

Design of Polybot for Irrigation Purpose Using Artificial Intelligence

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ABSTRACT: Snake robots may one day play a crucial role in search and rescue operations and fire-fighting where it may either be too narrow or too dangerous for personnel to operate. Properties such as high terrainability, redundancy, and the possibility of complete sealing of the body of the robot, make snake robots very interesting for practical applications and hence as a research topic. During the last ten to fifteen years, the published literature on snake robots has increased vastly. However, no thorough review of the theory presented in this period regarding structure and locomotion of snake robots in field of agriculture(irrigation) has been found. The purpose of this paper is to give such a review. The choice of modeling method is linked to robotic design characteristics and locomotion approach of NASA's Ames Research Center. Different approaches of biologically inspired locomotion and mechantronics structure of it is dicussed below.

KEYWORDS: Snake robots, dynamics, electronics, locomotion.

I.INTRODUCTION

Wheeled mechanisms constitute the backbone of most ground-based means of transportation, but it does not roll everywhere. Only on relatively smooth surfaces, such mechanisms can achieve high speeds and have good steering ability. Unfortunately, rougher terrain makes it harder, if not impossible, for such mechanisms to move. In nature, Snakes are unique creatures among the living organisms that their bodies allow them to get into the cracks and crevices of the world that most other creatures cannot perform better. Lacking rigid skeletons and extremities, snakes can contort their bodies in order to getting to tiny holes, wrap around tree branches and slither over otherwise unmanageable rocks. These serpentine qualities are the inspiration for a new type of robotic, interplanetary probe, called a snakebot. Thus chosen as main concept for the paper. It is able to move through narrow passages and climb on rough ground. This property of mobility is attempted recreated in robots that look and move like snakes. Snake robots most often have a high number of degrees of freedom (DOF) and they are able to locomote without using active wheels or legs, but use passive wheels. Snake robots suit a wide range of applications. One of many and known examples is rescue missions in earthquake areas. The snake robot could crawl through destroyed buildings looking for people. It could also carry small amounts of food or water to people trapped by the building prior to the arrival of rescue personnel. Also, snake robots with one end fixed to a base may be used as a robot manipulator which can reach hard-to-get-to places. The exterior can be completely sealed to keep dust and fluids out. Due to high redundancy and modularity, the snake robot. to mechanical failure. The first working biologically inspired snake robot was made by Shigeo Hirose. He presented a two-meter long serpentine robot with twenty revolute DOF joints called the Active Cord Mechanism. Multi-link articulated robots intended for crawling locomotion have been developed and they have been called by many names as multi-link mobile robot, snakelike or snake robot, hyper-redundant robot and G-snake. To emphasize that this paper deals with robots that mainly resemble locomotion of snakes, the term "snakerobot" will be employed. Motion patterns of snakes, inchworms and caterpillars are used as an inspiration for how the snake robots should move. Models of the snake robots are analyzed with the motion patterns and to simulate their motion. The relationship between snake robot design and the choice of gait is outlined, and some recent results on locomotion patterns are given. The choices of sensors and actuators will be discussed in below. The edition of its control will be down.

Proposed idea of snakebots in field of agriculture is dicussed below with required architecture module.

II. BIOLOGICAL SNAKES

Biological snakes, inchworms and caterpillars are the source of inspiration for most of the robots dealt with in this paper. We will therefore start with a short introduction to snake physiology and snake locomotion.

A. Snake Skeleton:

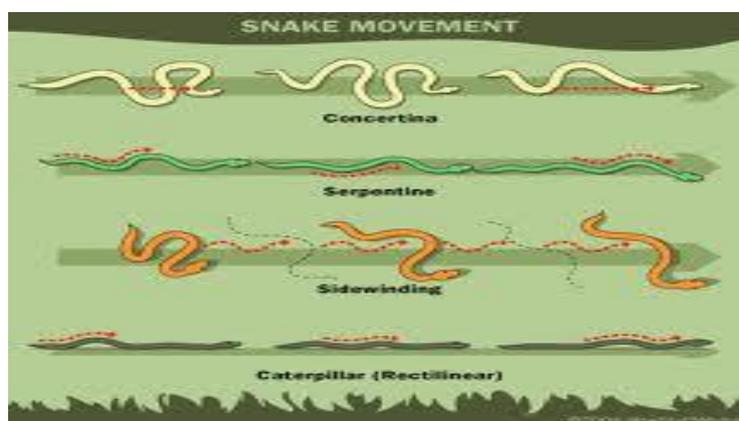
The skeleton of a snake often consists of at least 130 vertebrae(bones),and can exceed 400 vertebrae. The range of movement between each joint is limited to between 10° and 20° for rotation from side to side, and to a few degrees of rotation when moving up and down. A large total curvature of the snake body is still possible because of the high number of vertebrae. A very small rotation is also possible around the direction along the snake body. This property is employed when the snake locomotes by sidewinding.

Figure1 showing the real snake and snakeobt in tree.



B. Locomotion - The Source of Inspiration for Snake Robots

Most motion patterns used by snake robots to locomote are inspired by locomotion of snakes, but also inchworms and caterpillars. Figure3 shows the relevant motion patterns of such creature is outlined in the following.



1) *Concertina Locomotion*: A concertina is a small accordion instrument. The name is used in snake locomotion to indicate that the snake stretches and curves its body to move forward. Forward motion is obtained when the force needed to push back the fixed part of the snake body is higher than the friction forces on the moving part of the body. Concertina locomotion is employed when the snake moves through narrow passages such as pipes or along

branches. If the path is too narrow compared to the diameter and curving capacity of the snake, the snake is unable to locomote.

2) *Lateral Undulation*: Lateral undulation (also denoted serpentine crawling) is a continuous movement of the entire body of the snake relative to the ground. Locomotion is obtained by propagating waves from the front to the rear of the snake while exploiting roughness in the terrain. Every part of the body passes the same part of the ground ideally leaving a single sinus-like track. The body of the snake needs to touch the ground at three points to obtain a continuous forward motion. To prevent lateral slipping while locomoting, the snake "digs in" to the ground with help of the edge. It also uses contours such as rocks on the ground to push against.

3) *Sidewinding Locomotion*: Sidewinding is probably the most astonishing gait to observe and is mostly used by snakes in the desert. The snake lifts and curves its body leaving short, parallel marks on the ground while moving at an inclined angle. Sidewinding is usually employed on surfaces with low shear such as sand. The snakes can reach velocities up to 3 km/h.

4) *Inchworm and Caterpillar Locomotion*: Inchworms locomote by curving their body grabbing the ground with its front legs while the rear end is pulled forward. The rear legs then grab the ground and the inchworm straightens. Caterpillars send a vertical travelling wave through their body from the end to the front. Small legs give friction while on the ground.

5) *Other Snake Gaits*: Snakes also have gaits that are employed in special situations or by certain species. These are e.g. rectilinear crawling, burrowing, jumping, sinus-lifting, skidding, swimming, and climbing

III. STRUCTURE OF THE SNAKEBOT

The structure of the SNAKEBOT is modular. It is mainly divided in three parts: Body, Tail, and Skin. Body and tail modules run in a chain. Body comprises of 4 similar body modules. Total length of the snakeBOT is around 41 cm. It is 7.3 cm wide. The skin is the top cover, which covers the robot in a specially designed way so as to provide the flexibility and ease while moving. This design of the snakeBOT provides following important features:

- The combined torque provided by the modules is responsible for navigation on an uneven elevation.
- Even if one of the modules is twisted and rises above the ground at an angle around 70° to the horizontal.
- The S-shaped curve formed by the snake during motion aids moving around obstacles.

A. Body

Coupling similar body modules forms the body. In the present design, four body modules are connected to form the main body. A body module consists of three major parts:

1. Motor holding assembly
2. Two DC Motors
3. Passive wheels

Motor holding assembly has three sub parts. The bottom and top covering lids and the inner box, which holds the motors. It is the basic building block of the body module. The slots inside the inner box hold the motors. The slots are placed side by side to minimize the dimensions of a single module. The system is both dynamically and statically stable as the weight is uniformly distributed. Placement of motors side by side as shown gives the effective sinusoidal motion. DC motors running at 80 rpm with a gear reduction of 175:1 are used. These give the necessary torque to sustain motion in the adverse conditions. The bottom and top covering lids cap the two motors. This ensures the proper positioning of the motors.

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B.Tail

The tail is the inactive part of the SnakeBOT. It houses the battery pack; IR control and motors drive circuitry. Four idle wheels (castors) are attached to the bottom of this structure to make it mobile. Tail module is connected to the last body module by means of signal and power wires. These wires run all along the length of the snakeBOT

IV.SNAKEBOT ANATOMY

In order for a robot to mimic the movements of a biological snake, some special design features have to be used. NASA's snakebots as a model of the polybot developed by Mark Yim of Xerox Palo Alto Research Center, we have decided to use it. Polybots are robots that are able to change their shape in order to perform a variety of tasks. The snakebot frame will be constructed out of a polycarbonate material and covered by an artificial skin to protect it from the Martian elements. Here's a closer look at a snakebot's architecture and individual modules:

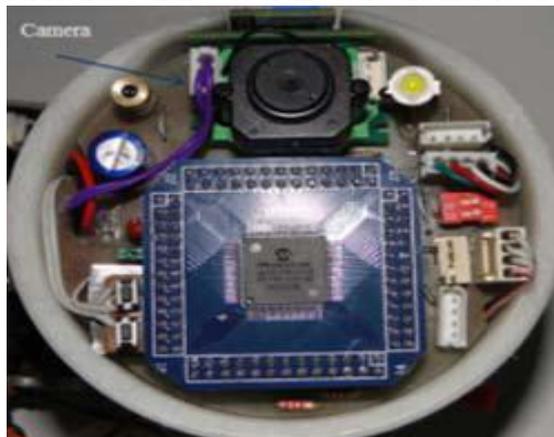


Fig 5:Circuit module

Electronics :

Each snakebot will have a central computer, possibly located in the snakebot's head, that works in conjunction with smaller computers in each module. Wires will connect each module to its neighboring modules, creating a network of modules that work together as a unit. The wiring will also carry communications and power to and from the computer brain.

Microcontrollers:

These tiny computers, a PIC microcontroller (PIC16F876) will interpret signals from the main computer to control movement. In later models, they may be connected to a set of sensors to provide reflexes. In later models, strain sensors may be added to the robot's metal rib frame. These sensors will indicate if the snake is in contact with anything, where it's touching it and how hard the contact is and tells about interrupt.

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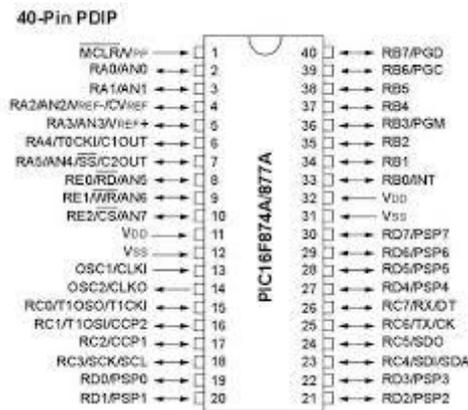


Fig 6:Microcontroller pin diagram

Motors:

Two servomotors, which are like of the shelf hobby motors, will be used to move the various parts in each module. Each motor will be activated by a signal from the main controller.

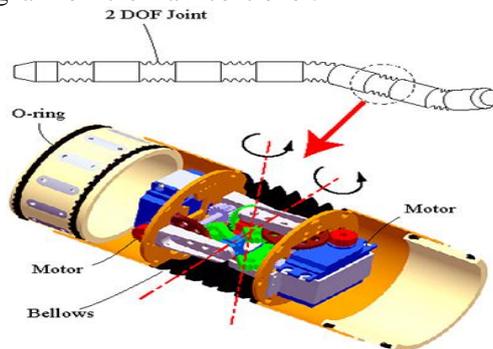


Fig 7:Motors involved

Gears:

Working in conjunction with the electronics, the gears will allow for movement of the joints. This will give the snake the ability to coil, sidewind and inchworm locomotion its way across the ground or wrap around objects.

Camera :

Small cameras probly a night vision camera, attached to the snakebots head will give a never be fore seen view of the capture.



Fig 8:Connecting rods

Connecting Rods :

When one section begins to move, these balljointed connecting rods will pull and activate the section next to it.

Castors:

Passive wheels are at body for the purpose of movement.

V.MOTION PLANNING

One of the snake's interesting behaviors is that when it moves rest of the body follows the path of the head. We planned to implement this behavior in our robot which eliminates the need of having sensors in the body to avoid obstacles. Each module is made to bend according to the movement of the predecessor with a certain delay. The potentiometer connected at the joint turn as a result. Each module's motion is planned such a way the potentiometer in front of each module gives preset value. All of these motions are coordinated by the master-microcontroller in the head/tail. The slave-microcontroller in each active body modules controls the motors in that module according to the potentiometer reading. When the robot moves in reverse direction the master-microcontroller in the tail will take control of all others . The motion planning for land detection is completely different from above. The head should follow the certain pattern to detect land for cropping. Initially the robot navigates in zigzag pattern and makes sure complete coverage of field. In later stages advance techniques like probabilistic method which uses priori information of land pattern and direct the robot to certain location where existence of cropping is very likely will be used. Micro controller in head executes sensor fusion algorithm by using sensor input data and this can reason proper action by expert system.

Snake robot has ultrasonic sensor, CMOS image sensor, gas sensor, temperature, illumination for sensing circumstance. Table 1 means the usage.

Sensor	Use	Character
Ultrasonic Sensor	Distance measurement, Avoidance	Range 3cm-3m
Image Sensor	Color recognition	120X90 Pixel
Gas Sensor	Gas detection	LNG, LPG
Temperature Sensor	Temperature measurement	-55-125 degrees
Illumination Sensor	Illumination measurement	CdS

Table 1. Sensors of Snake Robot

VI.MOTION ANALYSIS AND SIMULATION

Sensor fusion information used input of inference system. Inference system use expert system. Knowledge-based method utilizes rule-based expression method. Rule-based expression consists of next structure. The snake robot can recognize color and coordinates calculation about target by using IF *Antecedent* and *Antecedent*, then *Consequent*. Antecedent input of inference system used result which disposed of department of sensorfusion. So Antecedent of fuzzy rule was consisted of direction of ultrasonic sensor, result of environment sensor fusion, illumination value that handled separately and target value.

Consequent of fuzzy rule determine movement of the snake robot which consists of 7 actions, and its movement is forward motion, backwardmotion, left-turn, right-turn, rest,attack and precaution.

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Attacking Model



Warning Model



Sleeping Model



Locomotion Mode

Linguistic variables of direction element are made up of 4 kinds that consist of forward, backward, left and right and environment elements are 2 kinds (Danger, Safe) and target elements are 3 kinds (Nothing, Enemy, Prey). Finally, Linguistic variables of illumination elements is 2 kinds (Bright, Dark).

<p>Rule 1: If Dr is F, En is D, T is E and L is B, then A is <i>RETREAT</i>.</p> <p>Rule 2: If Dr is F, En is D, T is N and L is B, then A is <i>LOCOMOTION</i>.</p> <p>Rule 3: If Dr is F, En is S, T is N and L is Dk, then A is <i>SLEEP</i>.</p> <p>⋮</p> <p>Rule 48: If Dr is Bk, E is S, T is P and L is B, then A is <i>ATTACK</i>.</p> <p>● Dr: Direction, F: Forward, En: Environment, T: Target, S: Safe, D: Danger, Bk: Backward, L: Luminosity, B: Bright, Dk: Dark, A: Action, B: Bright, E: Enemy, N: Nothing, P: Prey</p>

VII. APPLICATIONS

A. INTIMATE TUMOUR WARNING:

One of the challenges with cutting away a tumour is making sure that all of it is removed. For this, the surgeon needs to understand where the tumour stops, which can be tricky. At the University of Bern in Switzerland, scientists inject a drug into the patient's body through the snakebots and once attached to the tumour, it starts glowing when light is shone on it. This imaging technology is also applied to instruments as they navigate inside the body. Of all the areas where engineering and technology is affecting medicine, surgery is probably the one where it has the potential to make the biggest changes. New imaging techniques and improved instruments help surgeons to identify the regions, they are remotely operated devices that allow surgeons to work through small incisions, rather than the large holes needed in conventional surgery for surgeons to see what they are doing. This reduces the size of wounds and therefore scarring, and reduces the time needed for recovery. Scientists and doctors are using the creeping metallic tools to perform surgery on hearts, prostate cancer, and other diseased organs. The snake robots carry tiny cameras, scissors and forceps, and even more advanced sensors are in the works. For now, they're powered by tethers that humans control.

B. USE OF GPS NETWORK BASED SNAKOBTS:

For military purposes, instead of facing a large life loss and property loss, we can use GPS connected snake robots. These types can be made to move through the enemy's colony or some terrorist group so that their formation or their presence at a particular location can be detected. The information recorded in the snake robot's camera can be obtained by the military officials or the user through the GPS network as follows:

- the time the message was transmitted
- satellite position at time of message transmission

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite using the speed of light. Each of these distances and satellites' locations define a sphere. The receiver is on the surface of each of these spheres when the distances and the satellites' locations are correct. These distances and satellites' locations are used to compute the location of the receiver using the navigation equations. Many GPS units show derived information such as direction and speed, calculated from position changes. The very accurately computed time is unused in many GPS applications, which use only the location. A few specialized GPS applications do however use the time; these include time transfer, traffic signal timing, and synchronization of cell phone base stations. Although four satellites are required for normal operation, fewer apply in special cases. If one variable is already known, a receiver can determine its position using only three satellites. For example, a ship or aircraft may have known elevation. Some GPS receivers may use additional clues or assumptions such as reusing the last known altitude, dead reckoning, inertial navigation, or including information from the vehicle computer, to give a (possibly degraded) position when fewer than four satellites are visible.



Fig10:Amphibious snakeobts

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VIII. FEATURED IDEA

In order to support the backbone of our country agriculture and to rise its economy for making our country a developed one. Taking ideas from nature and implementing it in robots is a growing area in robotic field. As a result the robot becomes much more efficient and easily deployable in natural environment. There has been lots of research in the area of Mobile Robots. Passive wheeled (castor) are so much faster and simpler with less parts. However, a legged robot designed to climb or go into volcano would probably do not much work than a crawled one.

Here to build a snake robot of type in fig.10 which carry sensors for land detection and to navigate through rough terrain with thick rocks and surface. The idea of long body with many contact points has evolved from snake. This feature makes the whole weight of the robot to be distributed along the body so that it can move over the field. Also the robot is made smaller with low centre of gravity cope with uneven terrain conditions and thick sand. The robot is able to move in both directions at same speed, blocks can be easily added in between head and tail and the whole body is made small enough to navigate safely are considered as main features of the robot. To reduce coverage time taking advantage of prior knowledge about field patterns is an appropriate method and will be implemented an addition to the sensor for obstacles a GPS device is added for positioning. In support for digging through underground bird's claw shaped connecting rods can be added for best outcome. In typical GPS operation, four or more satellites must be visible to obtain an accurate result. Four sphere surfaces typically do not intersect. Because of this we can say with confidence that when we solve the navigation equations to find an intersection, this solution gives us the position of the receiver along with accurate time thereby eliminating the need for a very large, expensive, and power hungry clock. These distances and satellites' locations are used to compute the location of the receiver using the navigation equations. It was also designed to be self-repairing. If any of its the moisture content. As it has night vision cameras it could be used for security of farms in form of fence so that the roaming creatures that destroy the farms could be avoided as that can also be recorded. As it is designed with the self-repairing software and the capability of toughness, with the attachment of bird's claws connecting rods, perhaps to identify and remove the diseased plants by new imaging devices and developed techniques in displays. It also has a shapechanging antenna to broadcast audio and video that is connected to main processor (personal computer).



Fig 12: Agriculture lab in CHINA.

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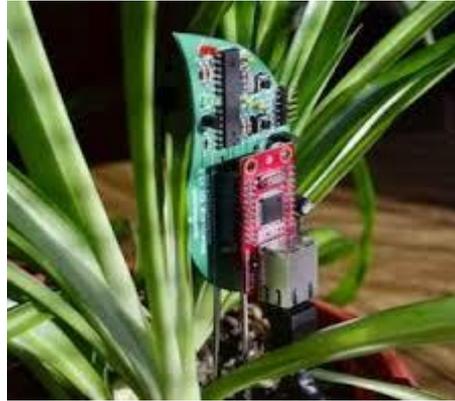


Fig 13:Nutrient sensor

IX.CONCLUSIONS

A snake robot has limited payload capability, poor power efficiency and a high number of degrees of freedom. Nevertheless, the snake robot exhibits great terrainability and has the capability of inspecting narrow places. Different types of snakes have different ways of moving through their environments, including sidewinding, slithering and inchworming. Snakebots will be able to perform all of those movements. They will also be able to coil and flip over in order to climb up and over obstacles. So far, the test versions of the snakebot have been remote controlled. Eventually, we will have to find ways to give these robots a form of intelligence so that they can operate far from Earth. It can also be made very robust to dirt and dust by covering the robot completely with a shell. These properties make the research on snake robots worth-while. It is hoped that this document will help me to promote further research on the fascinating topic of snake robots through the overview given on modeling and locomotion and future proposition.

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