that corresponds to the "1" logical level.

The determination of the third dimension it achieved by means of the sensors with detection transducers, depending on the deformation of elastic elements 6. This deformation is given by the displacement of sensing needle. By gauging the sensors with detection transducers, the third dimension can be determined, depending on the unbalance value of the Wheatstone bridge, as mentioned before.

SENSORS CONSTRUCTION AND THE WORK PRINCIPLE

The binary three-dimensional matrix sensors with detection transducers shown in Figure 2, can contain a certain number of tactile cells, depending on the application area and desired accuracy [3], [5].

The structure of the sensing system can be reduced to a single tactile cell with elastic element and the four electro resistive transducers connected by a Wheatstone bridge.

Under the action of a force, the sensing needles displace – achieving binary contacts between the elastic elements, by means of the cones – deforming in the same time elastic elements, what it corresponds with bridges lack of balance.

The measurement is achieved in an indirect manner and it offers two kinds of information. The first information is obtained at the realization of electric contacts, by the sensing needles displacement that is in contact with the object. The second information is obtained by successive sampling, at the same time with the sensing needles movement. Their position is determined by means of the graduation curves of sensors.

The third dimension is given by the overlapping of the planes obtained by reading the values of the tactile cells matrix. The contact between the sensing tactile system and the object will lead, depending on the object's shape, to the bending of the elastic elements. The Wheatstone bridge is, thus, unbalanced and the measured value of the parameter is a function of the third dimension that defines the position of the sampled 2D planes.

TACTILE CELL INTERFACING

The output of a Wheatstone bridge is a value with a magnitude of 10^{-3} volts (millivolts) and it is obviously an analogue signal.

For the sensor's interface analog – digital converters (DAC) are used. The value of the input signal for the converters ranges from 0 to 2 V. Under these conditions the signal coming from the Wheatstone bridge if amplified for the interval 0-2 V.

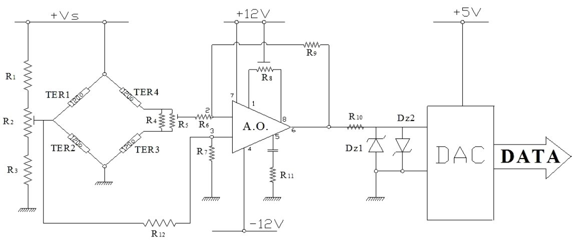

Figure 3: The electric diagram for measurement

For the sensor's interface analog – digital converters (DAC) are used. The value of the input signal for the converters ranges from 0 to 2 V. Under these conditions the signal coming from the Wheatstone bridge if amplified for the interval 0-2 V.

Figure 3 presents the electrical diagram of the tactile cell's interfacing, which includes the Wheatstone bridge with the balance circuit formed from the fixed resistors R_1, R_3 and the variable resistor R_2, the computing amplifier, AO, and the analog – digital converter, DAC. The signal transmitted to the data bus, DATA, represents the value of the object's third dimension [7].

THE SENSORS INTERFACING

The measurement of the sensing needles displacement from the tactile cells, the components of the binary three-dimensional matrix sensor with detection tensometer, can be achieved by using the technique of parallel measurement in a number of points [5]. In order to read all measurement points of the tactile cells of the tactile sensing system an electronic multiplexer device is used. All the measurement points are read in real time and the signals are sent through the data bus. The advantage consists of the fact that there are no switches, each measurement point being permanently connected and also having possibility of determining the sensing needles' position from the tactile cells.

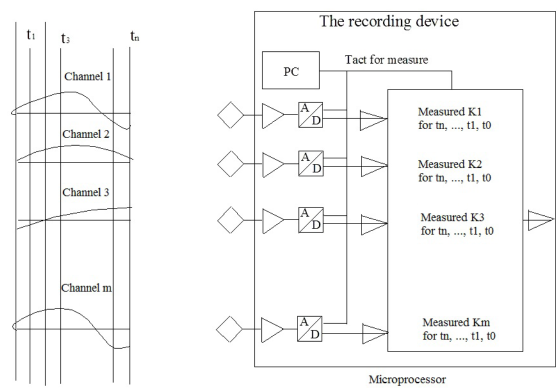

Figure 4: The block diagram for the MPDM measurement procedure

The technique of parallel measurements of the tactile cells of the tactile sensing system represents a synchronous determination in real time, which allows to obtain the 2D image, (with univocal temporary attribution of the measurement values), or as the attribution by juxtaposition, for example at the recording of one or more elongations dependent on the strain (the measured elongations are represented depending on the measured strain).

The Wheatstone bridges of the tactile cells of the system generate analogue signals, which are amplified, converted to digital signals and sent to the data bus of the computer. The speed of transmitting the data depends on the configuration of the connection and transfer elements of these data, as well as on the manufacturing technology of the electronic devices.

The processing technique of the signals which are sent by the tactile cells through parallel measurements uses multiplexers. In this situation it is necessary to implement a common analog – digital converter for all the measurement channels. The signals are transmitted to this converter by means of multiplexers. The purpose of the multiplexer is to shift the measurement signals, which are taken in a parallel manner over a sensing cycle, in time. Because of the discrete sensing – in time – of the measurement signals through multiplexer, it is necessary to use a sampler and a zero-order hold, and before these an antialiasing filter.

The modern technique of measuring values generated simultaneously, due to a physical process, allows real time evaluation and processing of the data, by means of software and hardware technologies. The system that works with the conversion procedure MPDM is represented in Figure 4 [6], where the block diagram of such a device with more than one channels is given.

The received signals from the tactile cells form a data base for each channel distributed to the cells that form the sensing system. Related to the time base of the determination system this data generates different curve sets that define the object's shape.

The channels can be equipped with different amplifiers, so that besides the electro resistive transducers more transducers can be connected. The measurement channels are synchronized by means of a central oscillator with quartz that offers an exact temporary attribution of the measurement signals for all channels. The processing central unit takes over the measurement values of all the channels and it saves them in an intermediate memory, from where they are transmitted, via a parallel or series connection, to the computer. Because the measurement amplifiers are fully adjustable by means of a computer, for the devices with measurements in points all the adjustments can be made from the computer. The measurements conducted through this method define in real time the 3D the image of the studied object. Through this procedure the objects can be identified and the technological process that uses the tactile sensing system accomplishes the function for which it was designed.

CONCLUDING REMARKS

The binary three-dimensional tactile sensor with detection tensometer compared to known three – dimensional sensors presents the following advantages:

Simple construction;
High accuracy;
The detection tensometer can be used for the state determination of the nodes from the lines and columns intersection as well as for the displacement variation of sensing needle in a tactile cell.

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