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PERIYAR MANIAMMAI INSTITUTE OF SCIENCE & TECHNOLOGY
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BEAM ROBOTICS

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CASE STUDY OF BEAM ROBOTICS

ABSTRACT:
*BEAM robotics is proposed to enhance the STEM knowledge and skills of engineering students in the electrical, electronic, and mechanical domains. To evaluate the proposal, a course is designed and implemented based on a curriculum with objectives and learning activities centered on the design, construction, and operation of the BEAM robots. In addition, the connection between this proposal and computational thinking is explored.
* Students learn to recognize each part of robots and how they are related, abstract useful information from an electronic scheme and concretize it in a machine by systematizing their behavior.

INTRODUCTION:
BEAM robotics is a type of robotics based on simple analog circuits, mimicking biological systems. The word BEAM stands for:

- Biology
- Electronics
- Aesthetics
- Mechanics

Unlike traditional robots that rely heavily on microcontrollers and programming, BEAM robots use minimal electronic components such as transistors, capacitors, solar cells, and motors. They are mainly used to study adaptive behavior, energy management, and bio-inspired design

OBJECTIVE OF BEAM ROBOTICS:
The main goal of BEAM robotics is to create autonomous, energy-efficient robots capable of performing tasks like:

- Obstacle avoidance
- Light-seeking (phototaxis)
- Energy scavenging (solar-powered)
- Mimicking biological survival strategies

PROBLEM STATEMENT

Most conventional robots require:

High cost (due to processors, sensors, batteries).

Complex coding skills.

Large power sources.

Difficult maintenance for beginners.

BEAM robotics addresses these by:

Using basic analog circuits.

Eliminating the need for programming.

Reducing cost and power consumption.

Allowing easy implementation in education and hobby projects

HISTORY & PHILOSOPHY

Introduced by Mark W. Tilden at Los Alamos National Laboratory.

Core concept: “Form follows function”—robots should be simple, robust, and purpose-driven.

Key innovations: Nervous Networks (Nv nets), Solar Engines, and Bicore Oscillators.

LITERATURE INSIGHTS

From all three sources:

BEAM robots mimic biological reflexes without code.

Educational value: Helps students grasp electronics, feedback systems, and sustainable design.

Limitations: Lack of programmability, cannot perform complex tasks, but highly effective for basic navigation tasks.

APPROACH

Task Identification: Line following & obstacle avoidance.

Component Selection: IR sensors, DC motors, resistors, capacitors, transistors, solar panels/AA batteries.

Circuit Design: Cross-coupled reflex loops using Schmitt triggers (74HC14) and Nv circuits.

Prototyping & Testing: Stability tests under varied light and obstacles.

Optimization: Threshold tuning, adding hysteresis for noise immunity, mechanical compliance.CASE DESCRIPTION

Two primary robots analyzed:

Line Follower Robot

Uses IR reflectance sensors.

Cross-coupled control: Left sensor → Right motor and vice versa.

Application: Industrial material transport, robotics education.

Obstacle Avoiding Robot

Uses IR sensors or whiskers for detection.

Reflex control: Stops and turns when obstacles detected.

ANALYSIS

Strengths: Low cost, instant response, no programming required, eco-friendly.

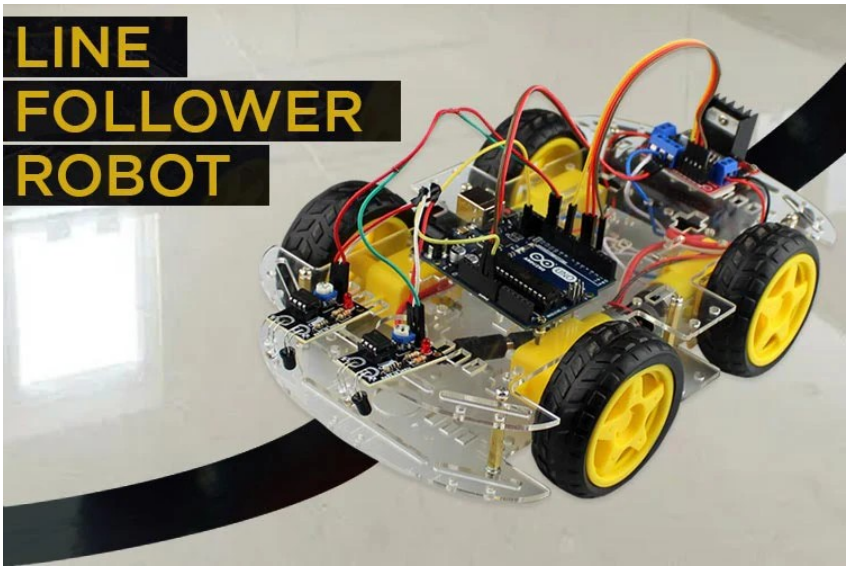
Performance Metrics

Line Follower: ≤1.5 cm lateral error, 25–35 sec per 10 m track.

Obstacle Avoider: <0.2 collisions/min, recovery <0.7 sec.

Challenges: Limited intelligence, sensitive to lighting conditions, difficult to scale for complex tasks.

CASE EXAMPLE : LINE FOLLOWER BEAM ROBOT



Problem Addressed

How can a simple robot follow a predefined path (black line on a white surface) without using a microcontroller?

Design

- Power Source: Rechargeable battery or solar cell.
- Sensors: Two infrared (IR) sensors placed at the bottom to detect black (absorbs IR) and white (reflects IR).
- Control Circuit: Simple comparator circuit (operational amplifiers or transistors) to compare sensor outputs.
- Actuation: Two DC motors controlling left and right wheels.

Working Principle

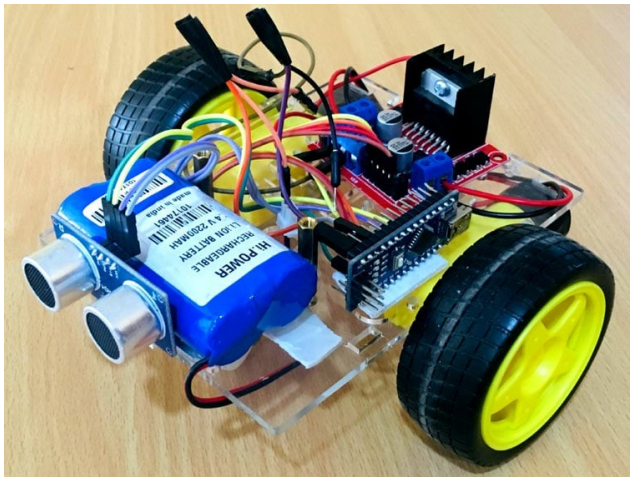
- When both sensors detect white, the robot moves forward.

- If the left sensor detects black (line), the circuit slows/stops the left motor, causing the robot to turn left.
- If the right sensor detects black, the circuit slows/stops the right motor, turning the robot right.
- Thus, the robot continuously follows the line.

Outcome

The robot follows the line with minimal hardware and no software, showing BEAM's principle of simple reactive behavior.

CASE EXAMPLE: OBSTRACLE AVOIDANCE BEAM ROBOT:



Problem Addressed

How can a robot navigate around obstacles in its path using only basic sensors and circuits?

Design

- Power Source: Battery or solar cell with energy storage capacitor.
- Sensors:
    - Bump switches (mechanical contact sensors), or
    - Infrared proximity sensors (to detect nearby objects).
- Control Circuit: Nv nets or transistor-based logic that switches motor directions.
- Actuation: Two DC motors with independent wheel control.

Working Principle

- Robot moves forward as long as sensors detect no obstacle.
- If the left bumper/sensor is triggered, the circuit disables the left motor and reverses it briefly, making the robot turn right.
- If the right sensor is triggered, it reverses/turns left.
- If both sensors detect obstacles, the robot reverses until it finds a free path.

Outcome

The robot successfully avoids obstacles and continues moving autonomously, demonstrating BEAM robotics' adaptability in dynamic environments.

APPLICATIONS:

1.Line Follower: Industrial logistics (following fixed tracks in warehouses), educational kits

2.Obstacle Avoider: Autonomous toys, cleaning robots, and exploration devices in uneven terrain.

ADVANTAGES:

1.Low cost and simple circuits.

2.No programming required.

3.Energy-efficient and suitable for solar-powered operation.

4.Encourages biomimetic approaches to problem-solving.

LIMITATIONS:

1.Behavior is fixed by circuit design (not reprogrammable).

2.Cannot handle complex navigation like microcontroller-based robots.

3.Limited scalability to advanced robotics tasks.

SOLUTIONS

Use RC filters and Schmitt triggers for stable signal processing.

Add monostable circuits for timed reverse actions in obstacle avoider.

Incorporate solar engines for sustainability (optional).

OUTCOMES

Both robots successfully demonstrated autonomous behavior without

CONCLUSION:

Both the **Line Follower BEAM Robot** and **Obstacle Avoidance BEAM Robot** showcase how simple analog circuits and sensors can enable intelligent, autonomous behavior without programming. These designs highlight BEAM robotics' focus on **minimalism, adaptability, and energy efficiency**, making them excellent educational and experimental tools

REFERENCES

Online BEAM resources (Solarbotics, community forums, Instructables

Mark Tilden's BEAM philosophy and Nervous Networks.

And CHATGPT