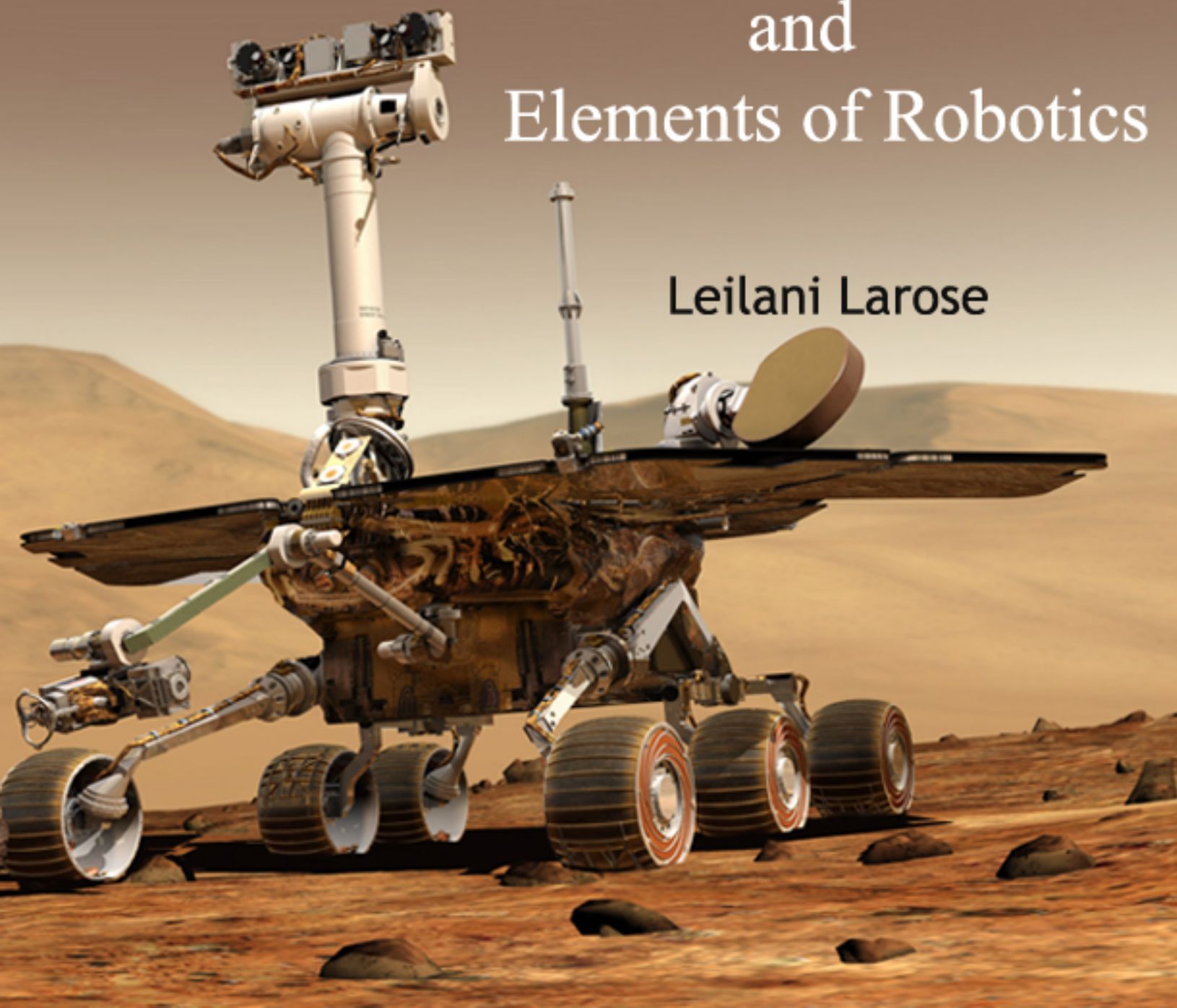


Major Branches and Elements of Robotics

Leilani Larose



Revised Edition: 2014

ISBN 978-81-323-3616-7

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Published by:

University Publications

4735/22 Prakashdeep Bldg,

Ansari Road, Darya Ganj,

Delhi - 110002

Email: info@wtbooks.com

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Chapter- 1

BEAM Robotics

The word "beam" in **BEAM robotics** is an acronym for *Biology, Electronics, Aesthetics, and Mechanics*. This is a term that refers to a style of robotics that primarily uses simple analogue circuits, such as comparators, instead of a microprocessor in order to produce an unusually simple design (in comparison to traditional mobile robots) that trades flexibility for robustness and efficiency in performing the task for which it was designed. Exceptions to the convention of using only analog electronics do exist and these are often colloquially referred to as "mutants". BEAM robots typically consist of a set of the aforementioned analog circuits (mimicking biological neurons) which facilitate the robot's response to its working environment.

Mechanisms and principles

The basic BEAM principles focus on a stimulus-response based ability within a machine. The underlying mechanism was invented by Mark W. Tilden where the circuit (or a Nv net of Nv neurons) is used to simulate biological neuron behaviours. Some similar research was previously done by Ed Rietman in 'Experiments In Artificial Neural Networks'. Tilden's circuit is often compared to a shift register, but with several important features making it a useful circuit in a mobile robot.

Other rules that are included (and to varying degrees applied):

1. Use the lowest number possible of electronic elements ("*keep it simple*")
2. Recycle and reuse technoscrap
3. Use radiant energy (such as solar power)

There are a large number of BEAM robots designed to use solar power from small solar arrays to power a "Solar Engine" which creates autonomous robots capable of operating under a wide range of lighting conditions. Besides the simplistic computational layer of Tilden's "Nervous Networks", BEAM has brought a multitude of useful tools to the roboticist's toolbox. The "Solar Engine" circuit, many H-bridge circuits for small motor

control, tactile sensor designs, and meso-scale (palm-sized) robot construction techniques have been documented and shared by the BEAM community.

BEAM robots

Being focused on "reaction-based" behaviors (as originally inspired by the work of Rod Brooks), BEAM robotics attempts to copy the characteristics and behaviors of natural organisms, with the ultimate goal of domesticating these "wild" robots. BEAM robotics also promotes the value of aesthetics in the design of the device, proving the adage "form follows function".

Disputes in the name

Various people have varying ideas about what BEAM actually stands for. The most widely accepted meaning is *Biology, Electronics, Aesthetics, and Mechanics*.

This term originated with Mark Tilden during a discussion at the Ontario Science Center in 1990. Mark was displaying a selection of his original bots which he had built while working at the University of Waterloo.

However, there are many other semi-popular names in use, including:

- **B**iotechnology **E**thology **A**nalogy **M**orphology
- **B**uilding **E**volution **A**narchy **M**odularity

Microcontrollers

Unlike many other types of robots controlled by microcontrollers, BEAM robots are built on the principle of using multiple simple behaviours linked directly to sensor systems with little signal conditioning. This design philosophy is closely echoed in the classic book "Vehicles: Experiments in Synthetic Psychology". Through a series of thought experiments, this book explores the development of complex robot behaviours through simple inhibitory and excitatory sensor links to the actuators. Microcontrollers and programming are usually not a part of a traditional (aka., "pure") BEAM robot due to the very low-level hardware-centric design philosophy.

There are successful robot designs mating the two technologies. These "hybrids" fulfil a requirement needing robust control systems with the flexibility of dynamic programming, like the "horse-and-rider" topology BEAMbots (eg. the ScoutWalker 3). The physical robot body (the "horse") is controlled by traditional BEAM technology, and the microcontroller and programming influences (and if needed, subsumes) the robot body from the "rider" position . The rider component is not necessary for the robot to function, but without it the robot will lose the important influence of a "smarter brain" telling it what to do.

Types

There are various "*-trophe*" BEAMbots, which attempt to achieve a specific goal. Of the series, the phototropes are the most prevalent, as light-seeking would be the most beneficial behaviour for a solar-powered robot.

Audiotrope

In BEAM robotics, an **audiotrope** is a robot that reacts to sounds. This term, which literally means "sound turning," is generally applied to sound-seeking robots. More accurately, audiotropes can either seek (audiophiles) or avoid (audiophobes) sources of sound.

Phototrope

In BEAM robotics, a **Phototrope** is a robot that reacts to light sources. Literally, "light turning," this term is generally (if somewhat inaccurately) applied to light-seeking robots. More accurately, phototropes can either seek (photophiles) or flee (photophobes) bright sources of light.

The simplest and most common form of phototrope is the photopopper—many are as simple as to be essentially two solarrollers stuck together.

One mechanism for phototropism in robotics is implementation of a light sensor where a direct feedback system allows for interaction with the environment. The phototrope analyzes "shots" of its environment and decides whether to move into a certain area depending upon the light intensity.

Alternatively, photovoltaic cells may be used to provide both control and energy for a phototrope. Clever geometry in construction allows for current yielded by a photovoltaic cell to cause motion in the direction of (or away from) the most intense light source in the robots vicinity.

Radiotrope

In BEAM robotics, a **radiotrope** is a robot that reacts to radio frequency sources. Literally, "radio turning," this term is generally (if somewhat inaccurately) applied to radio frequency seeking robots. More accurately, radiotropes can either seek (radiophiles) or flee (radiophobes) sources of radio waves.

Thermotrope

In BEAM robotics, a **thermotrope** is a robot that reacts to heat sources. Literally, "heat turning," this term is generally (if somewhat inaccurately) applied to heat-seeking robots. More accurately, thermotropes can either seek (thermophiles) or flee (thermophobes) sources of heat.

General

BEAMbots have a variety of movements and positioning mechanisms. These include:

Sitter (BEAM)

In BEAM robotics, a **sitter** is a type of robot that does not move. Such robots have no self-contained means of transportation and are non-mobile. Instead of moving, sitters are usually designed to power lights in some sort of pattern. Most sitters are built as decorations rather than serving a practical purpose.

As sitters usually have few parts and are not very complicated to build, many newcomers to BEAM robotics start with sitters, as they are a good place to begin learning the basics of the hobby.

Genera

- **Beacons** : Transmit a signal (usually a navigational blip) for other BEAMbots to use, often as a navigational device. Essentially, these consist of a solar cell, capacitor, LED(s), and possibly a solar engine. Beacons are often found within robot games and are used by other robots to use as a "base" for navigation.
- **Pummers** : Display a "light show" or a pattern of sounds. Pummers are often nocturnal robots that store solar energy during the day, then activate during the night.
- **Ornaments** : A catch-all name for sitters which are not beacons or pummers. Many times, these are mostly electronic art.

Squirmer (BEAM)

In BEAM robotics, a **squirmer** is a stationary robot that performs an interesting action (usually by moving some sort of limbs or appendages).

Slider (BEAM)

In BEAM robotics, a **Slider** is a robot that has a mode of locomotion by moving body parts smoothly along a surface while remaining in contact with it.

Crawler (BEAM)

In BEAM robotics, a **Crawler** is a robot that has a mode of locomotion by tracks or by transferring the robot's body on limbs or appendages. These do not drag parts of their body on the ground.

Jumper (BEAM)

In BEAM robotics, a **Jumper** is a robot that has a mode of locomotion by propelling the robot off the ground and from place to place on the ground.

Roller (BEAM)

In BEAM robotics, a **Roller** is a robot that has a mode of locomotion by rolling all or part of the robot.

Genera

- **Symets** : Driven mode of locomotion via a single motor. The robot is powered by a solarengine circuit that drives it by charging either three or four capacitors up, then releasing the stored energy in a single 'burst' of power for a period of time, before stopping again to recharge, starting the cycle again. The capacitors are arranged in either a triangular or square pattern along the cylindrical part of the motor. The capacitors are arranged so that they act as rests on which the motor shaft (acting as the 'wheel' for this robot) is balanced out on two other skids. The symmetrical design allows the robot to change direction when it hits an obstacle by tipping onto another set of two side capacitors, which then cause it to move into another direction.
- **Solarrollers** : Driven mode of locomotion by a single motor; Solar-powered BEAMbots that attempt to complete a fairly short, straight and level course in the shortest amount of time. They are driven by a 'solar engine' circuit; the circuit is designed so that it charges up energy gained from the solar panels and then releases it in one continuous burst. The two main types of solar engines are the

FLED engine, which uses a flashing LED to regulate the power, and a 1381 engine, which uses a 1381 voltage regulator to decide when to release the energy.

- Poppers : Driven mode of locomotion by multiple motors; Uses differential sensors achieve a goal.
- Miniballs : Driven mode of locomotion via one or two motors; Entire robot body is caused to move by turning over (on an axis) while on the ground.

Walker (BEAM)

In BEAM robotics, a **walker** is a walking machine that has a driven mode of locomotion by intermittent ground-contacting legs. They usually possess 1 to 12 motors. (ed. motors numbering above 3 are uncommon) "Muscle wired" walkers utilizes Nitinol (nickel - titanium alloy) for its actuators.

BEAM walking robots are creating using something called NV nets. An NV net consists of NV neurons each of which is a very simple oscillator setup. The most common form of BEAM walker is the master slave Bicore, this uses two suspended Bicore arrangements.

A BEAM walker does not use a processor, nor is it programmed in any way! despite this it is able to walk and respond to terrain via resistive input from its motors. This is an extremely clever method for creating locomotion.

An Example of a two motor walker can be seen at TomboT.net

Genera

- unimotor : Driven mode of locomotion via one motor.
- bimotor : Driven mode of locomotion via 2 motors.
- trimotor : Driven mode of locomotion via 3 motors.
- quadramotor : Driven mode of locomotion via 4 motors.
- pentamotor : Driven mode of locomotion via 5 motors.
- hexamotor : Driven mode of locomotion via 6 motors.
- septuamotor : Driven mode of locomotion via 7 motors.
- octamotor : Driven mode of locomotion via 8 motors.
- ennamotor : Driven mode of locomotion via 9 motors.
- dekamotor : Driven mode of locomotion via 10 motors.
- undecmotor : Driven mode of locomotion via 11 motors.
- dodecamotor : Driven mode of locomotion via 12 motors.
- Muscle wired : Utilizes Nitinol (nickel - titanium alloy) for its actuators.

Swimmer (BEAM)

In BEAM robotics, a **swimmer** is a robot that functions on or in a liquid environment. These are sometimes referred to as **aquabots** or **aquavores** (the latter being a misnomer, as they are not "water eaters"). Swimmers include various designs, but usually lie within a device class that can be delineated as a watercraft, usually a boat but includes any vehicle designed to move across (or through) water.

Genera

- Boatbots : Self-propelled on the surface of a liquid; construction akin to surface watercrafts.
- Subbots : Self-propelled under the surface of a liquid; construction akin to submarines.

Flier (BEAM)

In BEAM robotics, a **flier** is an aero-robot that functions in an atmospheric environment. They possess a driven mode of locomotion through and/or supported by the atmosphere. Fliers include various designs, but usually lie within a device class that can be delineated as aircraft, which includes any vehicle designed to move through the air (aerodynes or aerostats).

One idea for a solar powered blimp is to use the principle of the Solar balloon, and a standard photopopper circuit.

Genera

- Helicopter : Powered rotor provides both lift and propulsion; Utilizes differential thrust to hop toward brighter areas (aka. "Hoppers")
- Plane : Aircraft that has a fixed wing and is powered by propellers or jets; Usually powered via non-solar power source (such as pneumatic or battery); Solar power for control.
- Blimp : Aircraft that has neutrally-buoyant balloon for lift; Solar power for control and propulsion.

Climber (BEAM)