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INVESTIGATION OF LIGHT REFLECTION AND ABSORPTION BASED ON INFRARED SENSOR

ИССЛЕДОВАНИЕ ОТРАЖЕНИЯ И ПОГЛОЩЕНИЯ СВЕТА НА ОСНОВЕ ИНФРАКРАСНЫХ ДАТЧИКОВ

Annotation: Infrared (IR) sensors have become crucial in various scientific and industrial applications due to their ability to detect and measure light reflection and absorption. This study aims to teach students the laws of reflection and absorption using Huygens' principle of reflection and Beer's law of absorption.

Keywords: Infrared Sensor, Light Reflection, Light Absorption, Surface Properties, Optical Engineering

Аннотация: Инфракрасные (ИК) датчики стали незаменимыми в различных научных и промышленных приложениях благодаря их способности обнаруживать и измерять отражение и поглощение света. Цель данного исследования - познакомить студентов с законами отражения и поглощения, используя принцип отражения Гюйгенса и закон поглощения Бира.

Ключевые слова: Инфракрасный датчик, Отражение света, Поглощение света, свойства поверхности, Оптическая техника.

Introduction

In robotics, particularly in line-following robots, the interaction of light with surfaces plays a key role in guiding the robot's path. These robots typically rely on infrared (IR) sensors to detect and follow lines or paths on the ground. The principles of light reflection and absorption are central to the operation of these sensors, and understanding how these processes work is crucial to the robot's ability to navigate.

1. Theoretical Background

1.1 Explanation of the Huygens' Principle of reflection in IR sensor

In a line-following robot, an IR (infrared) sensor is often used to detect the contrast between a dark line (usually black) and the lighter surface (often white). The sensor typically works by emitting infrared light and then measuring the amount of light that is reflected back from the surface below. Reflection is a key component of how the robot detects its path and follows the line.

To explain this in relation to Huygens' Principle, we need to understand how light behaves when it interacts with surfaces. Huygens' Principle states that every point on a wave front of light acts as a source of secondary spherical wavelets. As these wavelets propagate, they form the new wave front. In the context of reflection:

1. Incident Light: The IR sensor emits infrared light (a form of electromagnetic wave) towards the surface.
2. Surface Interaction: When this infrared light reaches the surface, it interacts with the material. If the surface is reflective (like the black line), some of the infrared light is reflected back toward the sensor. The reflective behavior can be understood through Huygens' Principle, where the point of contact between the light and the surface can be seen as the origin of secondary wavelets that radiate away from the point of reflection.

Huygens' principle helps explain the scattering and wave nature of reflected infrared light as it travels back to the sensor. Essentially, it shows how the incident light interacts with the surface and then propagates away from that point, affecting the sensor's ability to detect changes in the surface's reflectivity.

In a line-following robot, this process allows the robot to 'sense' whether it is above the line (dark, low reflectivity) or to the side (bright, high reflectivity) and adjust its movement accordingly.

1.2 Explanation of the Beer's Law in Infrared sensor

In the context of this project absorption plays a key role in how the sensor detects different surfaces. The basic idea behind absorption is that when the infrared light emitted by the sensor hits a surface, a portion of the light is absorbed by the material instead of being reflected back to the sensor. This loss of light affects how much light is available for detection, which helps the robot determine whether it's over a light or dark surface.

Beer's Law states that the absorbance (A) of light passing through a medium is directly proportional to the concentration of the absorbing substance (C), the path length (L) through which the light travels, and the absorption coefficient (α) of the material:

$$A = \alpha \times C \times L$$

- A is the absorbance of the material (how much light is absorbed),
- α is the absorption coefficient (how strongly the material absorbs light at a particular wavelength),
- C is the concentration of the absorbing material,
- L is the path length the light travels through the material.

Experiment with project: effect of sensor height on IR detection.

Procedure:

1. The sensor placed over a black surface.
2. The height gradually (1cm, 2cm, 3cm) increased
3. The output voltage is recorded as height changes.

Data table:

Sensor height (cm)	**Sensor voltage Output(V)**	**Absorbance(A)**
1 cm	0.6 V	1.2
2 cm	1.5 V	0.7
3 cm	2.8 V	0.3

4. Design and Experimental setup

2.1 Experimental setup

- Arduino UNO – acts as the main controller
- Motor driver – controls the two DC motors
- DC motor – drive the wheels
- Jump wire – detect the path
- Battery snap – powers the circuit
- 2 IR sensors – used for connection
- 3 wheels

2.2 Design

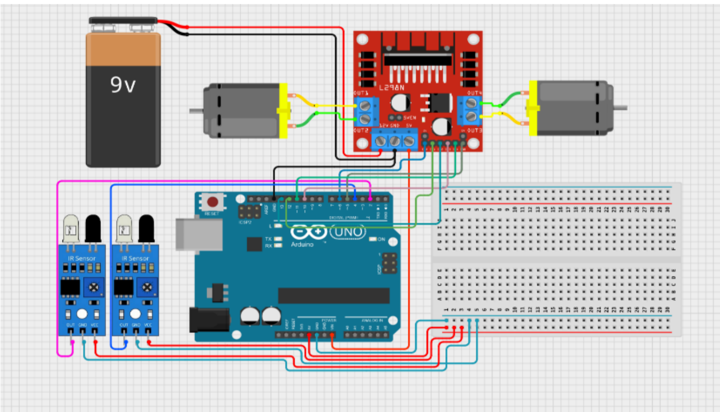
i. *Powering components*

- Connect the battery snap to the Vin&GND of the Arduino Uno
- Also connect the battery's positive wire to the VCC(12V) input of the motor driver and the negative wire to GND
- Connect the 5V output from the motor driver to the Arduino 5V pin for regulated power

ii. *Connecting the Motor Driver to Motors*

- Motor A: Connect its terminals to OUT1 &OUT2 of the motor driver.
- Motor B: Connect its terminals to OUT3&OUT4 of the motor driver
- Connect the motor driver's input pins (IN1, IN2, IN3, IN4) to Arduino's digital PWM pins (e.g., 9, 10, 5, 6)

Here is the diagram of the project:



Conclusion

The investigation of this project focuses on understanding how the robot uses variations in reflected infrared light to determine its position relative to a path or line. The amount of reflection depends on the surface's color and texture, with light surfaces reflecting more light and dark surfaces absorbing more. The robot continuously monitors these variations to stay on track and follow a designated path, making efficient use of IR sensor technology to navigate in a controlled manner.

References

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