

## Robot Automation Algorithms

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**Abstract:** Automation is the creation and application of technologies to produce and deliver goods and services with minimal human intervention. The implementation of automation technologies, techniques and processes improve the efficiency, reliability and/ or speed of many tasks that were previously performed by humans.

**Background:** As computers advanced into their infancy of the 1950s, it became possible to begin to model the rudiments of these theories concerning human thought. Nathaniel Rochester from the IBM research laboratories led the first effort to simulate a neural network. That first attempt failed. But later attempts were successful. It was during this time that traditional computing began to flower and, as it did, the emphasis on computing left the neural research in the background. Yet, throughout this time, advocates of "thinking machines" continued to argue their cases. In 1956 the Dartmouth Summer Research Project on Artificial Intelligence provided a boost to both artificial intelligence and neural networks. One of the outcomes of this process was to stimulate research in both the intelligent side, AI, as it is known throughout the industry, and in the much lower level neural processing part of the brain. In the years following the Dartmouth Project, John von Neumann suggested imitating simple neuron functions by using telegraph relays or vacuum tubes. Also, Frank Rosenblatt, a neuro-biologist of Cornell, began work on the Perceptron. He was intrigued by the operation of the eye of a fly. Much of the processing which tells a fly to flee is done in its eye. The Perceptron, which resulted from this research, was built in hardware and is the oldest neural network still in use today. A single-layer perceptron was found to be useful in classifying a continuous-valued set of inputs into one of two classes. The perceptron computes a weighted sum of the inputs, subtracts a threshold, and passes one of two possible values out as the result. Thus the first neural network was born.

**Key Word:** Neural network, latency reduction, efficiency increment, optimization, fuzzy logic algorithms

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### I. Introduction

An algorithm is a procedure or formula for solving a problem, based on conducting a sequence of specified actions. A computer program can be viewed as an elaborate algorithm. In mathematics and computer science, an algorithm usually means a small procedure that solves a recurrent problem.

### II. Study of the kinematics and dynamics of robot

The kinematics and dynamics play a vital role and thus are crucial for the robot locomotion. It allows the control of motion and is determinant for the path generation of the robot. We usually assume the leg of the robot to be a manipulator, so the Denavit - Hartenberg notation is employed to derive the kinematic model. The direct kinematics relates the joint variables to the position and orientation of the foot whereas the inverse kinematic does the inverse as the name suggests. It is important to note that we don't look at the forces that cause the motion yet. The forces will be taken into account while dealing with the dynamics. In general, two classical approaches are used for the dynamic modeling: The Lagrange-Euler formulation or the Newton-Euler formulation. The first one is based on the energy principles whereas the second relies on the balance of forces acting on the link Both lead to the same results and give an insight into the control problem. The "Free Body Diagram method" has been introduced by Barreto et al. as an alternative to the previous methods. The free body diagram was reposed on the dynamics of isolated links. The details of the process are provided in the paper as well as the kinematic modeling. The intricacy of the kinematic equations depends on the number of degree-of-freedom of each leg. Huang et al. [20] have provided the methodology to solve the three degree-of-freedom leg. The kinematic equations of a hexapod robot with legs distributed in a radial manner around the body have been presented by Chen et al. [9]. The kinematic analysis is also highlighted in [3] and [15] by the researchers. Nitulescu et al. [40] have established the legs kinematics and dynamics in their article.

### **III. Fuzzy Logics for Autonomous Hexapod Robots**

It is a new concept derived from the Boolean logic and based on human reasoning. In most of our systems, impreciseness is always prevalent. For instance, the values provided by the sensors attached to a robot. The rules are defined manually by the user. One thing is that it requires having a good knowledge of the system. This technique has been successfully applied in many industrial applications. Rajput and Hasan [50] have designed and implemented an intelligent walking structure with six legs, each possessing two degree-of-freedom. The hexapod robot MPS-I, with the help of a fuzzy logic controller, can navigate in any direction while avoiding obstacles. Satisfactory results are obtained from the fuzzy controller. Trial-and-error efforts are inevitable while constructing fuzzy rules, thus leading to time-consuming of the design procedure. This fact has motivated Chen et al. [9] to propose an effective way of constructing the fuzzy rules by combining the pseudo-inverse and fuzzy identification. Yang et al. [58] have discussed the orientation control of a six-legged robot while accomplishing a wall-following task. They have manually designed a fuzzy controller where the inputs were the infrared distance sensor values and the output, the swing angles of the middle legs of the robot. Barai and Nonami [24] have modeled a 2 DOF fuzzy controller: the first one made up by a genetic algorithm takes care of the flattery delay induced by the dead - zone in the hydraulic system. The second makes sure that the entire system is stable.

### **IV. Genetic Algorithm for Autonomous Hexapod Robots**

The genetic algorithm method tries to imitate the phenomenon of natural evolution observed in nature. Among a massive population of feasible solutions, it outputs the optimal solutions. It follows Darwin's theory of the survival of the fittest. Three consecutive phases have to be followed which are: selection, crossover, and mutation. Manglik et al. [39] have developed a GA to generate an adaptive gait for the hexapod robot. The aim is to allow the robot to walk even if one leg is damaged. This phenomenon can be well-observed for instance with dogs. This algorithm kind of increases the reliability and effectiveness of the autonomous six-legged robots. Apart from the simulation done in MATLAB, a test was performed on a real robot. The process of maturing of a hexapod walking gait within a MATLAB environment has been described by Currie et al. [12]. Thus, a genetic algorithm was used for the purpose. Successful evolution was possible after 700 generations. Most of the genetic algorithms that have been proposed don't conform to the cyclic nature of gaits. Hence, a variety of GA named Cyclic Genetic Algorithm has been presented by Parker et al. [43]. The convergence was quick, and it can be applied to any robot. The hexapod robot walking is a complex task that needs to pay more attention. Many parameters involved have to be optimized to get a stable movement. Pap et al. [42] have addressed the issue above by making use of a GA. In [29], a GA has led to the development of walking gaits of a six - legged robot, named Kafka. One of the advantages of the genetic algorithms is that they don't require a thorough or complete understanding of the robot or environment dynamics while designing a robust controller. Proper gaits are necessary to ensure that the robot walks quickly and efficiently. In [13], the researchers have portrayed the "staged evolution" that allows acceleration of the learning process so that testing can be done on real hardware, not simulations. Firstly, to control the hexapod robot, they have used the central pattern generators which are neural structures. Instead of using a learning algorithm for the gait synthesis, the authors have chosen a GA method to adjust the weights of the connections in the NN. Heinen and Osório [18] have depicted the LegGen system that can render the gait control of a simulated robot model automatic by using a genetic algorithm. The results prove that we can engender stable gaits effectively.

### **V. Particle Swarm Optimization for Autonomous Hexapod Robots**

The PSO algorithm is among the best swarm intelligence method. It is currently under investigation in many fields like robotics. One of its drawbacks is that it leads to the formation of local minima. The details of the swarm algorithms are depicted in [27] and [30]. The comparison done in [29] enables one to conclude that PSO is fast and performs better than the genetic algorithm. Burkus et al. [8] introduced a novel method to determine the optimal structure and gait of a six - legged robot. "SwarmOps," an implementation of the swarm optimizations was chosen for the purpose because it is fast and the parameters can be set with ease. An improvement of motion can be seen from the presented results. Yang and Juang [58] have proposed a particle swarm optimizer-based FLC approach for the locomotion control of a hexapod robot. The fuzzy logic controller's objective is to monitor the swing distance of the legs at the middle of the robot. Then all of the parameters in the fuzzy controller are learned through the PSO. This technique enables the robot to get around an obstacle and follow a circle. The swarm intelligence concept is well-known to deal with the local variations. Thus, it was applied by Jakimovski et al. [22] to a fault-tolerant hexapod robot to reconfigure itself. This approach has been tested with success on a hexapod robot – OSCAR. In [23] and [32], the authors have optimized the parameters of the leg's trajectory and the robot's structure by using the PSO method because of its simplicity and effectiveness. Compared to the results obtained in [13] and [35] using the genetic algorithm, the results, in this case, have proved to be better than the previous ones. Note that both approaches don't lead to a

global optimum. Juang et al. [24] have designed a controller which consists of FCRNNs automated by a symbiotic species - based particle swarm optimization algorithm (SSPSO).

## VI. Neural Network for Autonomous Hexapod Robots

The artificial neural networks simulate the functionality of the human brain which is composed of thousands of neurons. They learn from the historical data provided. With the latter, they can predict the outputs with quite high precision. Huang and Nonami [20] have developed a hexapod robot for humanitarian mine detecting. To render it autonomous, the authors have adopted a hybrid neuro walking control with position and force control of each leg. Distributed NN architecture has been presented by Beer et al. [5] to direct the walking motion of a hexapod robot. The network exhibits a wide range of gaits and degree of robustness. A six-legged robot designed by Roger Quinn and Espenschied [48] was controlled using a biologically inspired NN. In the article [55], the researchers have described the evolution of a complex motor pattern generator for the control of a legged robot. The plan is to evolve an artificial NN to generate a sequence of signals that can drive a 12 DOF hexapod robot by using genetic algorithm optimization. In [34], the authors have conducted some experimental studies on animals (stick insects) to get the properties of the hexapod's behavior. After that, the latter has helped them to design an NN named Walknet, which illustrates these properties and also show some interesting emergent properties. One can think of robots that can adapt to changes in the environment or robot capabilities. Parker and Lee [44] have used a genetic algorithm to evolve the architecture of the network intended to produce leg cycles for a six-legged robot.

## VII. Neuro – Fuzzy for Autonomous Hexapod Robots

Hybrid neuro-fuzzy systems have several advantages over both neural networks and fuzzy systems. Their mixing permits the execution of complex algorithms with ease. Real-time control of robots, in general, is said to be a quite tricky task. A neuro-fuzzy for a real-time control named – DANIELA has been described by Berardi et al. [6]. Expert systems are knowledge-based systems that provide expertise in a restricted field in the absence or impreciseness of data. Energy consumption and stability play vital roles in the conception of walking robots [1] and [52]. Roy and Pratihari [52] have designed three different adaptive neuro-fuzzy expert systems aiming to predict precise energy consumed and a margin of stability for the application of crab gait generation of a six-legged robot. Comparisons regarding percent deviation in predictions show that the GA-tuned multiple ANFIS has performed better than others approach. In [9], the authors have proposed a novel topology based on fuzzy and NNs and implemented it using a Motorola microcontroller to control a hexapod robot. The system was tested in unknown situations, and the resulting performance was excellent. Habumuremyi [17] has set up the six controllers attached to each leg according to a neuro-fuzzy approach for the motion control.

## VIII. Conclusion

Every single aspect/operation require a different algorithm to be focussed upon and it has different parameters as focus. The parameters considered in one algorithm/way/approach may be volatile in the perspective of other algorithm and vice versa. Hence, while selecting the approach, one should always aim for the best case scenario in the given situation.

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