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Biologically Inspired Robots into a New Dimension- A Review

Anil Antony Sequeira, Afeef Usman, Oommen Philip Tharakan, Mir Zeshan Ali

***Abstract*—This paper presents the state of art survey and future work to biologically inspired robots. Through decades people have constantly tried to emulate the appearance, portability, usefulness, astute operation, and intellect of fauna. This area of biological robots, having the name of biomimetics, has advanced from making stationary duplicates of human beings and other biological creatures as statues to the rise of robots that work with practical conduct. From the evolution of the first biologically inspired robots back in 1949; the well-known electromechanical tortoises. The history can be drawn back to evolution of the mechanical beverage serving waitress and musical players by Arab researcher and craftsman Al-Jazari in the thirteenth century and the mechanical dolls, for example, the famous Japanese karakuri ningyo in the eighteenth and nineteenth centuries. Similarly, the most well known example is the enormous effort made in the early twentieth century to advancement of flying machines. The field of biologically inspired robots and their technologies emerged vastly throughout the years. Yet, the term biologically inspired and the present idea of biologically inspired robots began in the last few years of the twentieth century. Technological development gave rise to fields such as man-made muscles, AI, artificial vision and in addition biomimetic capacities in mechanics, materials science, computing science, information technology, electronics and numerous others.**

***Keywords*—biomimetics, biorobotics, artificial intelligence, artificial muscles, biological inspiration**

I. Introduction

The thought of building machines that imitate features of fauna that we see around us has a long past. As in any machine that flies, walks, or swims can be said to be inspired by birds, legged creatures, or fishes, each moving robot that utilizes one of these method for movement or locomotion can be said to be biologically inspired.

Beer and his partners in their article [1] made a differentiation between just imitating some general character of a creature such as legs or wings and a more considered methodology in which particular basic or functional components of specific creatures is copied in hardware or program.

Since creatures are both structurally and practically intricate, it is evident that a complete proliferation of any creature in hardware and program is impractical. Henceforth, there is some argument among bioroboticists about where to take a stand. A few researchers take the methodology of Ritzmann and partners [2], who recommended that as many features possible should be fused into a robot, regardless of the possibility that any particular feature has an advantage or not.

Lately, the technologies in the Robotics and AI verticals have progressed tremendously permitting the development of sophisticated biomimetic frameworks [3]. Researchers and engineers are developing many of animal's performance features using these advancements. This interdisciplinary work has brought about machines that can perceive facial appearances, comprehend speech, and movement in robust bipedal gaits, like human beings. Lately, advances in polymer sciences have led to artificial muscles that shows practical characteristics like natural muscles [4]. The accelerated rate of developments in the field of biomimetics appears to make it obvious that the development of machines as our associate is fast approaching. In spite of the fact that this subject carries with it enormous significance including yet not limited to addresses in regards to the way of development and its part in innovative progress. The innovation is significantly benefited by fields such as Artificial Life, Psychology of Biomimetic Robots, Functionality Elements of Biomimetic Robots, Integrative Biology, Applications for Biologically Inspired Intelligent Robotics and Biomimetic Animated Creatures [5].

Recent technological developments have allowed one to easily animate graphically the appearance and conduct of biological creatures. Prior to this, designing such biological creatures as realistic robots was technically challenging. Developing such robots that can bounce and land securely without risking harm to the mechanism, or developing body and facial expression of satisfaction and excitement are simple tasks for human and fauna to do however greatly complex to build [6]. The use of AI, practical artificial muscles and other biomimetic innovations are relied upon to develop the likelihood of realistically looking and practically acting robots into more useful engineering models [7].

Developing biologically inspired robots requires understanding the biological models and progressions in physical implementation of the relevant technology, graphic simulation and analytical modeling. The engineering and research fields that are involved with the advancement of biologically inspired robots are multidisciplinary and they incorporate structures, actuators, materials, sensors, control, autonomy, functionality and intelligence [8].

With the engineering challenges there are some issues such as self-defense, controlled-termination and many others that

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Anil Antony Sequeira, Afeef Usman, Oommen Philip Tharakan, Mir Zeshan Ali

Manipal University Dubai
United Arab Emirates

needs attention. There is now broad history of making robots and toys that look and work like biological creatures and models for such robots are significantly inspired by sci-fi. These models have made expectation and desires that are a long way past the range of current engineering capabilities, which are compelled by current state-of-the-art and laws of physics.

II. Literature Review

Seeing the nature as a biologically-inspiring model, advancement over a thousand of years made nature to present solutions that are exceptionally control productive and impersonating them offers potential enhancements of our life and the tools we utilize. Human passion and ability to emulate nature and especially biology has constantly developed and with the enhancement in technology more challenging limitations are being considered. Bicker of birds was one of the early usage of biologically inspired devices, which was later invented in the form of tweezers [9]. More complicated innovation includes the advancement of aerodynamic structures and frameworks that utilizes the shape of seeds. Trees scatter their seeds by different procedures where the utilization of aerodynamics permits them to self-propel with the guide of wind to carry the seeds to extreme distances. The shape of such seeds has roused human beings to create objects that can be driven in air and those have led to the helicopter blades, gliders, boomerang and many other different parts of aircrafts [10]. Another plant that suggested an innovative idea is the tumbleweed and it was proposed as a mobility strategy for working on Mars utilizing wind instead of a power absorbing mechanism. Since wind is blown all through Mars, creating a rover that emulates the tumbleweed offers an appealing alternative of planning a vehicle that can navigate enormous distances with a negligible utilization of power.

The development of the wheel has been a standout amongst the most critical invention that human invented permitting to travel enormous distances and perform works that would have been generally not possible within the lifetime of a solitary person. While wheel motion permits achieving incredible speed and distance, wheeled vehicles are subjected to enormous restrictions as to crossing complex terrains with obstacles [11]. Clearly, legged animals can perform various tasks that are a long ways past the ability of an automobile. Creating legged robots is progressively turning into a target for robot developers and contemplations of utilizing such robots for space applications are at present in progress. Making smaller than expected gadgets that can fly like a dragonfly; hold fast to dividers like gecko; adjust the texture, shapes, and pattern of the neighboring enclosure as the octopus (can reconfigure its shape to pass through extremely contract tubing); develop complex 3D pictures continuously; reuse motility power for exceedingly proficient operation and movement; self-reproduce; self-develop utilizing available resources; artificially create and store vitality; and numerous different abilities are some of the fields that biology offers as a model for engineering inspiration and science [12]. While numerous parts of biology are still outside our ability to understand and use, important advancements has been made.

Let us see some various interesting innovations made in the field of biologically inspired robots.

Insects

- **Termes Robots**

Keeping in line with robots inspired by insects, the research team at Harvard analysed the behavior of social insects such as termites and their ability to construct complicated structures such as mounds with complex tunnel systems.

The design team aimed to create mini robots capable of building elaborate and complex structures with the primary focus being on its movement and load carrying capacity [13]. The design of the robot was kept simple. Each robot was equipped with whegs for locomotion and seven infrared sensors for navigation; an accelerometer to ascertain tilt angle for climbing; and five ultrasound sonar detectors for determining distance from and to nearby robots.

Special bricks were designed of the dimensions 21.5cm x 21.5cm x 21.5cm for the robots to lift lower and place them. Each robot had an arm with a spring-loaded gripper to hold a brick [14].

This project can be viewed as an initial developing stage for eventually building large robots that can construct complex structures in remote or hostile locations. The researchers regard this project as vital in the vision for the human colonization of mars [15].

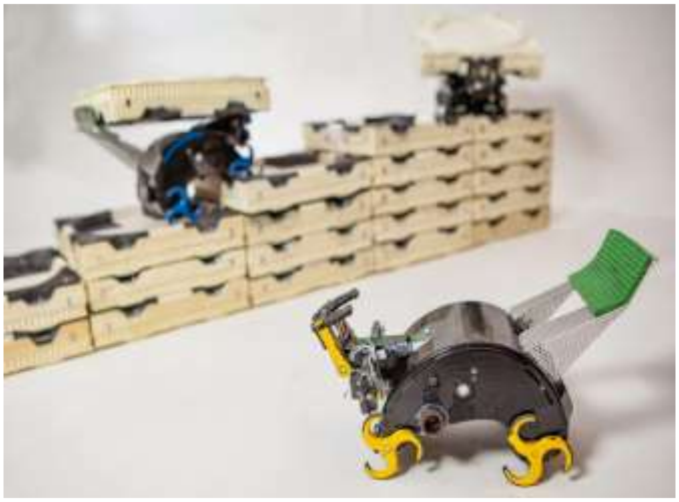

Figure 1. A robo termite assembling the designed bricks

- **Cockroach**

As part of cockroaches, for the LEURRE project under the IST programme, scientists aimed to implement the biological model of self-enhanced aggregation in a group of mini robots. They observed the behavior of cockroaches and how they aggregate in closed environments [16]. Even though the sensory abilities of robots and cockroaches are totally different, the aggregation model observed in robots is similar to that of their cockroach counterparts.

The cockroaches were placed in a homogeneous circular arena of 11 cm diameter. Each individual behavior of the cockroach was measured in a probabilistic way. How often the cockroach was going to repeat certain movements and its behavior.

It was observed that the cockroaches followed a random walk in the area. When they reached the edge, they followed a wall following behavior with a constant rate to leave the edge and return to the center part of the area. Also, the cockroaches can stop at any given moment, stay motionless for some time and then move again. Tests showed that the stopping rate for the cockroaches increased with the number of stopped cockroaches in the same area. Also the rate to leave an aggregate decreased with this number. This analysis formed a basis for a strong formation of aggregates [17].

Now this biological model of aggregation was to be implemented in the micro robots. These were very small robots of dimensions 22mm x 21mm x 20mm and had two watch motors with wheels and tires allowing a maximum speed of 40 mm s−1. Microcontroller PIC16LF877 with 8K Flash EEPROM memory was used in the robots.

The aggregation process is dependent on the number of robots in the vicinity and to determine this number each robot had its own specific identification number that counted the number of neighbor's in a distance less than 4 cm.

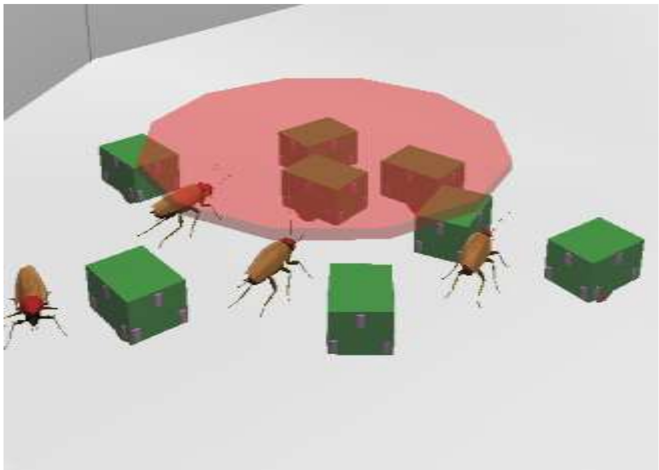

Figure 2. Experimental setup showing the cockroaches and the robots

Experimental setup showing the cockroaches and the robots. Two shelters made of plastic disks covered by red film filters are hanged above the floor of a circular arena. The darkness under the shelter is controlled by the number of layers of red film. Cockroaches aggregate under the shelters.

There were also small shaded areas within the housing in which the cockroaches were kept. The insects tended to converge to those shaded areas as they prefer the dark. Now for the robots to detect the light frequency, there were fitted with light sensors which measured the light intensity set for a specific threshold.

The next challenge was to get the cockroaches to accept a robot within the group. This was done by chemical tests which identified the main molecules that constitute the odour of the cockroach. The odour was concentrated on a filter paper and the robot was covered with the filter paper. Tests showed that the cockroaches were attracted to the scented robots and interacted with them. Pheromone luring was used here to integrate the robot into the group and therefore they affected the collective decision making process of the group. Not only do these robots navigate the environment autonomously but can also tune the time they are stationery in relation to the presence of other cockroaches in the vicinity. In turn, the cockroaches are also affected by the robots.

In conclusion this experiment showed that robots can be programmed to make a collective choice if they are used to assemble objects in vicinity and also this experiment shed new light on the process of making robots interact with animals [18].

- **Spider**

These days there are numerous circumstances where humans cannot finish a specific task in real life, for example, finding missing individual in forest for over 24 hours and investigating a cave with absence of oxygen. So as to perform these troublesome tasks, humans will need to depend on mobile robots. The huge test is to add to a self-adaptive system for the portable robots in adjusting towards uncertain changes in the surrounding. Scientists today start to concentrate on the novel configuration of self-adapting robotic system which incorporates trajectory tracking.

In 2011, Roy, Singh, and Pratihar assessed the ideal feet strengths and joint torques in the live system for working of six-legged robot [19, 20]. Their exploration is centered around acquiring an ideal point in the estimations of joint torques and conveyances of feet powers of a six-legged robot. The reduction of standard of both feet strengths and joint torques are studied in their project. Another research directed around the same time, Roy and Pratihar discovered that diverse duty factors will prompt different energy utilization [21, 22].

Figure 3. Spider Robot

T8X spider robot is a prime example of robotic spiders. It is the only robotic spider in the market that bears a close similarity to actual spiders and also has very fine movements, is customizable and easily programmable.

It runs with the help of 26 servomotors and is powered by the bigfoot robotics engine. The robot can make many bio inspired realistic movements.

The robot is run by the bigfoot engine. The user can control the movements by inputting simple commands on smartphones, tablets or computers. The robotics engine will automatically take care of complex calculations in the background such as leg trajectory planning, motor control, leg gait coordination, etc.

This simplicity of control makes the robot accessible to a wide variety of users ranging from novices to robotics or even experts in the field who can build upon the foundation of the robot. The robot is extremely user friendly.

Birds

With respect to the flight of feathered creatures, aeroplane designers are keen on the morphing limits of wings. This field got an increased advancement in 1996, when the Defense Advanced Research Projects Agency of E.U. introduced a project MAV of three years with the goal of making an insect with less than 15 centimeters long to make military acknowledgment.

A few works of fixed wings had been effectively illustrated, particularly the black widower, the AeroVironment Inc. A few MAVs had been similarly simulated, however no group has been able to effectively design a flight with flapping wings that could take off and fly [23]. As of late, few groups have similarly concentrated on the idea of morphing wings. On the basis of these ideas a few examples of advanced ornithopters are being developed. The examination gathering of the University of Toronto built up a plane with fluttering wings with an inward burning motor proficient to bolster a pilot (Fig. 4) [24].

Figure 4. Plane with flapping wings

The main application of Biologically inspired robots; biorobots of birds is in the field of designing aircraft wings. Birds are structurally and functionally complex and thereby replicating their feature for aircraft wings is a very efficient technology.

Micael S. Couceiro [25], et al., concluded that it is conceivable to recreate all sort of closed loop actions like taking off, flapping wings, following trajectories, gliding, landing and others. Data with respect to the physical way of the fluttering flight turned out to be essential to study solutions. The outcomes had been evaluated utilizing an intuitive investigation, and similarly accepted by other preceding analysis in this field. Undergoing dynamic analysis before the construction could effortlessly prevent the robotic platform issues. Two servos where utilized to control the wing beat of each wing separately. But it was later found that, such would not be essential. To accomplish identical movements, it can be easily implemented by changing the angle of attack of every wing and the tail revolutions.

Fishes

- **Boxybot**

Developed and refined at the Biologically Inspired Robotics Group [26], the Boxybot projects goals are the cognizance of an autonomous robot able to move in water. Boxybot is 25 cm long and can swim with a speed up to 0.37 m/s. It can plunge in water, swim in the forward direction, behind or on the side. Their speed depends on the amplitude and frequency of oscillations of the fins (with thresholds not to be exceeded), and also their size and rigidity.

A dc motor driven fish robot fit for crawling and swimming. It has two pectoral balances with three actuated fins along with one caudal fin. Utilizing the CPG model, the robot is fit for performing and exchanging between an assortment of various locomotor practices, for example, swimming forward and reverse, moving upwards/downwards, rolling, crawling and turning. These practices are activated and balanced by sensory input given by light and water sensors.

- **Robotuna**

The RoboTuna is a robotic fish designed and built by scientists at the Massachusetts Institute of Technology [27]. The main goal of the team when the development started was to create a robotic submarine that could mimic the swimming patterns of tuna fish and also find a superior propulsion system that could be utilized in autonomous underwater vehicles.

The robotuna project was a success and it has the ability to maneuver and also use less energy as compared to other robotic submarines.

Figure 5. Robotuna

- **Robopike**

This is another type of a robotic fish designed by researchers at MIT. Robopike can swim freely but it is not autonomous. Its navigation is directed by humans and it is the computer which decodes the orders and sends back the signals respective to each engine. Robopike is 81 cm in length. It lacks sensory capabilities to detect and avoid obstacles in its path [28].

Figure 6. Robopike

- **Robotic Koi**

A robotic fish inspired by Carp Koi was developed by Ryomei Engineering in Japan in 2006. The robot measures 80 cm and weighs 12kg. It is remote controlled and has sensors in its mouth which can be used to control the oxygen concentration of the tank or the pond in which the robot is present [29].

This is essential if one wishes to monitor the health of the fish. The robot also contains a camera which is used for examining resources present in the depths underwater. Other applications for this robofish include the monitoring of oil platforms to locate and supervise any damage that may have occurred. It is regarded as one of the most useful innovation and is greatly used for practical applications.

Figure 7. Robotic Koi

- **Robofish**

Researchers at the University of Washington built three robofishes that communicate with each other underwater [30]. The robots are programmed to swim either uniformly together as a group or in different directions, basic tasks which can provide a base for future research in the area of coordinated group movement of robots. Current capabilities of the robofish are limited to indoor test tanks but eventually can be upgraded to explore remote ocean environments. The robots need to surface from the water not because they need oxygen but in order to communicate.

The robots utilize fins instead of propellers thus making their design very similar to that of a fish. This property makes them more maneuverable and at the same time creates lower drag than that of propeller vessels. They also generate less air bubbles, a crucial characteristic in case they want to be utilized by the government for covert stealth missions.

Though many other robotic fish have been developed, what makes this project so special is that the robots in this project are able to effectively communicate with each other wirelessly underwater. The designers looked at the natural movement of schools of fish underwater as a reference model.

One of the challenges faced by the design team was to have the robots communicate effectively with each other and also transmit information while present in dense water. The ability of the robots to send information over long distances is limited due to the limited battery supply. Also the signals can become garbled or get disrupted due to the obstacles present underwater.

Tests were conducted in which messages were sent between the robots using low frequency sonar pulses or pressure waves. The results showed that only half the info was received successfully, yet because of the way the robofish were programmed, they were capable of completing their tasks [31].

Currently what the researchers are aiming for in this project is to make the trio of robofish trail a remote controlled toy shark successfully, an emulation of what real schools of fish do.

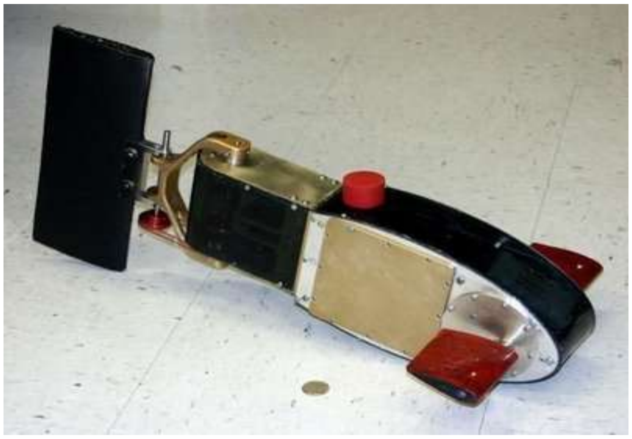

Figure 8. Robofish

Figure 9. View of a snake robot climbing the inside of a pipe

Animals

- **Snake**

Snake robots, also Known as Hyper redundant mechanisms. They use their many degrees of freedom to achieve locomotion [32]. They vary a lot in their form and dimensions. They can be four stories long or small enough to move around the organs inside humans. Some important characteristics of snakebots are their small cross section to length ratio which allows them to move through tight spaces and second being their ability to transform their body shape to perform different behaviors such as climbing staircases or trees.

Snake robots are manufactured by chaining a number of individual links. This trait helps them to avoid failure and emulates their real life counterpart as the snakebot can continue to function even though some parts of its body are ruined.

Their ability to maneuver a variety of terrain types, redundancy and also their ability to complete seal of their bodies are some of their main features. Also they were used by the Israel military in 2009.

Snakebots unique characteristics give them an advantage in maneuvering the environment [33]. Snake bots are in development to assist in search and rescue operations. Whenever there are a number of hindrances and obstructions in the environment that need to be overcome, the locomotive flexibility of snakebots make them highly reliable for such a scenario.

Snakebots are also utilized by animal control officers to subdue rabid or invasive creatures such as rats, raccoons and other rodents which react to the snakebots ubiety by hitting it. The snakebot releases an electrical charge on contact which paralyses the attacking animal.

Snakebots mostly use wheels or treads for locomotion. No snakebots have yet been made which can perfectly mimic the motion of real snakes. The different types of gaits which snakebots utilize are sidewinding’s and lateral undulation. Different types of snake bot gaits are designed by investigating changes in periods of time to the shape of the robot [34].

Current research in snakebots is mainly for search and rescue operations purposes, future research includes their use as robotic interplanetary probes by NASA.

- **RHex Robot**

RHex is a six legged autonomous robot based on a hexapod with high mobility [35]. The legs are individually controlled as well as powerful and devour rough terrain with minimum input. There is one actuator present in each leg. Four legged animals serve as the inspiration for their design. RHex can climb up and down slopes, stairways and also maneuver rock fields, muddy areas, railroads, etc.

RHex has a sealed body which makes it completely functional in rainy weather or swamps. The exceptional terrain capabilities of RHex have gotten it the attention of the US government and they have performed various tests with it. A total of more than 8 million dollars have been invested by various grants towards this project.

The RHex robot is controlled by an operation control unit which has a range of upto 700 metres.

The robot also has visible IR cameras and illuminators provided at the rear as well as the front of the robot. It also contains a modular payload bay for mission specific packages.

It weighs 27.5lbs without batteries and has dimensions of 22-inch length x 16-inch width x 5.2-inch height when the legs are not extended. It has a battery life of 6 hours and can run with a max speed of 2mph on natural terrain. It can perform continuously in ambient temperatures ranging from -15C to 45c. It is extremely tolerant to humidity as well as salt and sand.

- **Robot Cheetah**

The most recent advancement for the robot industry has been the development of a robot cheetah by the researchers at MIT which can see and detect obstacles as well as vault over them making it the first autonomous robot ever to achieve this feat [36].

Figure 11. RHex Robot

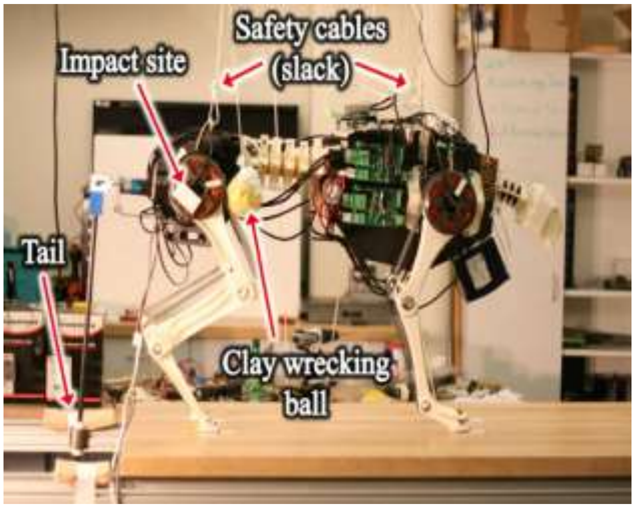

Figure 12. Robot Cheetah

The robot detects the obstacles height and distance as it approaches it and plans out its jump much akin to that of a human runner. The robot assesses the best position to make its leap from and adjusts its stride to land just short of the obstacle before it applies just enough force to push upwards and over. Based on the height of the obstacle present, the robot then exerts a certain amount of force to land without damaging itself and then resuming its initial speed.

In test conducted in an indoor environment as well as on treadmills, the robot successfully accomplished the task of clearing obstacles of a max height of 18 inches which is more than half the robots height. It also managed to maintain a very high speed of nearly 5 miles per hour.

The robot also performed this task untethered without the assistance of cameras or any other vision control. It does so by utilizing the use of an onboard LIDAR which is a visual system that converts reflections from a laser to map terrain. To plan out the robots path, the researchers made a 3-part algorithm based on LIDAR data. As both the vision as well as path planning system are on board the robot, it has complete autonomous control [37].

The three-part algorithm works as follows.

The first algorithm enables the robot to detect obstacles in its path and estimate its size as well as distance. The researchers developed a formula that simplifies the visual scene, the ground is represented as a straight line and any obstacles in the path of that line as deviations from it. With the assistance of this formula, the robot is able to calculate the obstructions height as well as distance in relation to it [38].

Once the obstacle has been detected, the second algorithm springs into action allowing the robot to adjust its approach while it nears the obstruction or obstacle. Based on the distance of the obstacle, the algorithm detects the best position from which to make the leap in order to clear it safely, then retracting from that position to make the rest of its straddle.

This algorithm works very fast, making decision as it goes by optimizing the robots strides with each and every step that it takes. The optimization takes about 100 milliseconds.

At the point when the robot achieves the jumping-off point, the third component of the algorithm assumes control to decide its jumping trajectory with respect to robot's speed and obstacle height.

During the tests conducted on the treadmill, the robot successfully cleared about 70 percent of its stride whereas on the open track it managed to clear 90 percent of the obstacles present.

The research team is currently working on making the robot able to jump on soft surfaces such as grass.

III. Future Scope

While the present idea of biorobots are effective, more advancement is important to accomplish a completely utilitarian, proficient and strong robot. A few expansions and upgrades to the present robot will lead to much more prominent features and utility. The flexibility and speed of the robot can be enhanced with the goal that future climbing robots start to approach the exact features seen in animals. Developing robots that are activated by artificial muscles and controlled by AI would empower designing reality that used to be considered sci-fi. Advancements can lead to insect like robots being utilized to review hard to reach regions of aircraft fuselage or engines where the robots can be dispatched to lead the investigation methodology and download the information after leaving the area. Adding haptic interfaces to robots can increase their capabilities. As the innovation advances, it is more reasonable to expect that biomimetic robots will get to be typical in our future surroundings. It will be progressively hard to recognize them from natural creatures.

Despite the fact that there have been numerous advances in the field of biorobotics, numerous research challenges are yet to be solved. Outline, control of biologically inspired robot systems for rapid speed with high mobility are exceptionally challenging, like the fluttering of wing-based flight, fast legged running on water or on ground, and fast climbing.

Most part of the present works have concentrated on single locomotion systems while creatures could have multimodal locomotion to work in ambiguous situations. Therefore, concentration of developing robots having multimodal locomotion has a very promising future.

Creatures can work on a wide variety of landscapes, and their biorobot counterparts are not that multiterrain efficient still. By concentrating on the multiterrain locomotion systems and their control it is possible to build biorobots that can work in any terrains.

Computerized low-and high-level control of dynamic biorobotic systems is still a vital test, and numerous individuals are still concentrating on such control strategies combined with the given robot's architecture and control.

Finally, it is critical to have progressed new bio-inspired or other artificial materials, which empower great performance and strong locomotion features of creatures, with constrained power utilization.

IV. Conclusions

This paper has presented the state of art survey of existing and future developments in the field of biologically inspired robots. Biologically inspired robotics is a rising and quickly developing field. In developing biologically inspired robots, several factors have to be considered and the robot must fulfill different requirements when faced with the difficulties of high-level gaits. The engineering design must consider weight, power and size while creating the vital torque in each joint.

Indeed, even research on issues like navigation and path finding in an open surrounding [39-41], which have typically seen a conventional engineering methodology, have as of late included biomimetic methodologies and ideas into the field [42, 43].

The advantages of designing mimics of biological systems have been expressed enormously by several scientists in these years.

A good synergy in integrating both biologists and engineers together have yielded the best results. A working relationship in the terrain, the mechanical flexibility and the electronic controller would ensure the successful operability of such robots. Weight, Power and Size were critical factors not for the robot as a whole but for every vital torque in each joint. The criticality can be understood by merely counting the number of joints in the T8X spider robot.

Projects enduring even nine years in the field of bio-inspired robot has not produced significant progress for many, the reason that many quoted were pertaining to the complexity involved in the engineering design phase. The rate of technology adoption has seen an upward boost after the emergence of Electro-Active Polymers or otherwise called as Artificial Muscles, the biggest advantage that was cited for these Artificial Muscles were the removal of Bearings, Gears and Motors from the design, this not only helped in saving size and weight of the power source that needed to be used but also made the robot get closer to its natural perfection.

The possibilities with the mechanical structure of the bio-robot makes the application for these are limitless, from research related activities to science projects the industry verticals that require these are numerous. However the biggest gainer of such robots are in the Space science research and the Military applications. Limbed Excursion Mobile Utility Robot (LEMUR) is a six-legged robot project that is being developed by Jet Propulsion Laboratory (JPL) and California Institute of Technology (CALTECH) to undertake sample acquisition and mobility tasks at Mars.

The research on issues like navigation and path finding in open surroundings [39-41], which have typically seen a conventional engineering methodology are checking the possibility of using biomimetic methodologies [42, 43].

Even though the projects are in its early stages, the magnitude of the severity of the tasks it is made to handle shows the trust that is being placed on the potential of these robots.

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About Author (s):

Anil Antony Sequeira is working as an Assistant Professor – Senior Scale in Mechanical Department, School of Engineering and IT at Manipal University, Dubai. He received the Master of Science in Engineering (by research) specialization in CNC Machining from St Joseph Engineering College, Mechanical research Centre, India, in 2012. He is involved in off-campus learning such as practicums and internships and participates in research projects and research teams and undertaking research projects.

Afeef Usman currently pursuing his B.Tech Mechatronics Engineering at Manipal University Dubai. His current research interests include Robotics, Image processing and visual control.

Oommen Philip Tharakan currently pursuing his B.Tech Mechatronics Engineering at Manipal University Dubai. His current research interests include Mechatronics Systems, Industrial Robotics and 3D Printing.

Mir Zeshan Ali currently pursuing his B.Tech Mechatronics Engineering at Manipal University Dubai. His current research interests include Embedded Systems and Electricals.