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Low-Power Architecture for Real-Time Object Detection and Counting in Industry

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Abstract

This project presents a compact and efficient microcontroller-based system designed for real-time object detection and counting, integrated with conveyor motor control. Leveraging the AT89S52 microcontroller alongwithanIRsensor,16x2LCD,andL293Dmotordri verIC,thesetupenablesautomaticobjectdetection and live count updates while managing conveyor movement. When an object interrupts the IR beam, the microcontroller receives an external interrupt, increments the count, and displays it on the LCD. The conveyor is powered by a DC motor, which can run continuously or at variable speeds using the L293D driver. The system demonstrates effective use of interrupt handling, peripheral interfacing, and real-time embedded control—offering a practical, low-cost solution for small to medium industrial automation tasks like packaging, sorting, and inventory management.

Keywords: Microcontroller, Object Detection, Conveyor Control, Embedded Systems, Automation

I. Introduction

The increased adoption of industrial automation is realized through the advent of microcontroller-based systems providing smart, low cost, and highly accurate process controls. As industries traditionally strive for greater productivity while reducing human error,theincreasingdegreeofautomationtoprovidereal-timemonitoringandcontrolhas generated new opportunities for projects such as this one. This project will the acknowledge the emerging need for an Object Detection and Counting System with ConveyorMotorControlutilizing anAT89S52microcontroller.Theobject detection and counting system proposed will be for counting objects or materials as the importance of accuracy and precision is high. The system makes use of an infrared (IR) sensor which detects objects passing as they travel along the conveyor. Once the IR sensor detects an object, the AT89S52 is triggered quickly, almost instantly depending on if the use of an external interrupt is used, at which point the counting of the object or material for the passingobject canstart.Statisticalcountsaredisplayedona16x2 LiquidCrystalDisplay (LCD) to give the operator ongoing information about the state of the machine. The conveyor will be powered by a standard DC motor driven by a L293D motor driver IC, permitting speed and direction control of the conveyor motor, which has great flexibility formany,ifnotall,applicationsandindustriesthroughfirmware.Thecombinationof interrupt-driven processing, peripheral interfacing, and real-time data display demonstrates an application of modern automation using microcontrollers. The system described in this project would be a very capable, scalable, inexpensive method for automated manufacture for a small or medium-sized industry with a desire to automate production, keep track of inventory, and improve other in-house logistical issues.

II. Literature Review

Over thepastfew years, therehas been ahugedemand for industrialprocess automation, particularly for object detection, counting, and motor control on conveyors. These applications demand accurate, real-time responses and low-cost solutions, which has resultedinthewidespreaduseofmicrocontroller-basedsystems.Thissectionsummarizes previous studies on object detection, automatic counting, and motor control based on embedded systems.

Microcontroller-BasedAutomatedControlSystems

Several studies have investigated the potential of microcontrollers like the AT89S52 for automating tasks. Patel and Thakkar [1] (2017) discovered that 8051-based microcontrollers are very well suited to applications requiring real-time control because they have internal timers, support for external interrupts, and large peripheral compatibility. Their low cost, ease of programming, and stability render them perfect for small industrial automation systems.

Object Detection Sensors Automated systems may use different sensors like ultrasonic, laser, and infrared (IR) sensors for detecting objects. Verma et al. [2] (2018) highlightedthesignificanceofobstaclesensorsinnear-rangeobjectdetectionbecausethey are inexpensive and space-saving. These sensors consistently output digital signals when an object breaks the beam, making them suitable for use with microcontrollers using externalinterrupts.Inthesuggestedsystem,aninfraredsensorisusedtodetecttheobject on the conveyor, and an interrupt event is generated when the beam is interrupted. 2.3. Industry Applications of Counting Systems Automatedcountingplays asignificantroleinproductionlines,especiallyinpackaging, sorting, and inventory.
Gupta andSharma[3](2016)discussedthebenefitsofinterrupt-drivenprogrammingfor accurate and power-efficient processing of real-time events such as object detection. Interrupts allow instantaneous system response without continuous polling, improving performanceandminimizingprocessingoverhead.Eachobjectdetectioneventherecauses an external interrupt on the AT89S52, which increments an internal counter and displays the new count on the LCD. 2.4. LCD Interfacing for Real-time Display Real-time presentation of data is necessary for efficient user interaction and monitoring. The study ofembeddeduserinterfaces(e.g.,Raoetal.,2019)[4]identifiesthat16x2characterLCDs find extensive application in low-cost embedded systems. It can be interfaced in either 4- bitor8-bitmodes,withtheadvantageofsavingI/Opinswith4-bitmode.Clearvisual feedback throughthesedisplays iscrucialfor industrialmonitoring.Thisprojectemploys a 16x2 LCD for presenting the real-time number of objects detected.

2.5.L293DICMotorControl
Electromechanical devicessuch asDCmotorsneed aninterfacebecause microcontroller currents are limited.Singal. [5] (2020) elaborated on the prevalence of using the L293D motordriverIC,adoubleH-bridgedriverfor bidirectionalmotor driving with logic-level inputs.

Itprotectsthemicrocontroller fromhighcurrentsandprovidesversatilemotor control.In this system, the AT89S52 provides control signals to the L293D, which drives the conveyormotor,mimickingobjectmovement.Futureimprovementsmightinvolvepulse- width modulation (PWM) for variable speed. 2.6. Comparison of Features with Past Systems Different earlier systems have employed different microcontrollers (Arduino, AT89S52)forthesameapplications[1][2][5]. Detectionisoftendoneusingsensorssuch asinfraredmodules,whiledisplayunitshavevariedfromseven-segmentdisplaysto16x2 LCDs. Motor control usually involves relays or motor driver ICs. System performance is based on design decisions influencing time, cost, and disruption minimization.

2.7.ResearchGap
AlthoughmanycontemporarysystemsuseArduinoorRaspberryPi[1][2],fewerprojects areonusingtheAT89S52microcontroller,whichisstill usedineducationandsmall-scale industriesduetoitseaseofuse.Additionally,usingexternalinterruptsforobjectcounting has more accurate and efficient operation than polling or using timers.

III. Methodology

The design’s goal is to produce a cost-effective and dependable microcontroller-based systemthatautomatesthedetection andcountingof objectsonaconveyorbeltwhilealso controllingtheconveyormotor.Thesystememploysinterrupt-drivenprogrammingusing the AT89S52 microcontroller to guarantee prompt and effective real-time response.

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Work flow Diagram

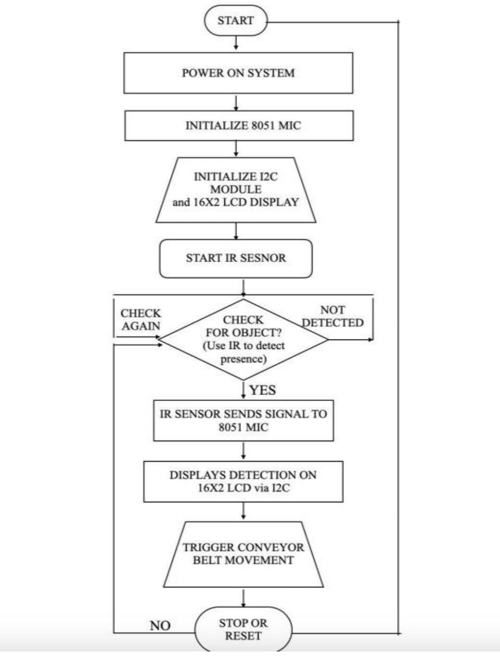

Figure1.SystemArchitectureofObjectDetectionandCountingSystemUsing AT89S52

Object Detection

The IR detector senses when an object interrupts the beam. The counting mechanism in theAT89S52usesexternalinterrupts,witheachobjectgeneratinganinterruptthattriggers an ISR (Interrupt Service Routine). The number of objects is displayed and updated in real-timeona16x2LCDscreen.ConveyormovementispoweredbyaDCmotorusingan L293D motor driver IC, allowing for either continuous running or speed control.

Description of Hardware Components

The detector identifies objects and transmits a digital signal to the microcontroller when the beam is broken. The AT89S52 microcontroller handles external interrupts, counts objects, displays information on the LCD, and controls motor operations. The16x2 LCD displays the real-time object count. L293D motor drivers connect low-power control signals to high-power DC motors. The DC motor drives the conveyor belt to simulate object movement. A regulated power source (12V for motors, 5V for logic circuits) supplies the system.

IRSensortoInterrupt Handling(INT0)

The infrared sensor emits radiation detected by a receiver. When no object interrupts the beam,theoutputremainsstable.Whenanobjectcrossesthebeam,thesignalchangesand islinkedto pinP3.2(INT0)ontheAT89S52 microcontroller. Thesystemisprogrammed to detect the rising or falling edge, triggering an external interrupt.

InterruptServiceRoutine (ISR)

Whentheinterruptisasserted,themicrocontrollertemporarilyhaltsthemainprogramand executes the ISR:

- Acountervariable incrementbyone.
- TheLCD is updatedtodisplaythenew count.
- Controlthenreturnstothemainprogram.

LCDInterfacing

The 16x2 LCD operates in 4-bit mode, minimizing data line usage. It uses four data pins (D4–D7) and two control pins (RS and EN). A 10k potentiometer is connected to the contrast pin (VEE) for visibility adjustments.

MotorControlUsing L293D

The L293D motor driver IC controls motor direction and speed. Two logic-level signals (from P3.0 and P3.1) determine motor movement, while the enable pin can be connected to a PWM signal for speed control. In this project, the motor operates continuously.

2. Hardware Implementation

System Architecture

Thesystemconsistsoffour modules:

- **Object Detection Module:**IRsensor.
- **ProcessingUnit:**AT89S52 microcontroller.
- **MotorControlModule:** L293DmotordriverICandDCmotor.
- **DisplayModule:**16x2LCDfordisplayingobjectcount.

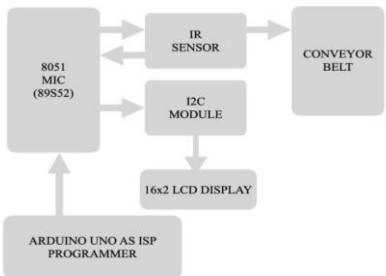

Figure2.WorkflowDiagramforObjectDetectionandC

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onveyorControlProcess

Components

AT89S52 Microcontroller

Figure3.AT89S52MicrocontrollerUsedintheSystem

Features:

- 8-bitCPU with4KBFlashmemoryand128bytes of RAM.
- Supportsexternalinterrupts(INT0).
- GPIOpinsforperipheralinterfacing.

Role:

- ProcessesexternalinterruptstriggeredbytheIRsensor.
- IncrementscounterandupdatesLCD display.

IR Sensor

Figure4.IRSensorUsedforObject Detection

Components:

- IRLEDtransmitter.
- TSOP1738receiver.

Interface:

- Receiveroutput connectedtoP3.2 (INT0).

Functionality:

- Triggersanexternal interruptuponbeaminterruption.

16x2 LCDDisplay

Figure5.16x2AlphanumericLCDDisplay Module

- Displaysupdatedobjectcounts.
- Operatesin8-bitmode.
- Datalines connectedtoPort0,controllines toP3.6and P3.7.

PowerSupply

- +5Vformicrocontroller,IRsensor,andLCD.
- +12VforDCmotoroperation.

CircuitDesign

Allmodulesareintegratedasfollows:

- IRsensoroutputconnectedtoINT0 (P3.2).
- L293DIN1/IN2connectedtoP3.0/P3.1.
- LCDdatalinesconnectedtoPort0,controllinestoP3.6andP3.7.
- Powersuppliesregulatedat+5Vand+12Vlevels.

Table1.Key Connections

Component	Microcontroller Pin	Function
IRSensor Output	P3.2(INT0)	Externalinterrupt input
L293DIN1/IN2	P3.0/P3.1	Motordirectioncontrol
LCDDataLines	P0.0–P0.7	Datatransmission
LCDRS/EN	P3.6/P3.7	Controlsignals

Table1summarizeskey connections:

Implementation Challenges

- **NoiseImmunity:**Added0.1µFdecouplingcapacitors.
- **SensorAlignment:**EnsuredcorrectIRtransmitter

andreceiverpositioning.

- **MotorSurgeProtection:**Flybackdiodesinstalledacrossmotorterminals.

Testing Protocol

- VerifiedinterrupttriggeringviaIRsensor.
- TestedconveyormotionusingL293D-controlledDCmotor.
- Confirmedreal-timecountingonLCDduringintegrated testing.

IV. Conclusion

TheObjectDetectionandCountingSystemwithConveyorMotorControlshowcaseshow microcontroller-basedautomationcansubstantiallyenhanceindustrialoperations.By leveraging the external interrupt capabilities of the AT89S52 microcontroller, the system achieves precise, real-time object detection and counting. The infrared sensor offers high detection precision, while the 16x2 LCD ensures clear, continuous count display. The L293D motor driver ensures consistent conveyor operation and safeguards the microcontroller. This project provides a low-cost, optimized solution suitable for packaging, sorting, and inventory management tasks in small- and medium-scale manufacturing industries.

V. Future Scope

1. Integration with Wireless Modules (Wi-Fi or Bluetooth): Facilitates remote monitoring, data logging, and control via mobile or web-based dashboards.
2. SmartSensorUpgrade:Utilizingultrasonicorlaser sensorscanincreasedetection rangeandprecision,makingthesystemcompatible withdifferentobjectsizesand materials.
3. ImplementationofSpeedControlviaPWM:Providesdynamicspeedregulationof the conveyor motor according to object flow rate or system feedback.
4. AddingCloudConnectivity(IoT):Connectsthesystemtocloudplatformsforreal- time analysis, remote diagnosis, and predictive maintenance.
5. Data Storage Using EEPROM or SD Card Module: Enables logging of object counts over time for reporting or auditing purposes.
6. Expansion to Multi-Sensor Setup: Supports multi-lane conveyors or multi-point detection, enhancing throughput and system flexibility.

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