Case Study

BEAM Robotics

Straight-Line Robot vs. Obstacle-Avoiding Robot

1. INTRODUCTION

BEAM robotics (Biology, Electronics, Aesthetics, Mechanics) represents a branch of robotics that emphasizes simplicity, efficiency, and biologically inspired behaviors. Unlike microcontroller-based robots, BEAM robots often rely on analog circuits, solar engines, and direct motor control to achieve lifelike actions. Two classic examples are the straight-line robot, which follows a deterministic path, and the obstacle-avoiding robot, which adapts to its environment through reactive circuits. This case study explores the design principles, challenges, and outcomes of these two models.

2. PROBLEM STATEMENT

Robotic locomotion is essential in applications ranging from exploration to education. However, designing robots that balance simplicity and adaptability is a challenge. A straight-line robot demonstrates minimalism but fails in real-world environments filled with obstacles. Conversely, an obstacle-avoiding robot demonstrates adaptability but introduces circuit complexity. This case study addresses the problem: How can basic BEAM robots demonstrate effective locomotion strategies while remaining energy-efficient and robust?

3. HISTORY OF BEAM ROBOTICS

Founded in the early 1990s by Mark W. Tilden, a physicist and robotics researcher.

Focused on creating robots with insect-like reflexes using analog nervous networks rather than digital programming.
BEAM robots typically use scavenged electronics and solar power, making them accessible and eco-friendly.
Early BEAM creations included photovores (light-followers), head-bots (tracking light sources), and walkers.

These designs inspired educational kits, hobbyist competitions (e.g., Solarbotics), and studies in minimalist robotics.

4. LITERATURE REVIEW

Tilden’s research emphasized low-power, autonomous robots capable of “lifelike” behaviors without microcontrollers.

McComb (Robot Builder’s Bonanza) highlighted BEAM as a teaching tool for introducing electronics and mechanics.

Academic studies compared BEAM robots with programmable robots, noting BEAM’s energy efficiency but limited adaptability.

Recent works show BEAM principles being applied in swarm robotics, where many simple robots collaborate to achieve complex tasks.

5. APPROACH

This study compares two BEAM robot models:

1. Straight-Line Robot – designed for deterministic forward locomotion.

2. Obstacle-Avoiding Robot – designed for reactive navigation in cluttered spaces.

The approach involves analyzing their mechanical design, electronic circuits, working principles, and behavior.

6. Case Description

Straight-Line Robot:

Uses two motors in parallel.

Powered by a solar cell or battery.

Symmetrical wiring ensures both motors spin evenly → straight path.

Behavior: Continuous forward motion until stopped by an external barrier.

Obstacle-Avoiding Robot:

Uses IR sensors, bumpers, or whisker feelers to detect objects.

Nervous Network (NV neuron) circuit redirects power based on sensor input.

When an obstacle is detected, one motor slows or reverses → robot turns.

Behavior: Moves forward until an obstacle is encountered, then adapts by changing direction.

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7. Analysis

Straight-Line Robot:

Strengths: Simple, reliable, efficient, ideal for controlled paths.

Weaknesses: No adaptability; fails in unpredictable environments.

Obstacle-Avoiding Robot:

Strengths: Adaptive, lifelike, suitable for exploration and demos.

Weaknesses: More complex, limited intelligence (cannot map or plan).

Both demonstrate BEAM's philosophy: complex behavior can emerge from simple analog interactions.

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8. Solution

A hybrid solution could integrate straight-line stability with basic obstacle sensing, combining the best of both designs. Optimizing motor symmetry, adding lightweight IR sensors, and maintaining low-power circuitry would create a more robust BEAM robot capable of handling both predictable and semi-unpredictable environments.

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9. Outcomes

Straight-Line Robot: Best suited for demonstrations, controlled experiments, and educational contexts.
Obstacle-Avoiding Robot: Effective in interactive demos, toy robotics, and autonomous exploration of cluttered environments.

Both robots provide valuable lessons in energy efficiency, circuit simplicity, and biologically inspired design.

10. Conclusion The case study highlights the strengths and weaknesses of two foundational BEAM

robots. The
straight-line robot demonstrates the elegance of minimalism but lacks adaptability, while the obstacle-avoiding robot achieves lifelike behaviors at the cost of added complexity. Together, they represent key milestones in BEAM robotics and provide inspiration for designing future low-power, autonomous systems.

11. References

1. Tilden, M. W. (1990s). BEAM Robotics: Nervous Network Circuits and Lifelike Machines.

2. McComb, G. Robot Builder's Bonanza. McGraw-Hill.

3. Solarbotics Ltd. – Educational Kits and BEAM Resources.

4. Academic articles on analog robotics and nervous networks (IEEE Robotics & Automation).

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