Design and Manufacture of Non-Contact Type Dimension Measuring System

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Abstract. *In today's world, manufacturing companies rely heavily on their suppliers to provide the correct components which meet the highest quality standards. A shipment which does not meet the quality standards can stall the entire line of the manufacturer. Corrugated boxes are components that are used by almost every industry. However, companies inspect only one or two boxes per batch. The researcher has tried to develop a low cost semi-automatic system which can be used to achieve 100% inspection. The system also allows the company to measure multiple SKU's with dimensions ranging from 100mm to 3000mm. A provision for storing data of the measured boxes is also made available for further quality analysis. The researcher has used IR sensors and has managed to design the entire system for less than $250.*

Keywords: *Quality Inspection, 100% Inspection, Low cost, Infra-red sensors*

INTRODUCTION

Cardboard boxes are widely used in the industry for packaging purposes. Due to this reason, the size of the boxes can vary from just over 100mm to around 2500mm. The current project deals with the measurement of cardboard boxes at Ms. Corru Carton. In single day, over 5000 boxes are manufactured at their plant. The company manufactures over 200 different SKUs. In a particular batch, at least 100 numbers of a particular SKU are manufactured. During inspection, however, only one unit out of hundred units is measured using tape. This method of sampling can result in rejections at the customer end and also result in losses to the customer who might have to stop his reproduction line. Thus 100% testing of products becomes imperative. A system, which is accurate and low cost, while at the same time easy to use and also fool-proof, must be developed.

Currently, laser sensors are used for the above purpose. However, they are prohibitively expensive and their accuracy tends to drop after a particular point. Thus, in order to solve this problem, we have developed a semi-automatic non-contact system which employs IR-sensors connected to an Arduino processor. The system is capable of warning the operator whether a particular box is within the tolerable limits and also maintains a record of the dimensions of the measured boxes which can be used by the customer. We believe that this system can be replicated in several other industries at a very low cost and can thus be improve the productivity of small-scale industries as a whole.

SOLUTION

Several paths can be adopted to solve the given issue at hand. However, each solution has its advantages and disadvantages. The most important decision to be made is the choice of the sensor. In today's scenario, there are several sensors available which can meet our demand. They are as follows:

1. Laser Sensor
2. Ultrasonic Sensing
3. Image Sensing
4. IR Sensor

Let us now delve into the different aspects of each sensor. After looking at each sensors disadvantages and advantages, we will select the most appropriate sensor.

1. Laser Sensor: Laser Sensors are sensors which send a beam of light towards the object. The light reflects from the object and is subsequently received by the sensor. The sensor then calculates the distance based on the time taken to receive the pulse of light. Laser sensors are highly accurate for small distances and most of them need little or no calibration. Industrial laser sensors are not affected by the environment they are working in. However for longer distances, their accuracy reduces. Since we have to measure distances of over 2.4meters, laser sensors will only provide an accuracy of +-4cm. This is not within the acceptable accuracy. Also, laser sensors cost more than Rs. 55000 per piece. Since we require a sensor on each of the two axis along the length and breadth of the table, the cost of just the sensors will rise to over Rs. 1,00,000.
2. Ultrasonic Sensors: Ultrasonic sensors work on similar lines as a laser sensor. The only difference is that ultrasonic sensors use ultrasonic sound waves for detection. However the accuracy of the sensors is not high enough for our application. Also, these sensors can be affected by different sounds emanating from the surroundings and can show wrong results. This is highly possible in a factory, where there are several mechanical machines on the same floor which produce vibrations of varying frequency. Also the cost of each Industrial grade Ultrasonic sensor is at least Rs 20,000.
3. Image Processing: In image processing, a camera is placed over the box. The camera detects the edges of the box and then processors it. It will then provide us with the length and breadth of the box after comparing it with predefined lines. However, a camera does not give any indication of the height of the box and boxes of the same size with different heights will show different length and breadth. For this, we will have to use a secondary camera and sensor and position it very accurately. If there is any movement, it will again show wrong values.
4. IR Sensors: IR sensors work similar to laser sensors but use Infra-red beams instead of laser beams. They are fairly accurate in small distances. Thus distance upto 50cm can be detected easily with a resolution of less than 1mm. This is enough for our application. IR sensors are also not affected by the environment in a factory and are proven to be reliable for long periods of time. Secondly, Sharp IR sensors cost Rs 500 per sensor. This makes them ideal for uses in industry where low cost is a main priority.

Type of System	Accuracy	Range	Reliability	Suitable for industry Environment	Cost of Sensor (Rs.)
Laser Sensing	High	Moderate	High	Yes	55000
Ultrasonic Sensing	Moderate	High	High	No (due to surrounding m/c frequency)	20000
Image Processing	Moderate	Moderate	High	Yes	> 2000
Infrared Sensing	Moderate	Moderate	High	Yes	500

Figure 1. Comparison of Available Sensors

MECHANISM

In our mechanism, we have decided to use IR sensors since it meets our criteria in almost all the cases. The only major drawback of the IR sensor is that their detection range is upto 50cm. To overcome this we have decided to have locking points on the table. We can have such pre-decided points along the length and also along the breadth. We can lock the sensors into position along these points and one we inform the processor about this, the IR sensor can start to measure the distance of the object from itself. Since the processor knows the distance of the IR sensor from the starting tip of the box, the dimension of the box can be calculated as:

Dimension = Distance of IR sensor from the tip – Distance of box from IR sensor

Once the IR sensor has been set and locked, the worker simply needs to keep the box on the measuring table and the values will continuously be displayed on the sensor. Thus for an entire batch of boxes, the worker requires less than one minute to setup the instrument and can then continuously place the boxes.

The entire system is made up of the following components:

1. Table: A table with length of 2700mm and breadth of 1300 mm has been utilized for the process of designing the system. Then entire system will be mounted on top of this table. The dimensions of the table can vary according to the size of the boxes that are being measured.
2. Guiderails: There are a pair of guiderails along the Length and Breadth of the Table. These are a pair simple aluminium L-plates mounted along the axis. One of the sides will be fixed on the table and the vertical side will have holes along the entire length of plates at regular intervals. These holes will serve as a locking mechanism for the system

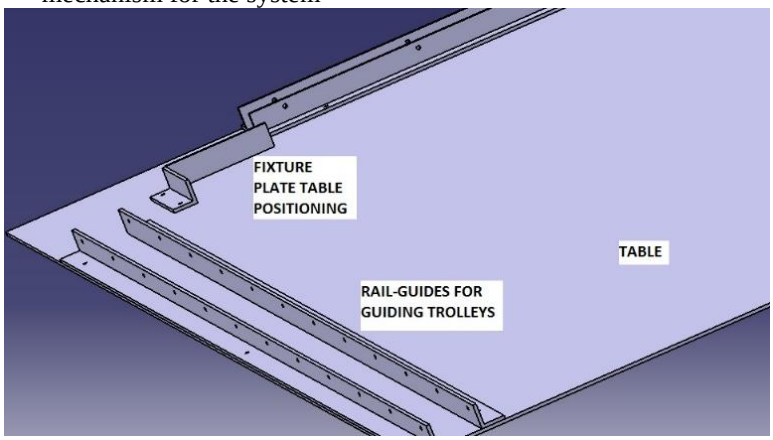

Figure 2. Table, Fixture Plate for placing Boxes, Guide-rails for trolleys and holes for locking sensors

3. Trolley: The IR sensors are mounted on a specially designed trolley. The trolley is placed in the guide-rails and can freely move back and forth along their axis. This trolley also has holes in its side skirts. A long bolt is also fixed on the trolley with the help of a chain. Once the trolley has been moved to the desired position, it can be locked on into position by inserting the bolt through the holes in the L-plates and the trolley.
4. Fixture Plate: Small length L-plates are mounted on the table to be used as a reference while placing the boxes. A corner of the box must be placed at the intersection of the plates and the adjoin sides must touch the faces of the L-plates. Once placed in this position, the sensor will provide accurate values about the size and dimensions of the box.

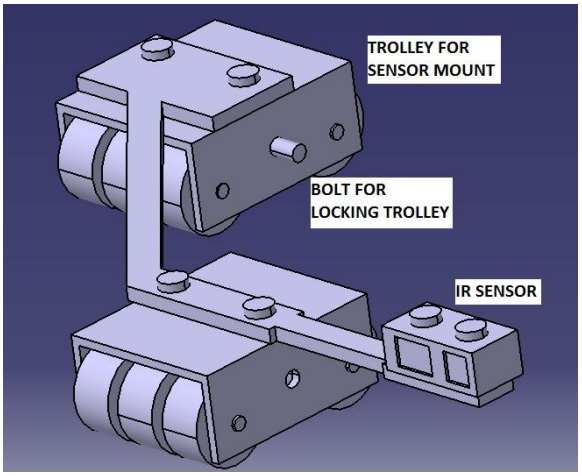

Figure 3. Trolley on which sensor is mounted. Holes for locking trolley in guide-rails**.**

5. Control Panel: A control panel has been designed for monitoring the entire system and storing the dimensions of the measured boxes. The control panel consists of the following parts:

- Arduino Processor

- LED Screen
- Numeric Keypad
- Rotary Dial for selecting Length and Base Values
- SD card slot for storing and accessing data

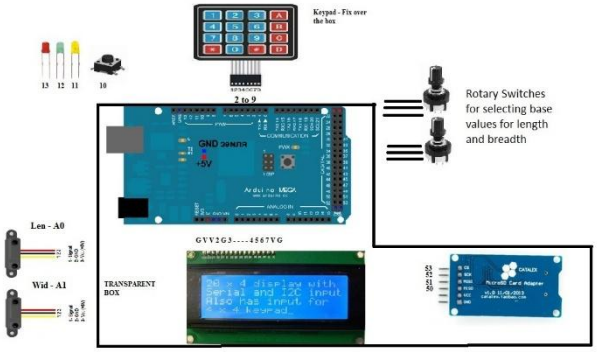

Figure 4. Layout of Control Panel

WORKING

The non-contact dimension measuring semi-automatic system requires the presence of at-least one person for measuring the size of objects.

The step-by-step process for operating the entire system is as follows:

1. All SKU's to be measured are given a specific numeric ID. A notepad file is created and the dimensions of a particular SKU are entered alongside its specific ID. This file is stored on the SD card and inserted into the control box
2. Once a batch is brought for inspection, the system must be set-up. The operator must first input the specific ID of the SKU to be measured. The system checks the dimensions of the desired SKU and displays it on the LCD screen.
3. Next, the operator must move the Sensors to the desired position. The trolley is then locked into place on the guiderails. The Locking position must be at a length which is greater than the dimension of the SKU. The operator must then set the dial indicator to the value of the position at which he has locked the trolleys along the length and breadth.
4. The system is ready for use. The operator must place the box to be measured on the fixture plate on the table. The measured dimensions of the boxes will be displayed on the LCD screen. The system will also compare the measured values along with the desired values to display whether the box is accepted. A led light will also glow according to the conditions as follows:

- Green led: Perfect size
- Orange led: Large Size
- Red led: Small Size

5. The operator then presses the register button. The value of the individual box is recorded and stored in an "Accepted" or "Rejected" file according to its measured dimensions.
6. The operator then places the next box and registers it. He continues this process till the entire batch has been measured and inspected. Once he has to inspect a new SKU, he simply restarts the system and repeats steps (1), (2), (3) to setup the system.
7. At the end of the batch, the SD card can be taken out and the data in the "Accepted" and "Rejected" file can be used for further quality analysis of the manufacturing process.

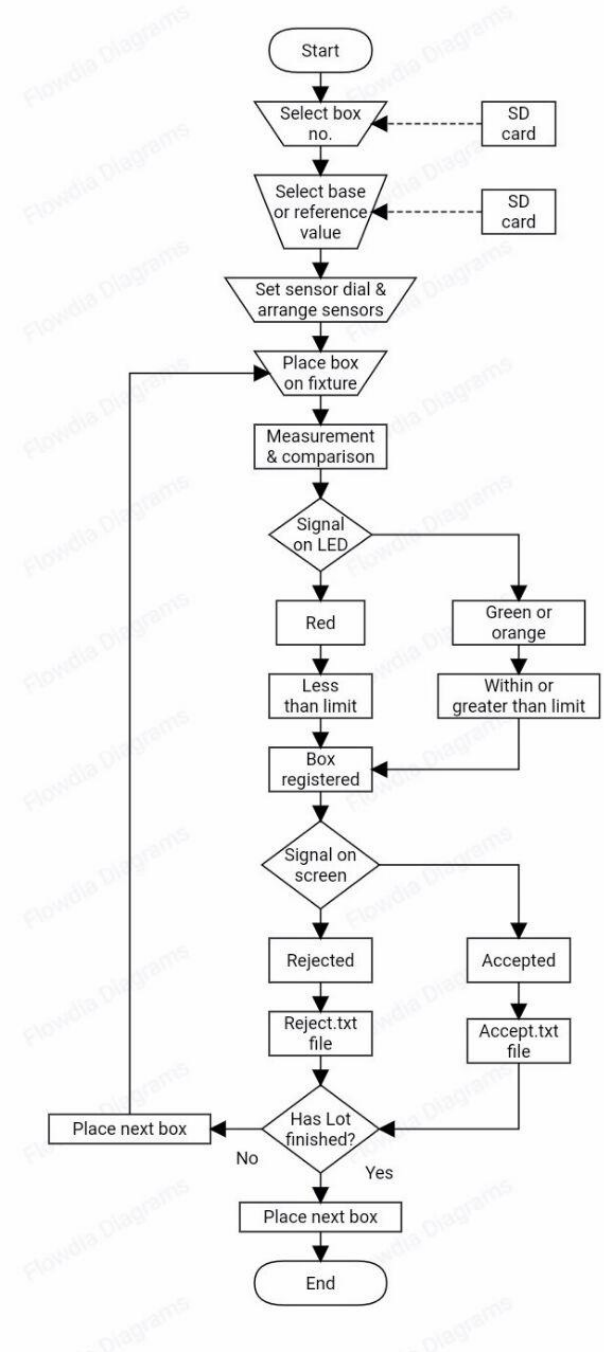

Figure 5. Working Methodology of System

RESULTS

The system has been implemented at Corru Cartons India Pvt. Ltd. The sensors give accurate readings and the deviations can be said to be up to 2 mm while measuring large boxes. The system is reliable and gives constant readings over a period of time. One must take multiple readings and average them before displaying the final measurement on the screen. Taking more than 50 readings gives a constant value when measuring the same box over multiple readings.

CONCLUSIONS

The system is a low cost device than can be implemented across several industries. It provides accurate measurement and also stores data of measured boxes. This is very important for further quality analysis. The system is intuitive and easy to use. Any operator can very easily handle the entire system and no further assistance is required. This system is very useful when an industry manufactures products with large variance in sizes and manufactures in bulk quantities. Since the set-up time is small, the measurement of several boxes can be done very quickly.

AREAS TO IMPROVE

This aim of the system is to develop a very simple and low cost system. However, there are several areas which can be improvised by an expert in the field. Even though the project is functional, scope for improvement still exists and can be made to be even easier to use in the following areas:

1. Since IR sensors are dependent on ambient light and their reading sometimes change in different settings of light, we have to calibrate them properly. Moreover one must try to use them in constant light environments so as to avoid the risk of faulty measurements.
2. The setup and locking of the trolley carrying the sensor is currently done manually. This requires extra efforts and adds a step in the setup process. One must automate this. After only selecting the specific ID of the box, the system must itself move the trolleys or sensor automatically and lock it into place. This will eliminate any labor induced error.
3. The system currently uses an SD card to store and recall data. A quality Inspector has to currently manually remove the SD card and connect it to his computer to withdraw stored data and to edit the file containing specific IDs of the SKU's. There are better systems possible and one must try to make the system wifi-enabled. Thus the inspector will not have to use the SD card since all data stored on the measuring system can be directly transferred to the computer of the inspector via wifi.

These changes will certainly go a long way in making the system user friendly.

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