BIOLOGICALLY INSPIRED ROBOTS

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Abstract:

This report is about biologically inspired robots or biomimetic robots which mimic living creatures such as insects, humans and birds. It also gives the basic definition, different projects, technological aspects and basic operations.
This report gives a brief knowledge on working of sensor nervous and reaction part of biomimetic robots.
We have discussed the flexible polymers EAP which are exclusively developed for making the muscles of these robots.
Light weight energy sources are required for their function but these could be able to create high power for long time.
We have elaborately explained the different researches happening on these robots. This report also includes the fields where these can be used and their future applications. May be some day we should be able to see these around us.

Introduction :

Biomimetic robots borrow their structures and senses from animals and insects. Their abilities are copied from Earth's greatest examples of success, living organisms; they tend to function better in the unpredictable real world than the controlled artifice of a lab. Robotics engineers are able to blend expertise from the fields of biology and computer engg . This report begins with basic definition of biomimetic robots. Later the report concentrates on technological aspects which includes the basic operation that drives these robots.It gives a brief knowledge on the working of sensor, nervous and reaction parts of biomimetc robots which are built artificially in lab. taking into consideration the behaviour of living organisms. Several researches of living organism done have been included.

Autonomous robots which may look like living creatures can potentially address the need to inpect structures with configurations that are not predetermined.
Making robots that are actuated by electroactive polymers, namely artificial muscles that are controlled by artificial intelligence would create a new reality with great potentials.
These can move anywhere, on any surface and in versatile conditions and hence can be used in different fields. Still much has to be done on this and requires more sophisticated technology and fund.

Biomimetic Robots:
Biologically inspired robots or Biomimetics is a general description for engg. A process or system that mimics biology.

The term emerged from biochemistry and applies an infinite range of electronics, communication, mechanical and chemical phenomena, from cellular process to whole organism functions. Biomimetic robots borrow their structure and senses from animals such as humans or insects. Their abilities are copied from earth's greatest examples of surface, living organisms: they tend to function better in the unpredictable real world than the controlled artifice of a laboratory. Robotics engineers are able to blend expertise from the fields of biology & computer engineering.

Strides made in biological research mean we know much more about how animals survive, for instance deep-sea creatures' sensory organs or geckos' gravity-defying feet. The speed, power, and size of computers mean we can create programs that mimic neurophysiological brain functions. Reverse engineering (tracking a result through its process to its source) has as a tenet that the cause exists. Therefore,
just knowing there is an animal that can track moving objects while flying through space without visible light, proves that it's possible.

To picture such a biomimetic robot, you might consider its method of locomotion. Remember, such a robot would never have wheels on an axle, but might wriggle like a worm or hop like a bird. It might have sensory "organs," like an instrument to measure temperature. Also, its abilities will probably be something humans aren't adapt at, like locating underwater mines or can't do tasks quickly enough .

Why Biomimetics ...?

- Insects, achieve exceptional physical robustness and an ability to accomplish basic tasks such as locomotion despite large perturbations in the environment.

- Insects are ideal for these studies because of their comparatively simple motor control systems.
- Insects have the ability to walk, climb, crawl and fly which makes them suitable for many applications.

- These are small in size

Technology behind ...
CPG :

Central Pattern Generators (CPGs) are neuronal groups that produce rhythmic patterned output without rythmic sensory or central input, and are responsible for most instances of rythmic movement found in nature, such as wing flapping, walking and breathing. Central to CPGs is the half-centre oscillator, a pair of neurons that are reciprocally coupled (firing one inhibits the other) to produce rythmicity. CPGs exist in the spine in vertebrates, therefore allowing spinal trauma victims to regain motor function through intense treadmill exercise.

Recently it was found that it is possible to regain some locomotor activity in patients suffering from an incomplete spinal cord injury through intense training on a treadmill. The ideas behind this approach owe much to insights that humans may have a central pattern generator for locomotion located at spinal level. Rhythmic motor patterns comprise a large part of the suite of mechanisms that contribute towards the control of an animal.

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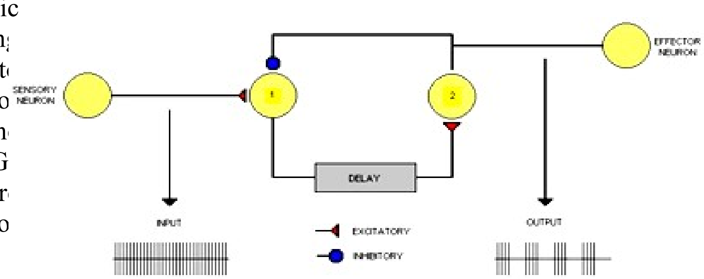
Central to CPGs is the half-centre oscillator, a pair of neurons that are reciprocally coupled (firing one inhibits the other) to produce rhythmicity. Looking at the figure, the reciprocally coupled neurons are labelled 1 and 2. Neuron 1 is excited by a sensory neuron, and this excitation causes neuron 1 to, after a delay, excite neuron 2 that produces an output, but also has an inhibitory effect on neuron 1, causing it to stop firing. Once the inhibition of neuron 1 has stopped, the sensory input refires neuron 1 and the process is repeated.

This leads to a rhythmic output to the effector neuron. CPGs exist in the spine in vertebrates, therefore allowing spinal trauma victims to regain motor function through intense treadmill exercise. Recently it was found that it is possible to regain some locomotor activity in patients suffering from an incomplete spinal cord injury (SCI) through intense training on a treadmill. The ideas behind this approach owe much to insights that humans may have a central pattern generator for locomotion located at spinal level.



their spinal.
Biomimetic CPGs have been used in several research projects in order to provide repetitive actuation to control locomotion. Examples of biomimetic projects that use CPGs include the Robotuna project and hexapod walking control.

The simplest types of control movements are reflexes, which are involuntary. There are several defined types of reflex, of which the Myotatic Reflex is the simplest type in vertebrates, dependent upon two types of neuron - a sensory fibre and a motoneuron. A familiar example of the Myotatic Reflex exists in the form of the knee jerk evoked by tapping with a hammer. Reflexive control obviously is obviously important in fastresponse actions such as withdrawing a limb from danger, but reflexive control also has the ability to coordinate limb motion in a fashion that produces directed, locomotive behaviour, by employing proprioreceptors in the limbs that trigger reactive movement upon certain a certain stimulation.

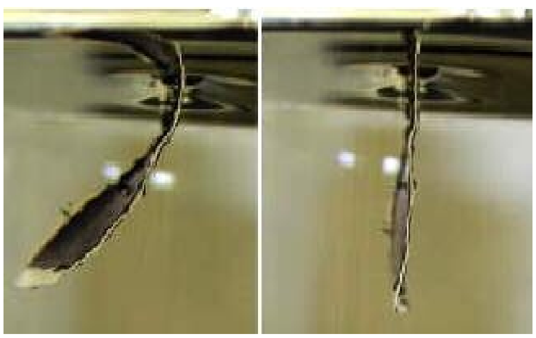
Several of the neuronal circuits that underpin these types of control have been well investigated in several invertebrates, and this has provided the inspiration for the construction of biomimetic robots.

Lobster chemotaxis to guide orientationrelated behaviour in the sea. Work into biomimetic reproduction of control using reflex driven methods also includes work on the Sahabot, and several others. (Cataglyphis), which detects polarised light.

Fly visual behaviour, in particular the optomotor response (the use of visual motion information to estimate selfrotation and actuate a compensatory torque response to maintain stability during flight.

EAP :

The beginning of the field of EAP can be traced back to an 1880 experiment that was conducted by Roentgen using a rubber band with fixed end and a mask attached to the free end, that was charged and discharged.



Generally there are many polymers that exhibit volume or shape change in response to perturbation of the balance between inter molecular forces, which act to expand the polymer network, and attractive forces that ac t to shrink it. Repulsive forces are usually electrostatic or hydrophobic in nature, whereas attraction is mediated by hydrogen bonding interactions. The competitions between these counter acting forces, and hence the volume or shape changes, can be controlled by subtle changes in parameters such as solvent, gel composition, temperature, Ph, light etc. This type of polymer can be activated by electrical and non electrical means.

As polymers, EAP materials can be easily formed in various shapes. There properties can be engineered and they can be potentially be integrated with micro electro mechanical system (MEMS) sensors to produce smart actuators. As mentioned they are most attractive features is their ability to emulate the operation of biological muscles with high fracture toughness, large activation is strain and inherent vibration damping. Unfortunately the EAP materials that have been developed so far are still exhibiting low conversion efficiency, are not robust, and their are no standard commercial materials available.

Given fig. demonstrates the flexibility of EAP actuators.

The easy capability to produce EAP in various shapes and configurations can be exploited using such methods as stereolithography and ink-jet printing techniques. Such processing methods offer the potential of making robots in full 3D details including EAP actuators allowing rapid prototyping. Making insect like robots could help inspection hard to reach areas of the structures. These creatures can be launch to conduct the inspection procedure.

Power Sources :

Allowing half an ounce for a payload such as a guidance system, video camera or transmitter leaves only 3‡ ounces for the body and propulsion system. Finding a power-source that is light enough to fit these specifications, but can still create a some useful power is the biggest headache for the designers. Fortunately there is a plethora of power sources under development for designers to choose from. There are four main contenders for the engine ,

Internal combustion :

Engines have the advantage that model aircraft enthusiasts are already using a number of very small engines. These engines are already in production and are a cheap and mature technology. The Cox 010, built by Estes, is the smallest mass-produced internal combustion engine in the world. The engine is only 0.01 cubic inches, but it can turn a 2 inch prop at 30,000 rpm and produces about 40 Watts of power. Despite fulfilling the criteria for size, the Cox 010, and other internal combustion engines, have a number of drawbacks.

Electric motor :

The second option under consideration is the electric motor. Electric flight offers the immediate advantage that it is quiet, and is more reliable and produces less vibration than internal combustion. Battery packs would be easy to change and discard on the battlefield. However they have a significant disadvantage that the most advanced batteries still offer an insufficient power to weight ratio. In short, their weight limits the performance, in particular the endurance, of the MAV. At present the most advanced lithium batteries do not allow a satisfactory endurance/weight trade-off and mission time for prototypes is limited to about 15 minutes.

Chemical muscle :

Another type of power source in development is the **Reciprocating Chemical Muscle (RCM**) which is used in a craft called the Entomopter. Looking more like a giant insect than a scaled down aircraft, the Entomopter has flapping wings and legs and is designed to be used in urban environments. The RCM powered flapping wings and scurrying legs allow the Entomopter to hover and move along the ground - something that fixed wing MAVs are unable to do. The RCM also produces small amounts of electricity, which can be used to power onboard systems for directional control or mission purposes. RCM engines offer a very promising method of powering an MAV, however their development has only recently moved beyond the conceptual phase. It will be a number of years before an RCM powered MAV is ready to be used on the battlefield.

Jets :

A hydrogen-powered jet turbine,Researchers at M.I.T., for example, are ambitiously trying to shrink jet engines to the size of shirt buttons. MIT's Gas Turbine Laboratory are working on a silicon carbide engine that is only 0.4 inches in diameter and 0.12 inches thick, yet produces 10 to 20 watts of power. The MIT team has already built a microscale combustor that works, but the engine's compressor, generator, and bearings still must come down in size. The researchers hope to have a complete micro engine running within three years. Meanwhile, engineers at M- Dot Inc., Phoenix, are working on an MAV turbojet roughly the size of a chicken egg. It weighs 78 gm and puts out 1.43 lb of thrust, the equivalent of a little over 2 horse power. Turbines offer MAVs several advantages, which include high power densities, high flight speeds, and relatively vibration- free flight, an important quality for an imaging platform.

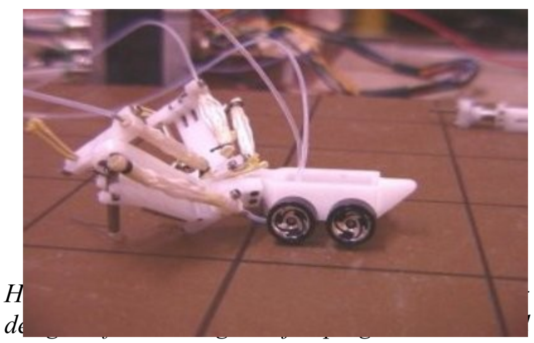
1.4. Researches :

1.4.1 Scorpion-Based Robot:

Systeme (AIS) in Germany. These robots are designed to work in harsh environments. They have eight legs and are bigger than the other robots mentioned above with a height of 60

centimeters and a weight of almost 10 kilograms.

1.4.4. Cricket Series Robot



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to find potential similar robots and is used for search and rescue missions.

At Case Western Reserve University (CWRU), researchers are building cricketinspired robots, which can walk and jump.

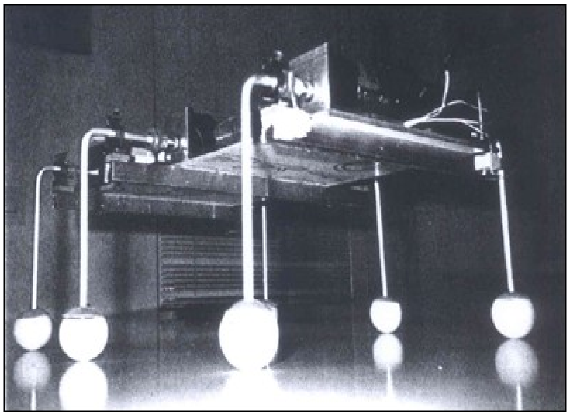
Roger D. Quinn, professor of mechanical engineering at CWRU and director of Biologically Inspired Robotics Lab, is working with his team are not only working on robots inspired by cockroaches and crickets, but also on a hybrid mechanism called Whegs (wheels plus legs).

1.4.5. Whegs series robots :

The Whegs series robots utilize a method of locomotion that combines the advantages of wheels and legs (wheel-legs). Wheels are relatively simple, and allow a vehicle to move over terrain quickly. Legs allow robots to climb obstacles that are higher than what a wheeled vehicle would be able to climb over.

Preceded Whegs :

It was designed in 1996 by A. Martin Alvarez at the European Space Agency. It uses 6 drive motors (one for each leg). Each leg consists of a spoke, which rotates in a circular motion. Picture of it can be seen below ,

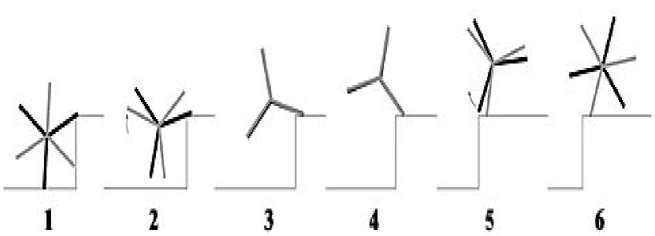


During the swing phase of walking, its feet rapidly rotate to return to the stance phase, when the feet rotate much more slowly.

It uses a total of 6 motors and spoke-like legs to move.

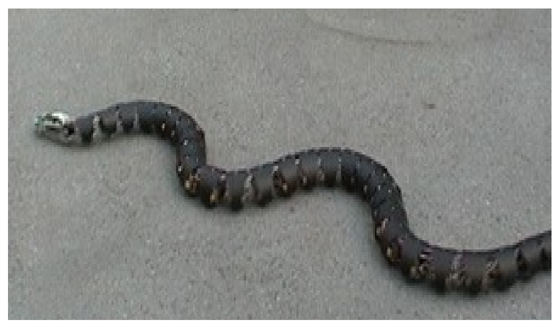
The drive motor in a Whegs robot runs at a constant speed, instead of accelerating and decelerating its legs during each walking cycle like RHex does. Whegs runs quickly and climbs barriers and stairs with the same multifunctional legs, whereas RHex requires different legs for different tasks.

The robot pictured above is Whegs 1. It is 20 inches long, and utilizes three-spoke wheel-legs and one drive motor. It can climb obstacles of heights up to 1.5x the wheelleg radius, and the robot can move up to a speed of 3 body lengths/second (5.5km/hr).



While walking on flat ground, three of the wheel-legs are 60 degrees out of phase with the other three wheel-legs, which allows the robot to use an alternating tripod gait (Part 1 in the figure below). This gait requires that the two front wheel-legs be out of phase with each other. In the illustration below, one front wheel-leg is dark grey, while the other front wheel-leg is light grey. When an obstacle is encountered (Part 2 in the figure below), passive mechanical compliance allows the front legs to come back into phase with each other, so that they can both be used to pull the robot up and over the obstacle.

1.4.6 Snake Robot Prototype (S5) :



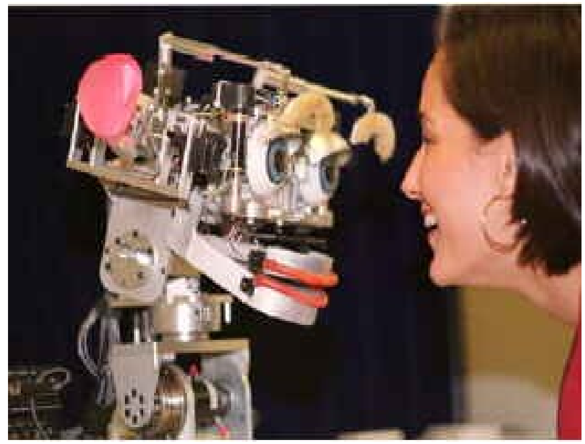
S5 represents a refinement of the S3 design. Parts were created using a numerically controlled milling machine. This allowed for much more accuracy, and a smaller cross-section. Almost doubling the number of segments allowed a robot that begins to resemble the length-to-width ratio of chubby real snakes. As the snake grows in size, the design starts to place heavier requirements on the wiring and control capability.

1.4.7 Entomopter based robot:

This generation of entomopter is designed for operation in 2 atmospheres; a 50g terrestrial version and an aerospace version designed for use in diffeent gravitational environments.

The entomopter might even be used on future mars mission.

The robot below named, KISMET, can respond to human expressions. It has been developed by Cynthia Breazeal's group at MIT.



1.4.8 Humanoid Robots :

Brussels, Belgium, January 25, 2005 - ASIMO, Honda's advanced humanoid robot, met with members of the EU institutions at an historic meeting at the European Parliament, Brussels. ASIMO's appearance, which included a demonstration of its unique ability to walk up and down stairs, was part of a wider presentation by Honda to the Parliament on developments in humanoid robots and their benefits to society. Professor Dr. Edgar Koerner, President of Honda Research Institute (Europe) led the presentations.

This advanced robot performs several jobs like humans do. It can walk, run, can grab objects and several other works.

1.5 CONCLUSION:

This science fiction scenario could become a reality at the trend in the development of biologically inspired technologies,and terms like artificial intelligence, artificial muscles and numerous others are increasingly becoming common engineering tools.

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