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CASE STUDY REPORT

BEAM ROBOTICS

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INTRODUCTION OF MECHINE LEARNING

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CASE STUDY ON BEAM ROBOTICS

Introduction :

Robotics has evolved into one of the most interdisciplinary domains, combining electronics, mechanics, and artificial intelligence. Among its various branches, BEAM Robotics (Biology, Electronics, Aesthetics, and Mechanics) emphasizes simplicity, efficiency, and analog circuits instead of complex programming. BEAM robots are often small, solar-powered, and designed to mimic biological behaviors. Two fundamental BEAM designs are straight-line robots, which move in a fixed direction, and obstacle-avoiding robots, which exhibit reactive navigation to prevent collisions. These robots highlight how minimal electronic systems can replicate intelligent behavior in real-world environments.

Problem Statement :

The key problem addressed in this study is:

How can simple BEAM robotics principles be applied to design robots that either move in a straight line or intelligently avoid obstacles, without relying on microcontrollers or programming?

How do these designs demonstrate the efficiency and limitations of BEAM robotics in comparison to programmable robots?

History of BEAM Robotics :

- BEAM robotics was pioneered by Mark Tilden in the early 1990s.
- Instead of software programming, BEAM robots use analog circuits, discrete components, and solar cells to perform tasks.
- The philosophy is to create lifelike behavior using minimalist hardware inspired by natural systems.
- Early BEAM robots were solar-powered "phototropes" that navigated towards light sources.
- Over time, designs evolved into line-following, obstacle-avoiding, and “insect-like” walkers, demonstrating emergent behaviors from simple circuit designs.

Literature Review :

- Tilden (1997) introduced BEAM robotics as an alternative to microprocessor-controlled robots, focusing on energy efficiency and robustness.
- Researchers such as S. Wilson (2002) studied BEAM-inspired autonomous navigation using neural-inspired circuits.
- Recent studies show BEAM designs are still relevant in education, due to their simplicity and cost-effectiveness, especially for teaching robotics without coding.
- Straight-line BEAM robots are widely used as beginner projects, whereas obstacle-avoiding robots demonstrate practical reactive control systems in robotics.

Approach :

The approach involves:

- Identifying core BEAM principles – minimal electronics, energy efficiency, biological inspiration.
- Studying circuit designs for straight-line movement (dual motor drive with symmetry) and obstacle avoidance (IR sensors or bump switches controlling motor direction).
- Building prototypes of both robot types.

Case Description :

- **Straight-Line BEAM Robot :**

Uses two motors connected in parallel with symmetrical wiring.

Powered by solar cells or batteries.

No sensors; simply moves forward in a straight line.

Behavior: Efficient but limited, as it cannot adapt to obstacles.

- **Obstacle-Avoiding BEAM Robot :**

Uses IR sensors or mechanical bump switches connected to motor driver circuits.

When an obstacle is detected, the circuit redirects power, causing the robot to turn.

Mimics insect-like behavior by avoiding collisions.

Behavior: Adaptive, more versatile, but slightly more complex.

Analysis :

- **Straight-Line Robot:**

Pros: Simplicity, low power, minimal components.

Cons: Fails in dynamic environments with obstacles.

- **Obstacle-Avoiding Robot :**

Pros: Higher adaptability, mimics intelligent behavior.

Cons: Requires sensors, slightly higher complexity and power usage.

Both demonstrate BEAM's bio-inspired, efficient, and robust philosophy but highlight trade-offs between simplicity and adaptability.

Solution :

To balance simplicity with adaptability:

Hybrid design can be proposed where a straight-line BEAM robot includes basic obstacle detection, maintaining efficiency while avoiding collisions.

Using solar panels with capacitors ensures sustainable energy.

Optimized mechanical design (wheels or legs) improves mobility.

Outcomes:

The straight-line robot successfully demonstrated minimalistic BEAM movement but failed when encountering obstacles.

The obstacle-avoiding robot showed robust navigation, validating BEAM principles of reactive intelligence.

These robots proved effective for educational demonstrations and highlighted the relevance of BEAM robotics in low-cost, sustainable robotics solutions.

Conclusion :

BEAM robotics continues to demonstrate the power of simplicity in design. Straight-line robots showcase efficiency, while obstacle-avoiding robots emphasize adaptability. Although modern robotics often relies on microcontrollers and AI, BEAM robotics remains relevant for teaching fundamental principles of energy management, bio-inspired control, and emergent behavior. This case study highlights how even the simplest designs can solve practical problems and inspire further exploration in robotics.

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