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Fruit Sorting By Pizzo-Electric Sensor and PLC Controlling

ABSTRACT

Abstract:The fruit sorting process traditionally relies on visual inspection, primarily considering size as a key quality parameter. However, industries engaged in large-scale fruit trading have turned to image processing technology for sorting, despite its high cost and impracticality for small traders. This paper proposes an alternative sorting system that offers an economical solution suitable for automated fruit sorting at various scales.

Aim:The aim of this study is to develop an economical automated fruit sorting system capable of classifying fruits based on their weight, thereby eliminating the need for manual labor and improving sorting accuracy and efficiency.

Place and Duration of Study:Department of Electrical Engineering Finolex Academy of Management and Technology, Ratnagiri, Maharashtra, between July 2023 to April 2024.

Study Design:This study employs a practical approach to design an automated fruit sorting system that utilizes Programmable Logic Controller (PLC) technology in conjunction with load cells. The system is designed to classify fruits based on their weight as they move along a conveyor belt, thereby automating the sorting process.

Methodology:The proposed sorting system integrates PLC technology and load cells to accurately measure and classify fruits based on their weight. By eliminating the need for manual intervention, the system enhances sorting efficiency and accuracy. The system is designed to be cost-effective and suitable for implementation by small traders and farmers.

Result:The developed sorting system demonstrates precise, reliable, and consistent sorting outcomes based on fruit weight. By automating the sorting process, the system achieves improved efficiency and productivity compared to traditional manual sorting methods. Moreover, the cost-effectiveness of the system makes it accessible to small traders and farmers seeking to enhance their sorting practices.

Conclusion:The proposed sorting system offers an economical and efficient solution for automated fruit sorting, particularly for small traders and farmers. By leveraging PLC technology and load cells, the system provides reliable alternative to costly image processing-based methods. The automation of the sorting process eliminates the risk of errors and inconsistencies associated with manual sorting, while ensuring accurate and quantitative classification based on fruit weight. This sorting system presents a practical approach to improving fruit trading operations, enhancing efficiency, and productivity.

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Keywords: PLC (programmable logic control), Fruit, Load Cell, Conveyor Belt.

11 **1. INTRODUCTION**

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13 In the realm of modern agriculture and commercial farming, technological advancements
14 have become imperative for maximizing efficiency, productivity, and quality. Among the
15 myriad of innovations, the integration of piezoelectric sensors and programmable logic
16 controllers (PLCs) stands out as a promising solution for fruit sorting[1]. This introduction will
17 develop into the rationale behind employing such technology, elucidating its significance and
18 the pressing need for its adoption in agricultural practices.

19 In the development phase of automation, the policy of country government will also effect.
20 Various automation technologies are available for fruit sorting in agriculture industry, but this
21 technology such as IoT, image processing is not economical [2-4]. The trend of technology
22 development with internet is become a trend but everywhere in country like India and other
23 developing country internet connectivity is not well available. The other technology such as
24 computer-based fruit grading system [5-10] focuses on why technology important for sorting
25 over manual sorting. The technology used to demonstrate the sorting of fruit disease
26 detection and classification specifically of apple[11].The computer vision technology used for
27 tomato sorting using conveyer belt processing [12]. The technology such as raspberry-pi
28 used in fruit sorting [13]. The major areas of quality evaluation of food grains, fruits and
29 processed fruits had also found useful for determination insects infection in fruits and
30 vegetables [3].

31 The computer vision or image processing analysis is based on size, shape and color
32 analysis[14]. The sorting is based on the shape, color for quality. The mostlyused technology
33 for sorting is image processing.This technique is tested on various fruits such as apple,
34 tomato, mango etc[15].

35 The other traditional techniques are manual sorting, size bases weight based which may
36 include the hard labor, timing and cost for labor as well as low efficiency output.

37 The other technology in development process uses conveyor robots which uses
38 electropneumatic conveyer belt robots with two separated lines. The control operation
39 handled by PLC, sensor[16], gripper arm and electronics switches the procedure gives the
40 unique accuracy and efficiency with medium cost. The conveyor robotics well given for the
41 device sorting in [17].

42 The paper is well written and divided into sections and subsections. The section starts from
43 introduction, followed by problem formulation, working principal part includes equipment
44 used for the process, sematicdiagram, ladder logic program, hardware implementation of
45 conveyer belt, result, conclusion followed by references.

46

47 When we had studied about fruit sorting based on different criteria, we realized that the
48 weight-based fruit sorting is best technique for small farmers over manual sorting. We got
49 the result as weight-based sort, we categorized two weights above 120gm and below 120gm

50 **2.PROBLEM FORMULATION**

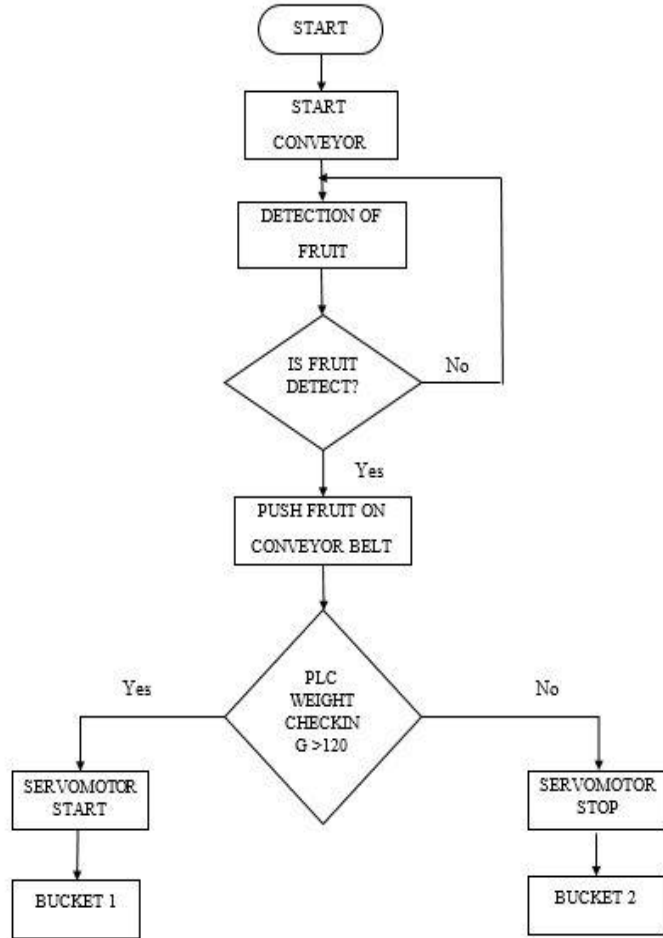
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52 In agriculture industry,especially considering the farmer sorting of fruit have various
53 methods. Such as image processing, computer vision, weight sorting, ripe sorting these all
54 method and machine equipped with these methods are not economically suitable for the
55 farmers specially from under developed countries, developing countries. On the other hand
56 manual procedure suffers from inefficiencies, inaccuracies and time consuming. The section
57 identifies these challenges and the need of economically efficient sorting system on weight
58 based as Indian marketing system is based on weight.

59 **3.WORKING**

60

61 In this project we have proposed a low-cost automation system for fruit sorting on the basis of
62 their weight variation. The project mainly focused on sorting fruit using a load cell, a dc gear
63 motor, a servomotor interface with a programmable logic controller (PLC). A dc gear motor
64 is used for pushing fruit using a conveyor belt. The system consists of a conveyor belt which
65 takes the fruit from the load cell and thus sorting is decided by PLC. PLC is programmed with
66 different logic for sorting different fruit based on their weight. In this system the load cell
67 is used to detect the weight of every fruit. Using a conveyor belt, the fruit is segregated by their
68 weight.

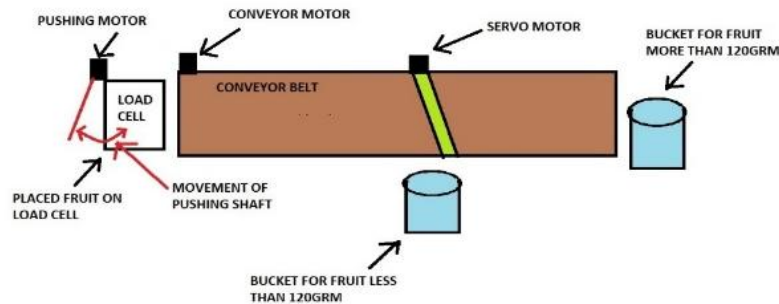


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Fig. 1. Flow chart of system for fruit sorting process



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73 **Fig. 2. Planned hardware system with load cell placement and operating motors**

74

75 The figure 1 represents the process of fruit sorting using flow chart. The figure 2 represents
 76 the planned structure of the conveyer belt with operating motor, pushing motor, load cell.
 77 The two basket is placed which collect the fruit sorted less than 120 gm and greater than
 78 120 gm.

79 If fruit is not above 120gram then motor will not start and that fruit is separated from
 80 conveyor. we use pushing motor to push fruit from load cell to conveyor. In our case
 81 the weight of fruit is above 120gram hence fruit goes straight on
 82 conveyor and separated. The figure 6 represents the projected structure for fruit
 83 sorting conveyer belt.

84

85 **3.1 Components:**

86 **3.1.1. Load Cell (1kg) :-**

87 Capacity - 1Kg

88 Rated output (MV/V) - 2.0 ± 0.15

89 Input resistance – 402 ± 6

90 Output resistance – 350 ± 3

91 Operating temperature range - $-35 \sim +80^{\circ}$

92 Method of connecting wire - Input = Red (+), Black (-)

93 Output = Green (+), White (-)

94 Output signal of load cell is a millivolt level voltage signal proportional to weight/load. Load
 95 cells usually have an excitation voltage of between 3 and 15 volts DC.

96 **3.1.2. Load cell Transmitter/Weight Transmitter :-**

97 The analog input module of ordinary PLC cannot directly process. So, additional analog load
 98 cell Transmitter is required to convert weak sensor signal into the standard industrial process
 99 signal of (0-5) V/ (0-10) V or 4-20 mA (0-20mA).

100 Input signal = 0-20mV.

101 Output signal (DC) = 0 - $\pm 5V$, 0 - $\pm 10V$, 4-20mA.

102 Excitation voltage (selected) = DC (5-15V).

103 Power supply = DC (18-30V).

104 The general formulas for weight measurement, signal processing, threshold sorting, control
 105 logic and efficiency are as follows.

106 1. The weight measurement using Piezoelectric sensors

107
$$W = m \times g$$

108 2. Signal Processing for weight detection

109
$$V_{out} = S \times F$$

110 3. Threshold Determination for Sorting

111
$$F_{Threshold} = k \times W_{average}$$

112 We assuming the value of K is (+ - 0.5).

113 4. Control Logic using Programmable Logic controller

114
$$F_{measured} \geq F_{Threshold}$$

115 It is the logical sorting mechanism,

116 5. Efficiency Calculation

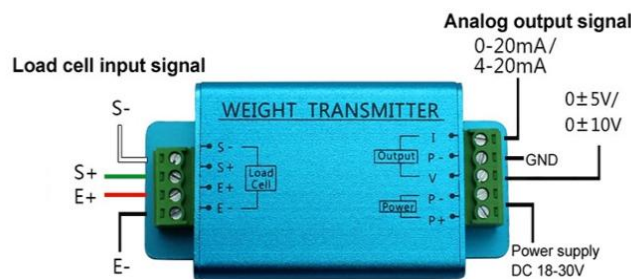
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$$\eta = \frac{\text{Number of fruits sorted correctly}}{\text{Total number of fruits sorted}} \times 100$$

118 We take total 100 fruits for performing our sorting process. In this process 65 fruits are
 119 greater than 120 gm and 35 fruits are less than 120 gm. We sorted our fruits accurately on
 120 their weight basis and it gives 100% efficiency.

121 In above W is the weight of the fruit, m is the mass of the fruit, g is the acceleration due to
 122 gravity. V_{out} is the output voltage of the piezoelectric sensors. S is the sensitivity of the
 123 sensor, F force exerted on the sensor by fruit. $F_{threshold}$ threshold force for sorting, k
 124 constant factor determining the threshold level. $W_{average}$ is the average weight of the fruits
 125 being sorted.

126 The weight signal transmitter plays a role in the fruit sorting system employing
 127 piezoelectric sensors and PLC controlling. The component used to convert physical weight
 128 of the fruit into an electrical signal that can be processed by control system.

129



130

131

FIG. 3. Weight signal transmitter

132 **3.1.3. Servomotor MG996R (360° rotation) :-**

133 Weight = 55g

134 Operating voltage = 4.8 ~ 6.6 V

135 Operating speed = 0.19sec/60degree

136 Stall torque = 9.4kg/cm (4.8V), 11kg/cm (6.0V)

137 Gear Type = Metal gear

138 Dead bandwidth = 1us

139 Wire Length = 32cm

140 **3.1.4. DC Gear Motor: -**

141 Speed = 100 rpm

142 Voltage = 12 volts

143 Material = Iron

144 **3.1.5. Arduino Uno:**

145 The Arduino Uno is a microcontroller board based on the ATmega328P chip. It is a popular
146 development board used for various electronics projects and prototyping. The board comes
147 with a range of features that make it ideal for beginners and professionals alike.

148 The main features of the Arduino Uno board include:

149 **Microcontroller:** The Arduino Uno is built around the ATmega328P microcontroller, which is
150 a 8-bit AVR microcontroller with 32KB of flash memory, 2KB of SRAM, and 1KB of
151 EEPROM.

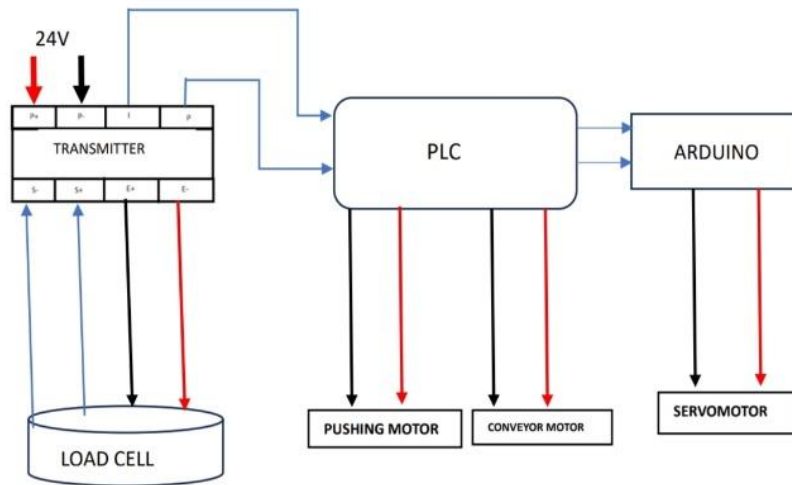
152 **I/O Pins:** The board comes with 14 digital input/output pins, 6 analog inputs, and 6 PWM
153 (Pulse Width Modulation) outputs. These pins can be used to connect various sensors,
154 actuators, and other devices to the board.

155 **USB Connection:** The board has a USB port that can be used to connect it to a computer,
156 allowing it to be programmed and powered through the USB cable.

157 **Power:** The board can be powered by either USB or an external power supply (7-12V DC).

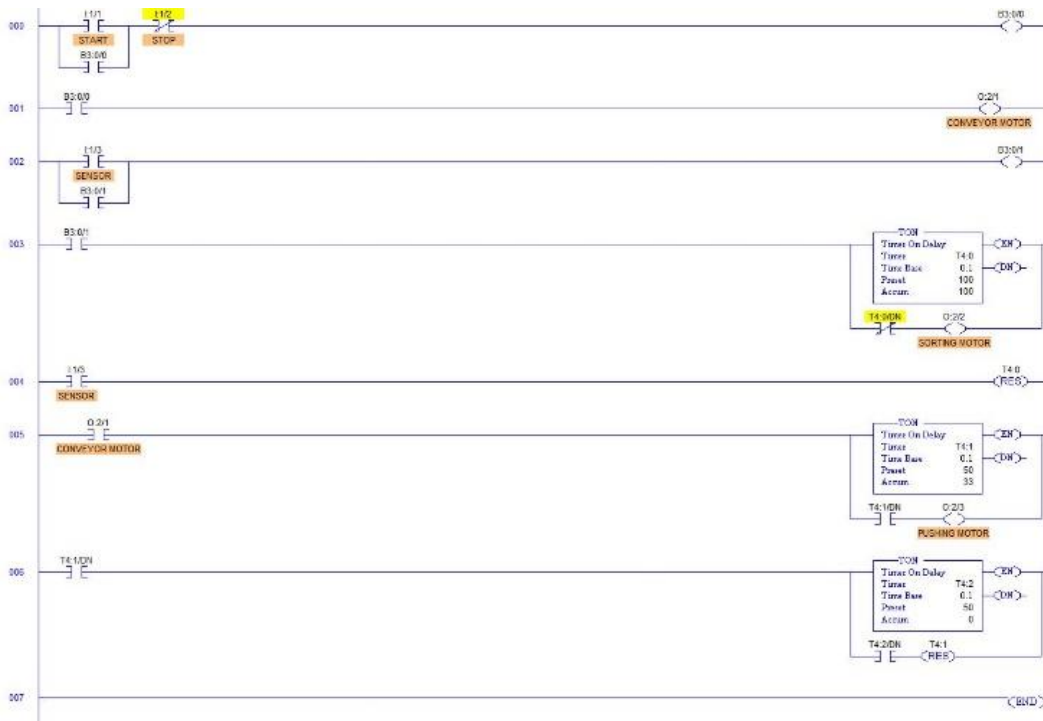
158 **Compatibility:** The Arduino Uno is compatible with a range of shields (boards that plug into
159 the Arduino board to extend its functionality) that can be used to add additional capabilities
160 to the board.

161 The Arduino Uno board is programmed using the Arduino Integrated Development
162 Environment (IDE), which is an open-source software application that allows users to write,
163 compile, and upload code to the board. The IDE comes with a range of libraries and
164 examples that can be used to get started with the board.



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Fig. 4. Block Diagram of Model Connections



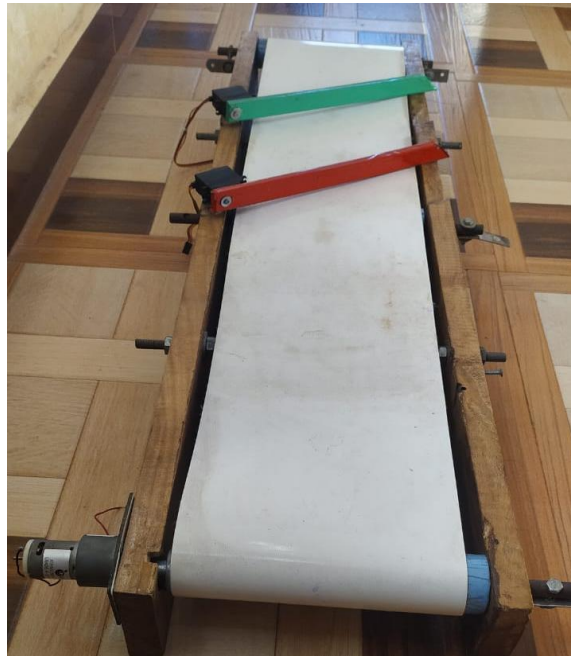
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Fig. 5. Ladder logic program for fruit separation and operation the motor

170 In summary, the Arduino Uno is a versatile microcontroller board that is popular for various
171 electronics projects and prototyping. Its wide range of features, ease of use, and
172 compatibility with shields make it an ideal choice for beginners and professionals alike.

173 In system, to place the fruit on load cell mechanism. when push the start button the conveyor
174 have start. once the conveyor starts after 5sec pushing motor is also start(give 5 sec time
175 delay between conveyor motor and pushing motor for sensor to sense the weight of fruit)

176 between that 5sec if sensorsense the weight of fruit is above120gram then the servomotor
 177 will start and on for 10sec and fruit goes straight on conveyor.
 178



179

Fig. 6. Hardware system for fruit sorting

180

181 The following table gives the technical analysis details of technology on factors such as
 182 technology used, cost and other aspects. The table shows that the technology offered have
 183 high accuracy, speed with moderate complexity, Cost scalability maintenance requirement
 184 and flexible. The ability to handle the various fruits type is good.

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Table 1. COMPARASION OF SORTING TECHNOLOGIES USING VARIOUS ASCEPTS

Aspect	PIZOELECTRIC SENSORS AND PLC CONTROLLING	IMAGE PROCESSING BASED SORTING	WEIGHT-BASED SORTING	SIZE-BASED SORTING	MANUAL SORTING
Technology Used	Piezoelectric sensors, PLC	Cameras, image processing	Load cells	Mechanical sizing	Human labor
Accuracy	High	High	High	Moderate	Variable, depends on human operator
Speed	High	Moderate	Moderate	Moderate	Variable, depends on human operator
Cost	Moderate	High	High	Moderate	Low
Complexity	Moderate	High	Moderate	Low	Low
Flexibility	Moderate	High	Moderate	Low	High

Scalability	Moderate	High	Moderate	Low	High
Maintenance Requirements	Moderate	High	Moderate	Low	Low
Ability to Handle Various Fruit Types	Good	Good	Good	Limited	Limited
Automation Level	High	High	Moderate	Low	None
Integration with Existing Systems	Moderate	Moderate	Moderate	Low	Low

187 Conclusion

188 In conclusion, employing PLCs for fruit sorting based on weight improves efficiency and
189 accuracy within fruit processing industries. By streamlining operations and maintaining
190 consistent quality control, this system utilizes load cells or weight sensors to precisely gauge
191 the weight of individual fruits against predetermined thresholds. This approach reduces
192 reliance on manual labor, diminishes errors, and boosts throughput, ultimately driving cost-
193 effectiveness and profitability. Moreover, the adaptable nature of PLC programming enables
194 customization to accommodate different fruit varieties and sorting criteria, making it a
195 versatile solution tailored to the evolving demands of the industry.

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199 invaluable assistance and technical support throughout the development process of the fruit
200 sorting technology employing piezoelectric sensors. The guidance and expertise have been
201 instrumental in the realization of this project. The department's assistance in implementing
202 weight-based fruit selection using piezoelectric sensors, a critical aspect of our technology.
203 Their support has significantly contributed to the advancement and success of our project will
204 undoubtedly have a positive impact on agricultural practices.

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