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Design and Development of Automated Capsicum Sorting System Using PLC

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Abstract – Holding the top position in the global market by providing superior product quality and retaining the customers is a big challenge for every industry today and adopting Industrial Automation could be one of the ways out under continuous improvements made. Automation offers advantages in terms of reduced cycle time and labour intervention and enhanced product quality and accuracy and timely delivery of products. Food processing, sorting and packaging industry has incorporated automation to a greater extent for performing various tasks.

The paper deals with the problems with the current sorting system of capsicums of various colours and a proposed automated sorting system using pneumatics, image processing and PLC.

Keywords— Industrial Automation, PLC, Image Processing, Capsicum Sorting,

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INTRODUCTION

Industrial Automation encompasses noteworthy amount of hardware technologies, related to Instrumentation and sensing, actuation and drives, Electronics for signal conditioning, communication and display, embedded as well as stand-alone computing systems etc.

Farmers and distributors sort and grade agricultural and food products through traditional inspection which is time consuming, laborious and less efficient. The quality attributes often used for deciding on harvest maturity are colour, appearance, texture and odour which mainly depends on manual sensory observations but human perception could easily be fooled. The sophisticated automated sorting system is vital for businesses targeting at high distribution capacity and products requiring short times to market.

Most of industrial information systems have to be real-time. An accurate result, which is not timely, may be less preferable than a less accurate result produced in time. If the food industry is considered, hygiene is another main consideration along with the time and accuracy. Hence it is pertinent to explore the possibilities of adopting faster systems for saving time and above requirements thus reducing human intervention. [1]

PROBLEMS WITH THE EXISTING SYSTEM

The problems with the current manual sorting and grading system are as follows:

1. Huge post harvest losses in handling and processing and the increased demand for food products of high quality and safety.
2. Determination of insect infestation in blemishes in fruits and vegetables is important.
3. Despite the training of grading personnel and the availability of reference slides, the current methods for capsicum quality evaluation is time consuming, tedious, costly and inherently inconsistent.
4. More labour is required and wages are high.
5. Human fatigue can lead to reduced efficiency and hence the errors in inspection.
6. Ease of report generation on daily basis or as per shift, the report can contain the number of capsicums of particular colour dispatched, number of good and defective capsicums etc.

METHODOLOGY ADOPTED

The methodology adopted for development of system after finding out the problems with conventional system included frame and column design for correct orientation followed by design of conveyor belt to run between the pulleys.

Then selection of sensors, motors and other electronic components was followed by designing of

PLC ladder program for the application and system validation.

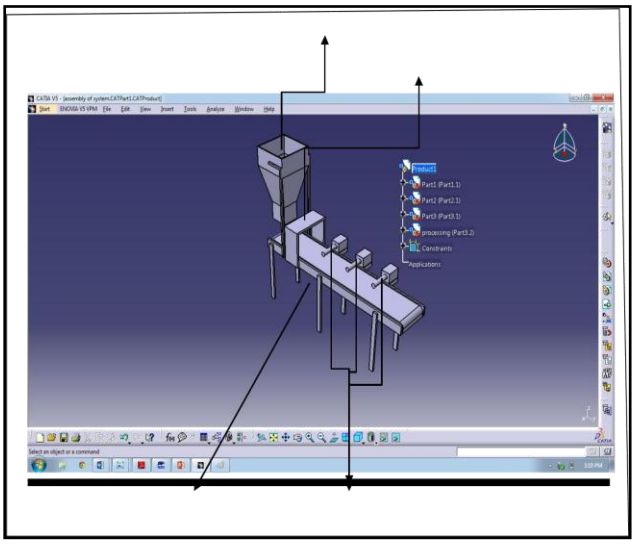

Fig.1. CATIA model of selected mechanism

Fig. 1 shows the CATIA model of the proposed working prototype. The capsicums would be placed on the conveyor after plucking. If it's a large scale system, hopper can be used to provide a temporary storage and directing the capsicums to conveyor. The camera attached to the frame then would take the image of the capsicum when the conveyor halts.

The program written in MATLAB software will analyse this binary image and give the result in terms of colour i.e., red, green or yellow. Based on the prominent colour of capsicum and the output from the software, either cylinder 1, 2 or 3 would extend diverting the capsicum to the particular bin.

If the capsicum has turned black due to over ripening or has damaged surface with cracks, none of the cylinder would be actuated and the defective capsicum would travel over the conveyor and gets collected in the fourth bin for trash.

Pneumatic System

Pneumatic system is preferred since automation calls for faster speeds and oil in hydraulic system might contaminate the food products and might make the entire system and food products dirty.

The maximum weight of capsicum is approximately 200 grams and thus maximum pressure required in the system is 0.6 to 1.2 bar. The requirement of the pneumatic system means the pressure and movement that is to be produced by the system.

The components used in the pneumatic system are compressor, 5/3 solenoid operated valve and 3 double acting cylinders. FluidSim software is used for designing and validating the pneumatic circuit.

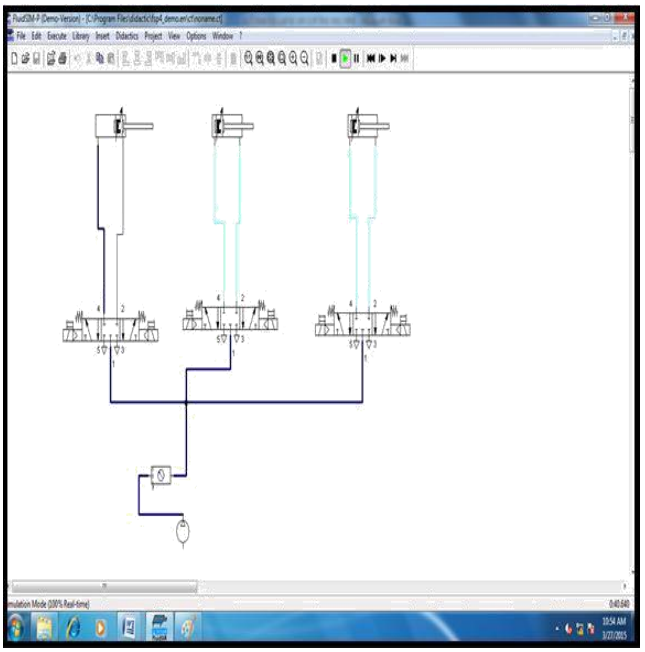

Fig. 2. Pneumatic circuit for the system using FluidSim

Mechanical Components

The mechanical components included shaft, pulley, conveyor belt, bearings and frame. The components are designed, manufactured and assembled. The frame incorporated the above listed mechanical components and pneumatic circuit.

Electronic Components

These components mainly included Programmable Logic Controller (PLC) for controlling the movements of mechanical and pneumatic components according to the ladder program designed.

The PLC provides an easy way to reprogram the wiring rather than actually rewiring the control system. They are rugged, designed to withstand vibrations, temperature, humidity and noise and can be easily programmed. The PLC can be selected based on input and output capacity required, types of inputs and outputs required, size of memory and speed and power of CPU.

Allen Bradley Micrologix 1200 PLC is used and RSLogix 500 was the associated software. This PLC had 16 I/O ports for connecting signal lines and operates on 24 V DC. Capacitive proximity sensors are used in the system.

A camera is used in the system for taking the images of capsicums and processing these images for colour and any cracks present. The camera was attached overhead to take the snapshots of capsicums moving on the conveyor belt. The camera specifications are as follows:

USB Webcam / PC Webcam / Mini camera, Supports MSN Messenger, yahoo messenger, etc. and able to rotate in 180 degree. Its transmission rate is 640*480/30 fps and 1280*960/10-15 fps.

VFW interface: It supports seizure of both still and moving image.

It offers features like automatic white balance, automatic gain control and automatic colour compensation. [2]

Image Processing

Digital image processing is the use of computer algorithms to create process, communicate, and display digital images. Digital image processing algorithms can be used to convert signals from an image sensor into digital images, improve clarity, and remove noise and other artifacts, extract the size, scale, or number of objects in a scene and prepare images for display or printing.

The capsicums are evaluated for their colors. This is done by averaging the RGB content within the boundaries of the objects. For example an object with relatively high average value of R over its surface, may possess a shade of Red. In MATLAB, impixel command can be used to acquire the RGB information in a 1 x 3 matrix over the entire object surface which can be averaged. Using the principles of additive mixing, a large number of colors can hence be recognized.

RESULTS

After interfacing hardware with PLC and computer containing MATLAB, various trials were conducted and it is seen that use of sophisticated electronic systems allows for high operative speed, easy calibration and flexibility to required classification features. It will always have better flexibility and will be better than human sorting.

The other benefits include high efficiency with good sorting speed, high precision through use of softwares, use of this system can be extended to sort any fruits or vegetables or even various objects, high degree of intelligence can be introduced and better reliability.

The screen shot of ladder program is as shown in fig. 3 while the processed images of capsicum after image processing are shown in fig.4.

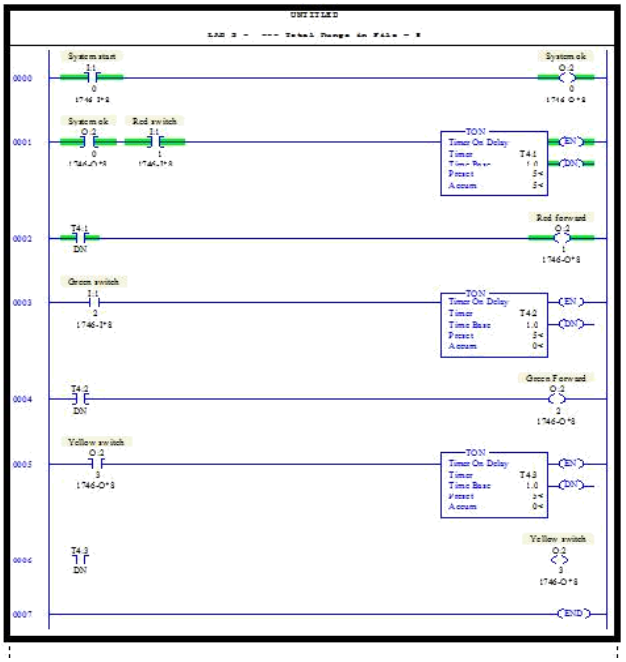

Fig.3. Ladder screen shot for capsicum sorting

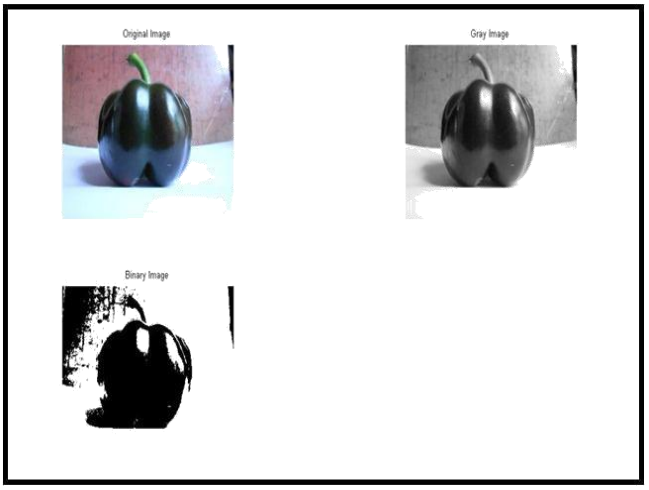

Fig.4. Processed images of capsicum after image processing

CONCLUSIONS

With the use of PLC and image processing complex industrial process of grading and sorting can be controlled with ease and accuracy and increased output.

In this system, information about colour and position was processed into sequence of commands that were transmitted to the driving unit of handling device. The system was able to perform successful sorting operation with the help of vision application. Testing with non-specified colour (black or colour other than red, green and yellow) gave 70 %

accuracy while testing with defined colour resulted in 100 % accuracy. Thus with required modifications and scaling in the system, similar systems can be used successfully for grading and sorting of various objects.

Reports could be produced in excel format which can be used in SAP or related softwares. The only problem is that skilled workers are required to change the program and if the job changes new images need to be taken and create new programs. Due to sensitivity the system need to be used in clean area.

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