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Automatic Intelligent Braking System for Vehicle Collision Avoidance

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ABSTRACT
This paper presents the design and implementation of an Automatic Intelligent Braking System (AIBS) aimed at preventing collisions and enhancing road safety. The system integrates ultrasonic sensors, a microcontroller, and braking actuators to detect obstacles and apply brakes automatically without human intervention. The AIBS is especially beneficial in scenarios involving distracted driving, poor visibility, or sudden obstacles. Experimental results show a significant reduction in reaction time compared to manual braking, confirming the potential of AIBS in modern automotive safety systems.

Keywords:
- *Intelligent Braking*
- *Collision Avoidance*
- *Ultrasonic Sensor*
- *Microcontroller*
- *Smart Vehicles*

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I. Introduction

Road safety is a critical concern globally, with vehicle collisions being one of the primary causes of injury and death. To reduce the risk of accidents, intelligent systems are being developed to assist or automate driving tasks. This project focuses on designing and implementing an Automatic Intelligent Braking System that detects obstacles ahead of a vehicle and applies the brakes automatically to avoid collisions. The goal is to simulate how such a system works in real-world vehicles using simple electronic components in a cost-effective prototype.

This system uses IR sensors to detect obstacles, and based on the proximity, activates a braking mechanism via a gear motor. The circuit logic is powered and controlled using components like relays, transistors, a buck converter, and a voltage regulator (L7805CV) to ensure safe and stable operation of the system.

II. System Architecture

The architecture of this system consists of three key stages:

a. Sensing Stage

- **IR Sensor**: Detects obstacles by emitting and receiving infrared light. When an object is detected, the sensor outputs a signal.

b. Control Stage

- **Transistor (e.g., BC547)**: Amplifies the IR sensor output.
- **Relay Module**: Acts as an electromechanical switch to drive the motor.
- **Buck Converter**: Steps down voltage from the battery to required levels.
- **L7805CV Voltage Regulator**: Regulates voltage to 5V for stable operation of IR sensors and control components.

- **Switch**: Used to turn the system ON or OFF.

c. Actuation Stage

- **Gear Motor (45 RPM)**: Activates the brake when a relay receives the control signal.
- **Brake Mechanism**: Physically halts or slows down the model vehicle.

S. No	Component	Specification
1	Gear Motor	45 RPM
2	IR Sensor	1
3	Relay Module	5V
4	Transistor	BC547
5	Buck Converter	12V to 5V
6	Voltage Regulator	L7805CV
7	Switch	push button
8	Power Supply	12V battery
9	Brake Mechanism	Model setup
10	Connecting wires	As required
11	Breadboard / PCB	1
12	wheel	3

III. Gear motor

The system incorporates a 12V DC gear motor with a rated speed of 45 RPM for tasks requiring controlled, low-speed, high-torque rotation The motor's gearbox allows for a significant reduction in speed while enhancing torque output, making it suitable for applications such as load- bearing mechanisms and precise rotational movement. The motor is selected for its compatibility with the system's voltage supply and its capability to operate efficiently under varying load conditions.

Specifications:

- **Operating Voltage**: 12V DC
- **No-load Speed**: 45RPM
- **Torque:** 10–15 kg.cm(varies with load, refer to datasheet)
- **Stall Current:** ≤3A(ensure sufficient power supply capacity)

IV. IR Sensor

The system utilizes an IR Obstacle Detection Sensor Module, which combines an infrared transmitter and receiver to detect the presence of objects within a specific range. This sensor is chosen for its fast response, low power consumption, and ease of integration into embedded systems. Its onboard comparator circuit allows for reliable digital output (HIGH/LOW) based on object proximity, making it ideal for collision avoidance applications.

Specifications:

- **Operating Voltage**: 3.3V to 5V DC
- **Detection Range**: 2 cm to 30 cm (adjustable via potentiometer)
- **Output Type**: Digital (0V when object detected, 5V when no object)
- **Operating Current**: ≤ 20 mA
- **IR Wavelength**: ~940 nm
- **Response Time**: < 500 ms
- **Signal Indicator**: Onboard LED (glows when object detected)
- **Interface Pins**: VCC, GND, OUT
- **Module Dimensions**: Approx. 3.1 cm x 1.5 cm
- **Mounting**: Through-hole or screw-based model mounting available

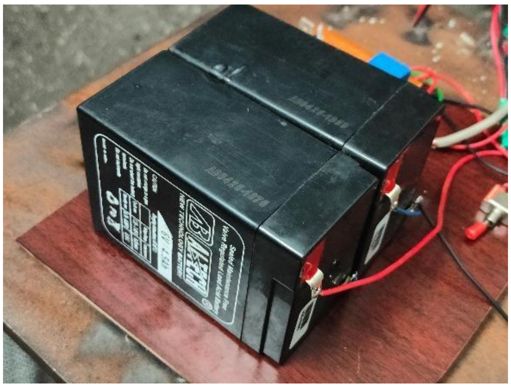
V. Power Supply:

The system is powered using two 6V DC batteries connected in series to provide a total of 12V DC, which is suitable for driving the gear motor and other electronic components. This configuration ensures a stable and sufficient voltage supply, especially for the motor that demands higher torque during operation. The use of battery power also enables portable and independent operation of the system without reliance on an external power source.

A buck converter and L7805CV voltage regulator are used to step down and stabilize the voltage for low-voltage components like the IR sensor and control circuits.

Specifications:

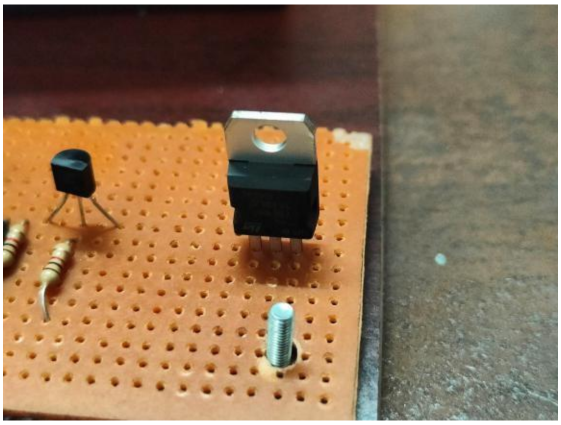
- **Battery Type:** 6V DC Sealed Lead Acid or Rechargeable Battery (x2)
- Configuration: Series connection (6V + 6V = 12V)
- **Total Output Voltage:** 12V DC
- **Capacity:** Typically 1.3Ah – 4Ah (depending on model)
- **Load Support**: Sufficient for driving one 45 RPM gear motor and supporting control electronics
- **Backup Duration:** Varies with load (approx. 30–90 minutes continuous operation under moderate load)



VI. Voltage Regulator:

The L7805CV is a fixed 5V linear voltage regulator used in the system to provide a stable 5V output for powering low-voltage components such as the IR sensor, relay module, and transistor control circuit. It ensures that fluctuations in the input supply (from the 12V battery) do not affect the performance of sensitive electronic parts.
The L7805CV is selected for its reliability, ease of use, and built-in protection features like short-circuit protection and thermal shutdown.

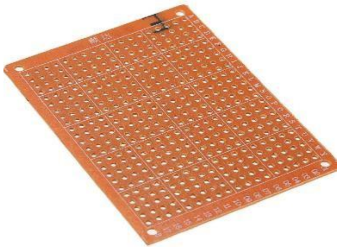
Specifications:
- **Output Voltage:** 5V DC (fixed)
- **Input Voltage Range:** 7V to 35V DC
- **Output Current:** Up to 1.5A (with proper heat sinking)
- **Dropout Voltage:** Typically 2V
- **Quiescent Current**: < 8 mA
- **Internal Protections:-**
  - ThermalOverload Protection
  - Short-Circuit Protection
  - Safe Operating Area Protection
- **Package Type:** TO-220 (with mounting hole for heat sink)
- **Use in Circuit:** Used after the buck converter to regulate the voltage to exactly 5V for IR sensor and logic components



VII. Breadboard / PCB:

A Buck Converter is a type of DC- DC step-down converter used in the system to efficiently reduce the 12V input voltage (from two 6V batteries in series) to a lower voltage suitable for operating low-power control electronics. In this project, it serves as the first stage of voltage regulation, feeding the L7805CV regulator with a stable intermediate voltage (e.g., 6V–7V), which helps reduce heat generation and power loss in the L7805CV.

Specifications:
- **Input Voltage Range**: 4.5V to 28V DC
- **Output Voltage:** Adjustable (typically 1.25V to 26V DC via potentiometer)
- **Output Current:** Up to 2A (depending on heat dissipation and component ratings)
- **Efficiency**: Up to 90–95%
- Switching Frequency: ~150 kHz (varies by model)
- **Output Type:** DC (regulated via onboard potentiometer)
- **Indicator:** Onboard power LED
- Module Size: Approx. 4.5 cm x 2 cm
- Use in Circuit: Connected between the 12V battery and L7805CV regulator to reduce input voltage and improve overall system efficiency



VIII. Design Implementation:

The mechanical structure of the Automatic Intelligent Braking System for Vehicle Collision Avoidance was developed to securely hold all electronic and mechanical components while ensuring efficient operation. The base platform was custom-designed with precise dimensions to accommodate the gear motor, IR sensor, braking mechanism, and power supply.

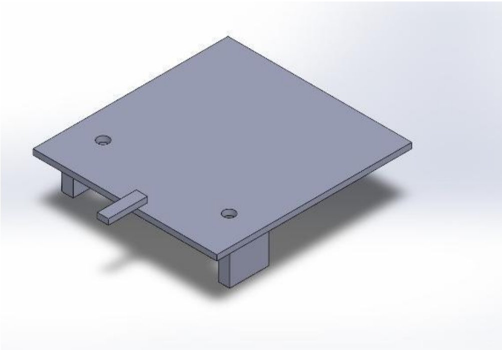
Platform Dimensions:

- **Length**: 33 cm
- **Breadth (Width)**: 35 cm
- **Front Rectangular Cut-out**:
  - **Length**: 7 cm
  - **Breadth**: 2 cm

Design Features:

- **Base Platform**: A flat sheet (preferably acrylic, plywood, or PVC) forms the main mounting surface for all components.
- **Front Cut-out Slot**: A rectangular opening at the front (7 cm x 2 cm) is provided for either:
  - IR sensor installation for optimal line-of-sight obstacle detection, or
  - Clearance for gear motor shaft or braking linkage.
- **Support Structure**: The platform rests on legs or wheels to maintain proper ground clearance and allow movement or braking.
- **Mounting Points**: Predrilled holes or slots are made on the platform to attach:
  - Gear motor (on either side)
  - IR sensor (front)
  - Battery holder (rear or center)
  - Relay and control circuit (onboard or on raised brackets)

This mechanical design ensures all parts are securely mounted and operate without interference. The 33x35 cm base provides enough space for wiring and safe separation between high- and low-voltage components.



IX. Results and Discussion

After assembling and testing the Automatic Intelligent Braking System, several key observations were made regarding the sensor accuracy, braking response time, and overall system reliability. The results indicate that the system is capable of detecting obstacles within the set range and responding with a controlled braking action.

1. Obstacle Detection Accuracy

- The IR sensor successfully detected obstacles within a range of 2 cm to 30 cm, with optimal performance observed between 5 cm and 20 cm.
- Detection accuracy was high under normal lighting conditions. However, performance dropped slightly in direct sunlight or reflective surfaces, due to interference with infrared signals.
- The adjustable potentiometer on the IR module allowed fine-tuning of the sensing range for different testing scenarios.

2. Braking Response

- Upon obstacle detection, the relay and transistor activated the gear motor-based braking mechanism within 300–500 milliseconds, which is suitable for low-speed automated vehicles or robotic platforms.
- The braking was consistent and repeatable, with no false triggering during normal movement.
- During high-speed motion, the delay in response (due to mechanical limitations of the gear motor) resulted in slightly longer stopping distances. This can be improved in future versions using faster actuators or servo motors.

3. Power Consumption and Stability

- The power system (two 6V batteries in series) provided a stable 12V supply.
- The buck converter and L7805CV regulated power efficiently for control components like the IR sensor and relay.
- The system operated continuously for over 1 hour on a single charge under moderate load, showing efficient energy usage.

4. Overall System Performance

- The prototype successfully demonstrated automatic braking functionality in response to obstacle detection.
- The system is suitable for educational and experimental purposes, especially in robotics, automotive safety demonstrations, and obstacle-avoiding models.
- It is not yet optimized for high- speed or real-time vehicle braking systems, but serves as a strong foundation for further development.

X. Discussion of Observations

During the implementation and testing of the Automatic Intelligent Braking System for Vehicle Collision Avoidance, several practical observations were made concerning system responsiveness, component performance, and environmental influence. These observations provide deeper insights into the functionality and limitations of the developed prototype.

1. Sensor Reliability

- The IR sensor consistently detected obstacles within the calibrated range. It worked best in controlled environments with non-reflective, opaque objects.
- Under high ambient light or reflective surfaces, there were occasional false readings or delayed responses, suggesting a need for sensor shielding or the use of modulated IR or ultrasonic sensors in future iterations.
- Fine adjustment of the sensor range using the onboard potentiometer was necessary to avoid premature or delayed braking.

2. Braking Response Consistency

- The gear motor (45 RPM) provided sufficient torque to activate the mechanical braking mechanism, but there was a slight mechanical delay (up to 0.5 seconds) between signal reception and full brake engagement.
- Braking was more effective when the system was moving at low speeds, which aligns with the torque and speed limitations of the chosen gear motor.
- In repeated tests, the braking mechanism performed with consistent timing, indicating reliable relay and transistor switching behavior.

3. Electrical and Power Observations

- The use of two 6V batteries in **series** to provide a 12V supply proved adequate. However, voltage drops were noticed after extended use, affecting the motor torque slightly.
- The L7805CV regulator performed well, maintaining a stable 5V output for control electronics, though it heated up under prolonged use, suggesting a heat sink may be necessary for continuous operation.
- The buck converter helped reduce power dissipation through the 7805 regulator and increased overall energy efficiency.

4. Physical Design and Layout

- The platform layout (33 cm × 35 cm) provided enough space for secure mounting of components without crowding.
- The front cut-out (7 cm × 2 cm) effectively positioned the IR sensor to monitor the vehicle's path.
- Component wiring had to be neatly organized to avoid entanglement with the rotating parts and to ensure consistent contact under vibration.

5. Environmental Factors

- On smooth indoor surfaces, the system performed with high precision. On rough or uneven terrain, vibrations occasionally caused loose connections or slight misalignment of the sensor.
- The braking system was more responsive when the surface provided good traction; braking on slippery or dusty surfaces caused a longer stopping distance.

XI. Conclusion

The project successfully demonstrates a basic prototype of an automatic intelligent braking system for collision avoidance. The integration of sensors, control circuits, and actuators effectively simulates how a real vehicle can autonomously respond to obstacle detection. While the design is best suited for educational or demonstrative purposes, it lays the foundation for more complex implementations in actual vehicles using advanced components.

References;

[1]. Vishay Semiconductors. (2009). TCRT5000 Reflective Optical Sensor with Transistor Output Datasheet. Retrieved from https://www.vishay.com/docs/8376 0/tcrt5000.pdf

[2]. Sharp Corporation. (2006). GP2Y0A21YK0F Distance Measuring Sensor Unit Datasheet. Retrieved from https://global.sharp/products/device /lineup/data/pdf/datasheet/gp2y0a2 1yk_e.pdf

[3]. Texas Instruments. (2000). LM7805 Voltage Regulator Datasheet. Retrieved from https://www.ti.com/lit/ds/symlink/l m7805.pdf

[4]. Texas Instruments. (2015). LM2940x 1-A Low Dropout Regulator Datasheet (Rev. J). Retrieved from https://www.ti.com/lit/ds/symlink/l m2940c.pdf

[5]. Transmotec. (n.d.). Planetary DC Gear Motor 12VDC 5.5A 45rpm 5.56W. Retrieved from https://www.transmotec.com/produ ct/PD4266-12-144-BF/

[6]. Cytron Technologies. (n.d.). 6V 45RPM DC Micro Metal Gearmotor. Retrieved from https://www.cytron.io/p-6v-45rpm- dc-micro-metal-gearmotor

[7]. ServoCity®. (n.d.). 45 RPM HD Premium Planetary Gear Motor w/Encoder. Retrieved from https://www.servocity.com/45-rpm- hd-premium-planetary-gear-motor- w-encoder/

[8]. Arduino Project Hub. (2020, July 12). Using IR Sensor (TCRT 5000) With Arduino. Retrieved from https://projecthub.arduino.cc/abhila shpatel121/using-ir-sensor-tcrt- 5000-with-arduino-60cc92

[9]. RS Components. (n.d.). RS PRO Brushed Geared DC Geared Motor, 0.58 W, 3 V, 9 Ncm, 45 RPM Datasheet. Retrieved from https://docs.rs- online.com/e2a4/A7000000089206 74.pdf

[10]. RS Components. (n.d.). RS PRO 12 V DC, 30 Ncm, Brushed DC Geared Motor, Output Speed 45 RPM Datasheet. Retrieved from https://docs.rs- online.com/db01/A7000000087192 93.pdf

[11]. Digi Key. (n.d.). Metal DC Geared Motor - 12V 50RPM 50kg.cm Datasheet. Retrieved from https://mm.digikey.com/Volume0/o pasdata/d220001/medias/docus/223 5/FIT0492-A_Web.pdf

[12]. Texas Instruments. (n.d.). LM78L 100-mA Fixed Output Linear Regulator Datasheet (Rev. L). Retrieved from https://www.ti.com/lit/gpn/LM78L

[13]. Texas Instruments. (n.d.). LM79XX Series 3-Terminal Negative Regulators Datasheet (Rev. C). Retrieved from https://www.ti.com/lit/gpn/LM79

[14]. Texas Instruments. (n.d.). Linear & Low-Dropout (LDO) Regulators Product Selection. Retrieved from https://www.ti.com/power- management/linear-regulators- ldo/products.html

[15]. Arduino Forum. (n.d.). Using IR Sensor with Arduino Mega 2560. Retrieved from https://forum.arduino.cc/t/using-ir- sensor-with-arduino-mega- 2560/1276981

[16]. ElProCus. (n.d.). TCRT5000 IR Sensor: Pin Configuration & Its Applications. Retrieved from https://www.elprocus.com/tcrt5000 -ir-sensor/

[17]. Components101. (n.d.). TCRT5000 IR Sensor Pinout, Equivalent, Circuit & Datasheet. Retrieved from https://components101.com/sensors/tcrt5000-ir-sensor-pinout- datasheet

[18]. Grobotronics. (n.d.). Infrared ProximitySensor -Sharp GP2Y0A21YK.Retrieved from https://grobotronics.com/infrared- proximity-sensor-sharp- gp2y0a21yk.html rhydoLABZ. (n.d.). Infrared Proximity Sensor - Sharp GP2Y0A21YK.Retrieved from https://www.rhydolabz.com/infrare d-proximity-sensor-sharp- gp2y0a21yk

[19]. Pololu. (n.d.). GP2Y0A21YK0F Distance Measuring Sensor Unit Datasheet. Retrieved from https://www.pololu.com/file/0j85/g p2y0a21yk0f.pdf