

A Mechanism Concept and Design of Reconfigurable Robot for Rescue Operation

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Abstract

There seem to be a lot of robots that have been built up until today. Basically, the creation of robot is supposed to be a helper for a human. Robot will replace human whenever the task is really difficult or dangerous to be done by human. Recently, the robots that have been created were made reconfigurable. The purpose is to make the robot to function in more type of surroundings rather than only one surrounding. With this ability, the robot can be more useful to human, and less number of robot is required to complete a certain task. This report emphasizes on the reconfigurable robot project, where in this report, the robot that has been created is using the walking motion. It presents a description with pictures and construction drawings of a fourleg reconfigurable robot.

Index terms— robot, mechanism, reconfigurable, rescue, controller.

1 I.

Overview t is believed that a mechanism must be designed with a cosistent structure and invariant functions during operation. However, as the knowledge for mechanism design was surprisingly promoted in the past century and new design ideas are continuously evolutionary and born, people started to realize that a mechanism may be elegantly structured so that its configuration can be manipulated. The manipulation should be with multiple operation modes in order to collectively fulfil multiple tasks based on a sole mechanism. Because of the problem faced, people start to search to another alternatives, and the alternatives lead to creation of robot which can be reconfigured to adjust itself to suit to the environment. Such mechanism, which can change its configuration during operation, is normally so-called the reconfigurable mechanism. One of the objectives in the field of mobile robot is so that it can replace man to achieve a task whenever man are not capable of doing it. The building systems of a robot are created to operate in natural environment which are dramatic, unstructured and hazardous, which is very difficult for human. Nowadays, the reconfigurable mechanism have caught so many attention among people. It has also found excellent applications in various industries [1] [2] [3].

The study on reconfigurable mechanisms especially in structural design and kinematics has not been noticed even until the middle 1990s. From then on, some pioneering researches were started to surface.

After that, the attentions onto this topic gradually increase. Until today, the results of its relevant work have show progressing succesful work around this new mechanism concept.

Several new studies such as kinematotropic linkage, metamorphic mechanisms, mechanism with variable chains, and etc are leading the reconfigurable mechanism studies into a new level.

According to Merriam-Webster Dictionary, "configuration" is defined as "relative arrangement of parts or elements." Basically, the configuration looks at the relative arrangement. The relative arrangement that we discuss may be relative distance, relative angle, relative position, etc. The "parts or elements" are the links and joints of the mechanism and the "relative arrangement" are the relative positions, or further the relative motions, among the links and joints. Since the movement of the mechanism is depend not only by the arrangement of the joints but also their kinematic types, the configuration of the mechanism is described together by geometric arrangement and the kinematic types of its all kinematic joints [1-5].

2 a) Reconfigurable to robots

In our times today, we can see a lot of handful of commercially available mobile robots, whether used in industry factory, house, or for research in the laboratory. Most of all cases, the robot get around on wheels, or perhaps tracks. For example, the remote-controlled bomb disposal robot. It cannot be denied that the wheels are definitely the most sensible choice for the environments that these robots run in. Wheels are very easy to control since it act predictably given a flat surface to run on. Other than cheap in cost, the power systems behind the locomotion are very well developed and understood. Besides, the wheel's speed can be easily configured just by controlling the amount of torque applied to the shaft connected to the wheels. Thus, it can make the robot to run faster [3][4][5][6].

However, wheels may not fully function in some cases. There are environments in which wheels become useless such as getting up to stairs. Although today's large buildings that have uses for robot have uses lift to accommodate the robot, it is not practical to implement it to the outside world. Some estimates suggest that half of the earth's surface is presently inaccessible to wheeled vehicles [4][5][6].

Thus, engineers take the idea of using the walking leg as another alternatives to overcome this problem. Plus, the legs can be reconfigured to adjust itself to the environment. It is quite difficult for a wheeled robot to suddenly change the tyres to a different direction compared to walking leg robot [5].

3 b) History

Starting from 1960's, most of legged machines have used a degree of computer control. Since its advent, this system technique has become greatly compacted and also be applied to the small machine. The idea of building systems by homogeneous components comes from von Neumann's "Theory of self reproducing cellular automata". His model assumes complete homogeneity of initial modules. This is an analogy to biological systems. In the system, the cell division from a single cell after fertilization produce the differentiated cells. However, the biological system has its own weakness as it need a large number of cells in order to form their bodies [4][5][6][7]. (N. ?nou etal, 2003) In 1988, a robot called CEBOT ??Fukuda etal, 1990) was created and this is the first self-reconfigurable robot designed based on heterogeneous components. It is composed of several different module. The module include transportation, rotational joint, telescopic arm, and grasping modules. Because of these modules combination, the CEBOT was able to perform a lot of different tasks [3].

Following the heterogeneous module, the study of reconfigurable robot with homogeneous module takes place. In the homogeneous system, all the modules are identical. A set of common rules should sufficiently describe the differentiation and behaviour of each module. Any module can be replaced with another module as soon as this is realized. This property makes the self-repair and self-reproduction schemes become easier.

4 c) Problem statement

People nowadays normally use a lot of help from the robot to do something that they cannot do by themselves. A lot of robot that we see in the market today have their own programme to do a task, but unfortunately every robot have their own limitation. As we can see today, the normal robot may be able to move into a certain direction only. Most of them cannot adapt to sudden change in environment. Whenever the surrounding change, such as from a floor to the staircase, the robot will become completely useless. In the end, people need to replace that robot with another robot that is built only for that task. This makes the time taken to complete the task become very slow. It such a waste of time and a bit tiring.

5 d) Objectives

This paper approach four central challenges-

To develop a robot that will be able to reconfigure if it stuck in a changed environment. To design the mechanical system for the robot. To design the control system so that the robot can move efficiently without any problem. To test the performance of the robot.

6 II.

7 Introduction

Reconfigurable robot is a robot where it can modify their shape and size in order to accomplish difficult mission. This capability is very desirable in many tasks. Such reconfigurable robot is very useful to overcome obstacles during doing the task. Reconfigurable robots offer a new approach in robotics.

The applications can be applied in many areas such as urban search and rescue, military reconnaissance and civil exploration [5][6][7].

This late few years, considerable progress has been made in the field of reconfigurable robotic systems. Normally, it would compromise with several segments that are connected with joint. The kinematic modes that we commonly see are multiple legs, wheeled and chain-track vehicle. According to study, the robot with multiple legs kinematic is less adapted compared to wheeled and chain-track vehicle robot. The multiple legs was said to be too complex since the structure has so many degree of freedom. Robots with wheeled and chain-track vehicle are usually portable since the adaptability to unstructured environment is high [6].

102 Usually for reconfigurable robot with multiple legs, the robots are fabricated based on modularity. Modularity
103 consists of any number of identical interconnected units or modules. This system has advantages in terms of
104 manufacturing and robustness because of their homogeneity and redundancy. However in this type of kinematics,
105 there are many degrees of freedom (D.O.F) which make it complex and difficult to build. For example, a 14 degree
106 of freedom (D.O.F) reconfigurable manipulator robot has been developed as a part of the Dockwelder EU project
107 to perform in ship manufacturing industry. This paper emphasizes the reconfigurable robot with four legs. It
108 would not be complex enough since it will have several degrees of freedom only. Each of the legs contains two links
109 which will be connected through a servo motor. The principle of the movement of this robot is simple enough to
110 understand. The servo motor will act as a joint and the movement of the legs will be based on the servo motor
111 rotation or translation move.

112 **8 Figure 2.7 : Servo motor a) A chronological development of** 113 **self reconfigurable robot**

114 CEBOT is the first modular self-reconfigurable robot that has been ever created in history. The modules were
115 considered cellular in structure [7].

116 ii. Fracta (Murata et al, 1994) This robot (Murata et al, 1994) is capable of reconfiguration, transportation in 2 dimensions,
117 and self-repair [8,9]. This robot (Hosokawa et al, 1998) has climbing stairs-like structures and has a capability to
118 reconfigure against gravity. This robot also has potential to be used as to build a bridge structure for transporting
119 cargo across a gap. There were four prototype modules that have been built [11][12][13].

120 As we can see in the figure below, these types of robots (Unsal et al, 1999) consist of active links and passive cubes.
121 The cubes can be rotated, translated simultaneously in two directions, and also act as pivot joints for a moving link.
122 These types of robots are very potential to move over obstacles, climb stairs, traverse through tunnels and pipes,
123 manipulate objects, form bridges and towers, and be utilized for space applications [12][13][14]. Crystalline robots
124 (Rus et al, 2000) are homogeneous square modules. Similar to muscles, this type of robot performs locomotion
125 using expansion and contraction movements. Using a key and lock (channel) mechanism, the connection between
126 the modules can be performed [14].

127 **9 ix. Polybot (2000)**

128 This robot, polybot (Yim et al, 2000) was built from a chain structure consisting of segment and node modules.
129 The structure makes the robot capable of several types of locomotions, including rolling, earthworm motion, and
130 spider-like motion. The modules are connected by using a pin/hole mechanism [13][14][15]. xi. Pneumatic (2002)
131 The pneumatic (Inou et al, 2002) was inspired by animals such as worms and caterpillars with hydrostatic
132 skeleton. The pneumatic modules are homogeneous, cubic-shaped structures with pneumatic actuators consisting
133 of flexible bellows [15][16][17][18][19][20].

134 xii. Telecubes (2002) This type of robot (Vassilvitskii, 2002) performs motion by expanding and contracting
135 the sides of the cube. Permanent switching magnets are used for the connection mechanism [14][15][16][17].

136 xiii. Chobie (2003) This robot, Chobie (Koseki et al, 2004) can reconfigure by means of slide motion
137 and successive cooperative movements. This robot is potential in cooperative transportation, collection, and
138 construction [15][16][17][18].

139 xiv. Deformatron (2006) It is a homogeneous 3D modular robot (Stoy, 2006) with modules. The modules
140 can form in two structures which are rigid lattice and flexible chain. This robot has limitations which are
141 no communication between modules and the modules do not contain power source. Therefore, it needs to be
142 controlled externally [15,16].

143 **10 xv. Odin (2007)**

144 It is a hierarchical lattice-based robot (Stoy et al, 2007). It is built with two different types of modules which
145 are cylinder-shaped and sphere-shaped. The link modules are able to communicate with neighbours, performing
146 computation, and power sharing among modules [16,17].

147 xvi. Morpho (2008) Morpho robot is based on deformation and tensegrity model of cellular structure. The
148 cells exert expansion and contraction forces on the entire structure. There are four types of modules where
149 this robot can be assembled. They are active link, passive link, surface membrane, and interfacing cubes [18].

150 xvii. Anatomy-based catomns (2008) The claytronics project (Goldstein et al, 2004) is an inspiration for this
151 anatomy-based catomns (Christensen D.J., 2008) robot being built. Truthfully, this type of robot has not been
152 physically created yet. However, several promising simulations have been done using Open Dynamics Engine.
153 This type of robot is expected to be able to perform computation, sensing points of contact with neighbours,
154 sensing the gravity direction and local actuation. This robot can assemble a muscle-actuated arm, and grasping
155 objects by using whisker feedback [17][18][19][20]. xviii. Swarmorph (2009) The SWARMORPH (O'Grady et al,
156 2009) project involves the development of a distributed scheme for generating morphologies using autonomous
157 self-assembling mobile robots [18,19].

158 This technique is applied to the swarmrobot (sbot) platform. However, there is a limitation of this
159 self-assembling mobile robots. There is little control over the structure of the formed robot assembly. This

13 CONCLUSION

160 work proposes a mechanism for control of the growth of morphological structures based on self-assembly. One
161 by one, individual robots connect to the forming assembly.

162 11 III.

163 Drawing of the Robot The main thing that should be consider when doing this project is about how the motion
164 of the robot would be. In this project, after consulting with the supervisor, we agreed on building a robot with
165 walking leg for this type of reconfigurable robot. A servomotor is a crucial part to determine the direction of
166 the robot to move, wether forward or backward. The servo motor can be placed into the robot once the code
167 have been made and have been transferred through arduino board. For the robot to turn the leg, we also need a
168 motor to turn the bevel gear. The rotation motion from the bevel gear will be tranferred to a worm gear. Since
169 the leg is attached to the worm gear, it will automatically turn the direction of the leg once the worm gear start
170 rotating.

171 The robot also consists of inertial sensor that will detect when the robot fall or flip, so that the robot will be
172 able to reconfigure and walk again.

173 12 b) Force division between the legs

174 The whole body of the robot will stand on two legs while it is taking forward motion. Thus, the whole weight
175 will be divided between these two legs equally so that the robot will stand balanced.

176 13 Conclusion

177 The design of the robot for this project is not achieved just by thinking once. The redesign and the development
178 of this reconfigurable robot is always challenging. In the process of making this project, some fundamental design
179 principles which are applicable to all components of the system became more clear. The very first important step
180 that we should be aware of before beginning the implementation of a robot systemis to go through a thorough
181 design, analysis and also the specification. It is crucial in order to verify wether the implementation will work or
182 not.

183 Upon completing this project also, I also learned that the simplicity of the design should not be overlooked.
184 As an engineer, it is our job to make something which is easy for humankind to handle but at the same time
185 give a maximum output. In designing, creativity and experimentation are two of the most valuable design tools
186 available until today. From the research that have been made, it can be concluded that the reconfigurable robot
is one of the most desirable technology that people need today.



Figure 1: Figure 1

21

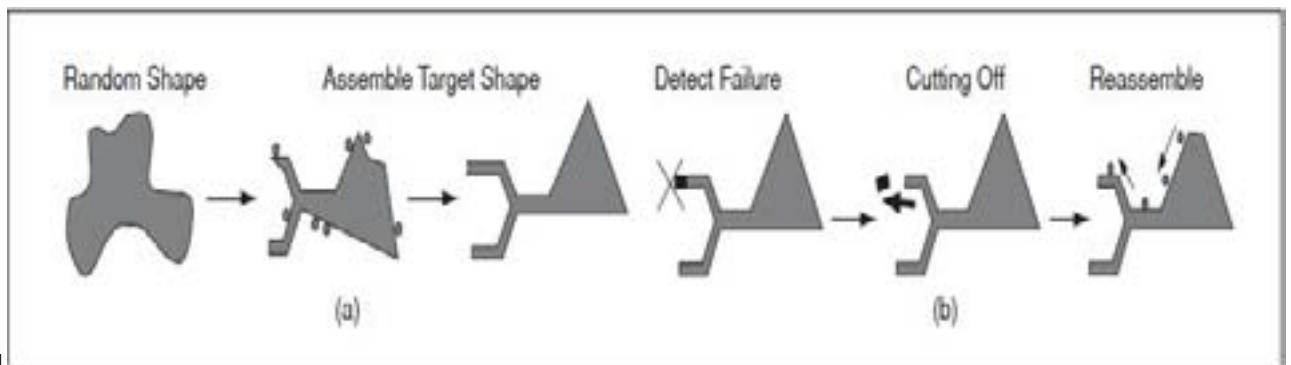


Figure 2: Figure 2 . 1 :

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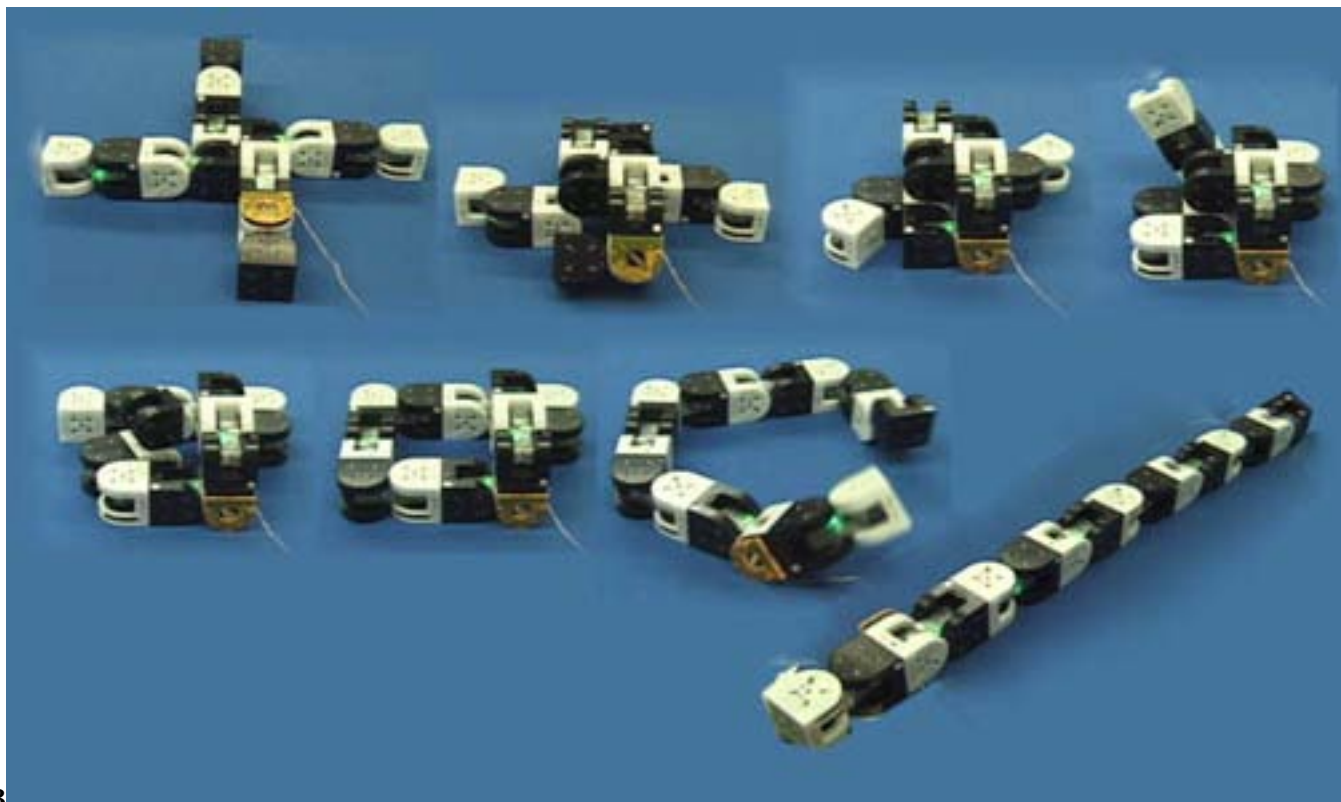
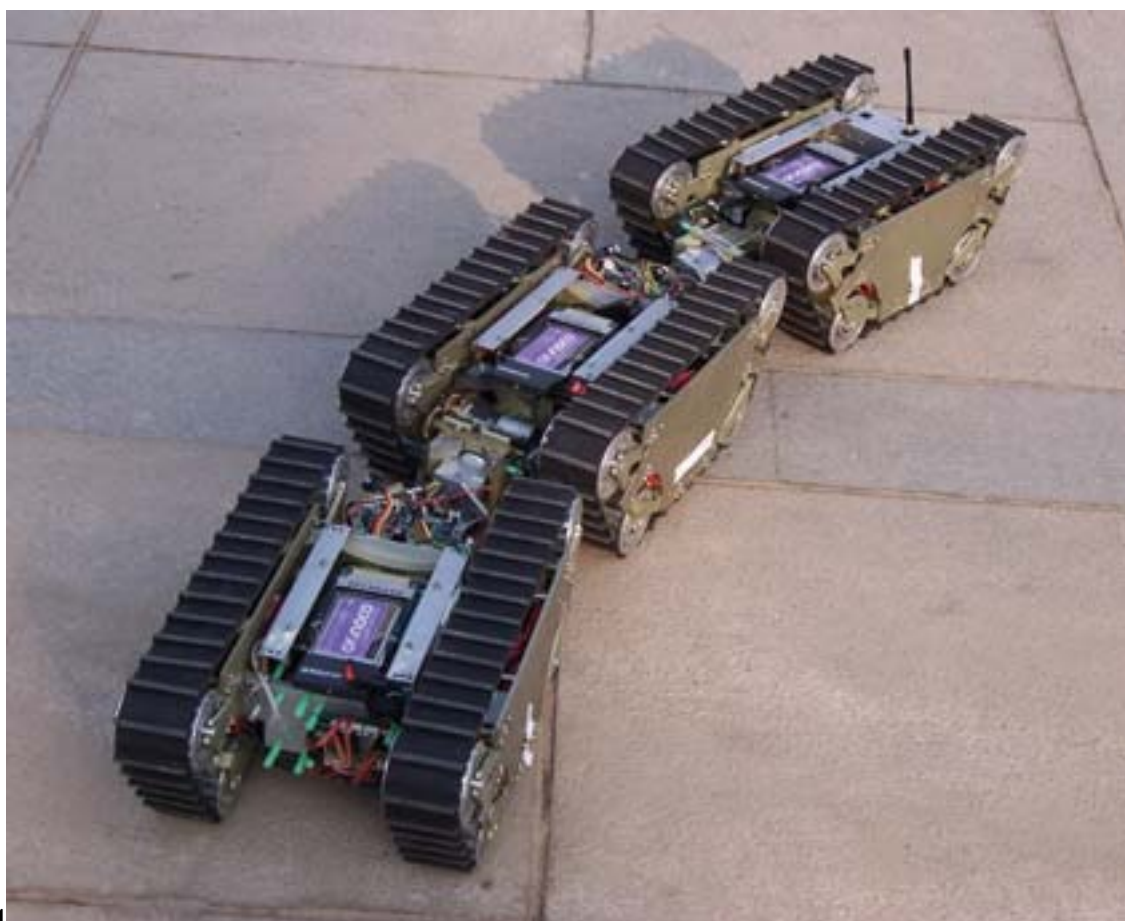
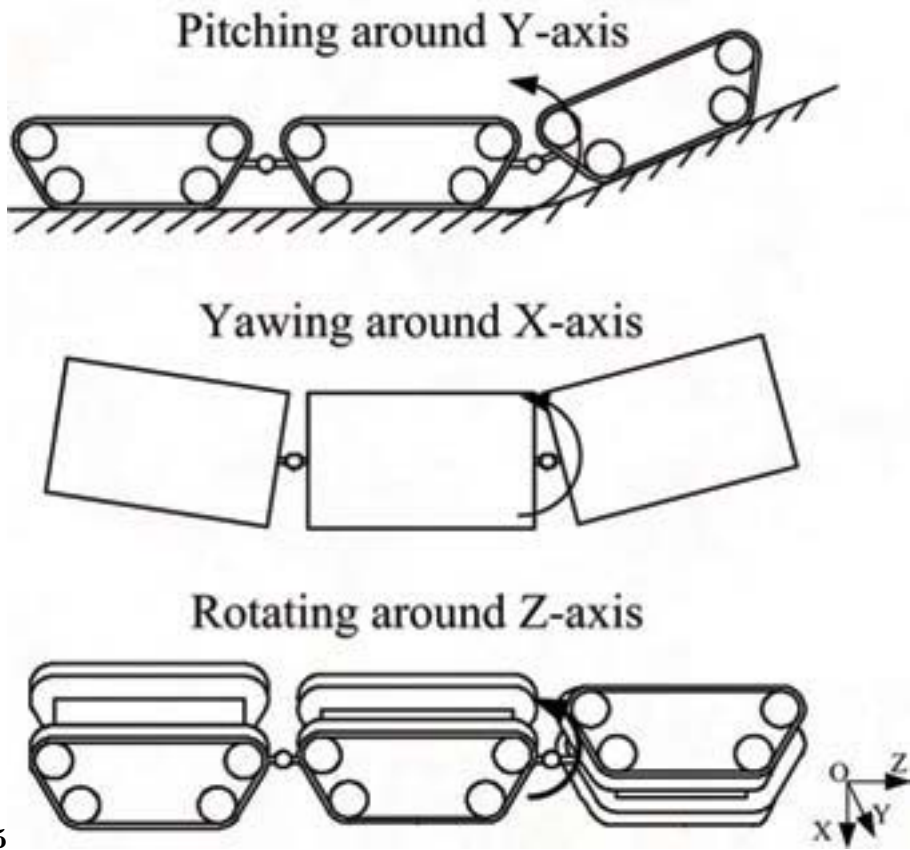


Figure 3: Figure 2 . 3 :



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Figure 4: Figure 2 . 4 :

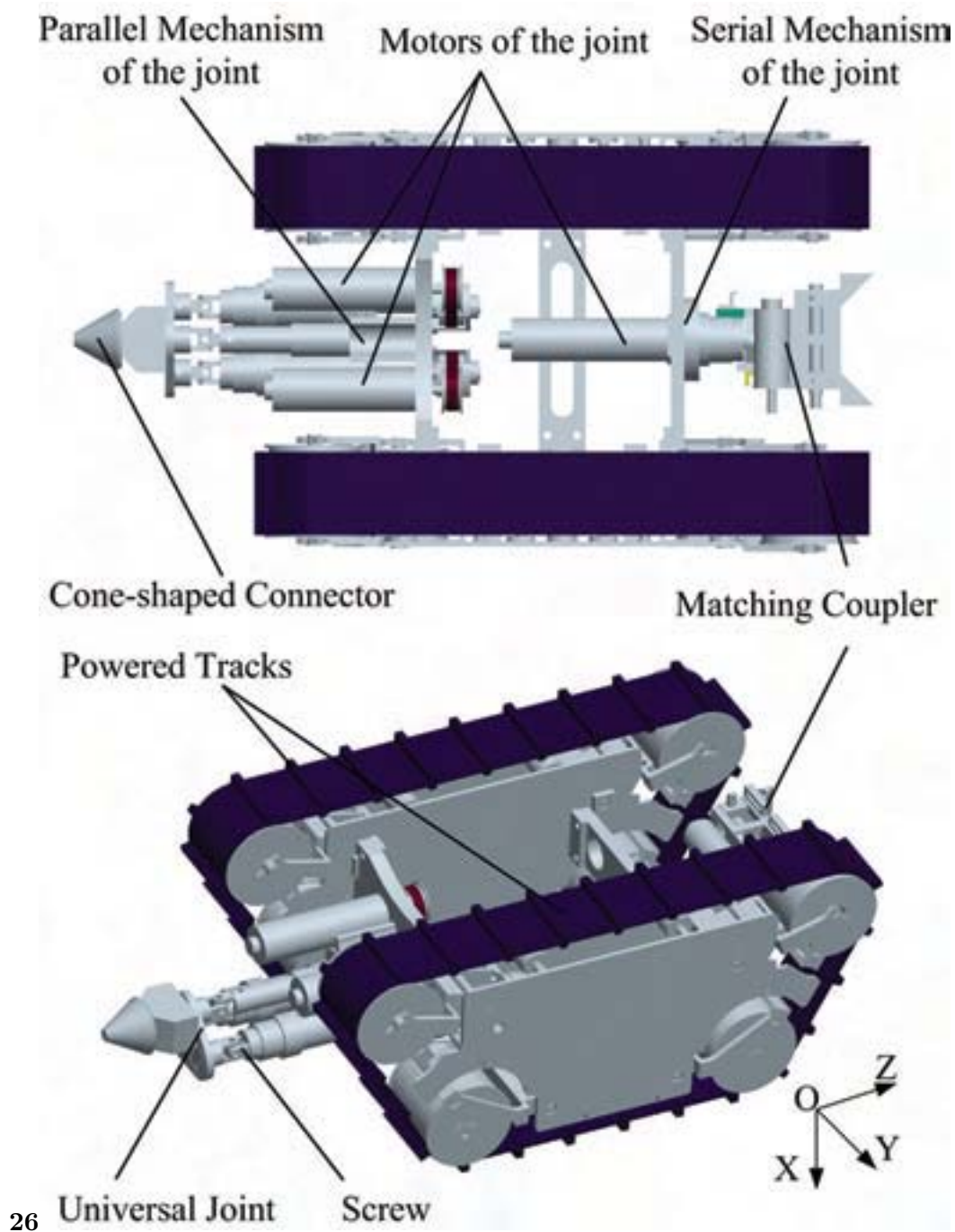


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Figure 5: Figure 2 . 5 :

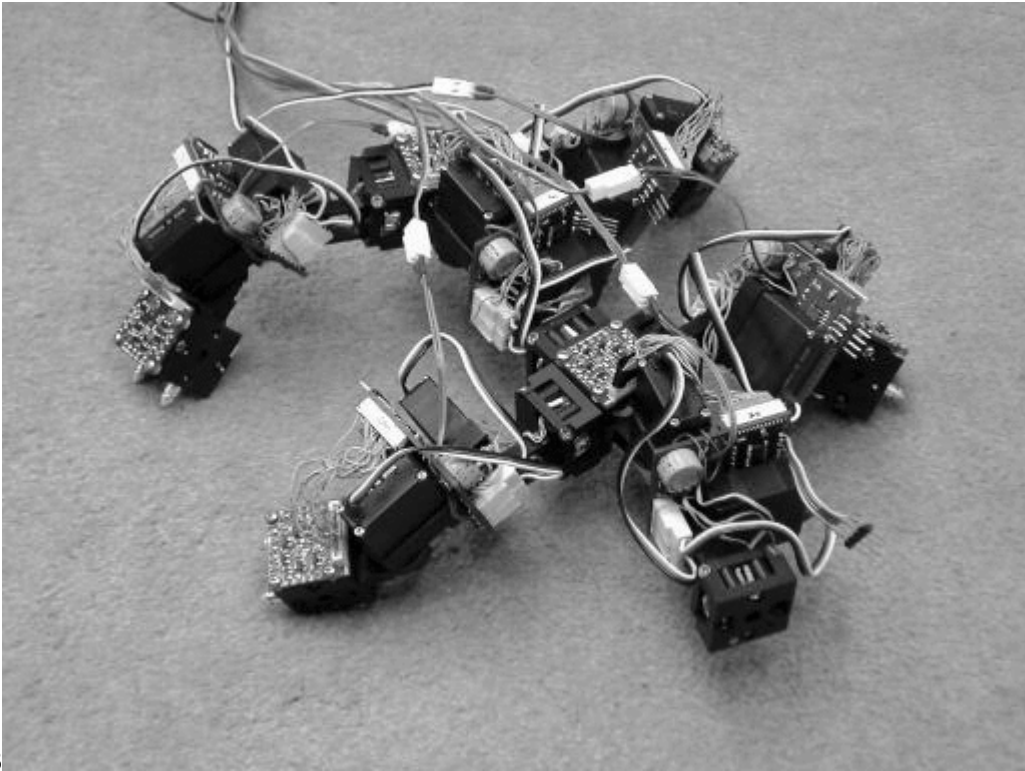
¹© 2016 Global Journals Inc. (US)

²© 2016 Global Journals Inc. (US) vii. I-Cubes(1999) x.Conro (2000)



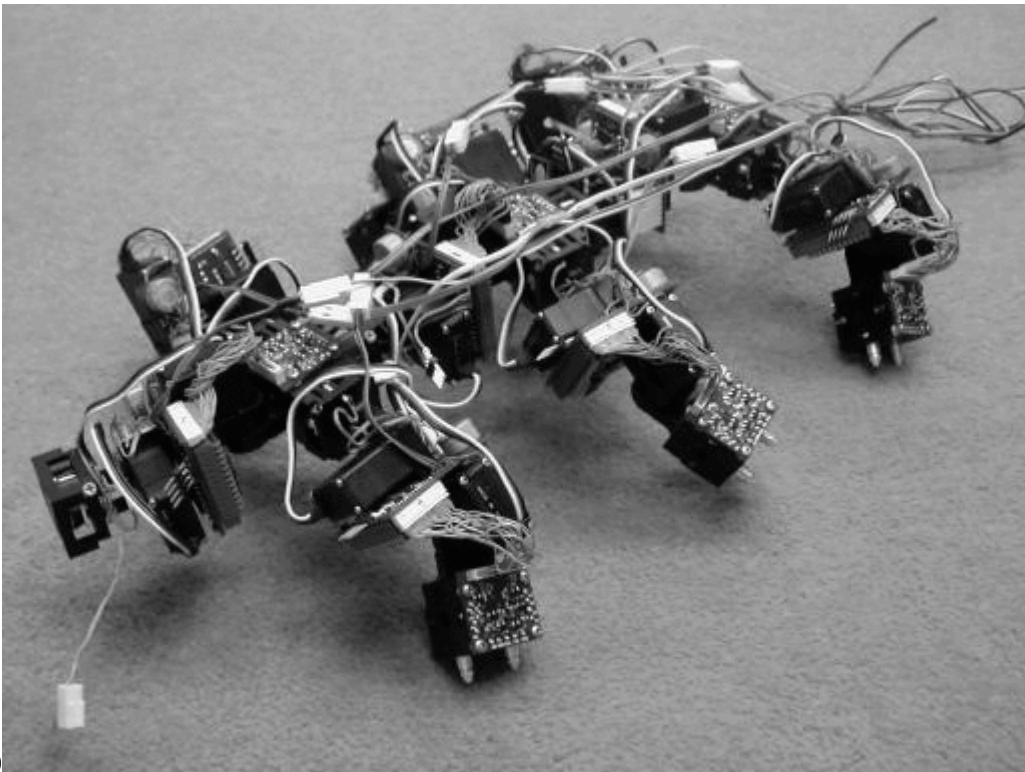
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Figure 6: Figure 2 . 6 :



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Figure 7: Figure 2 . 8 :



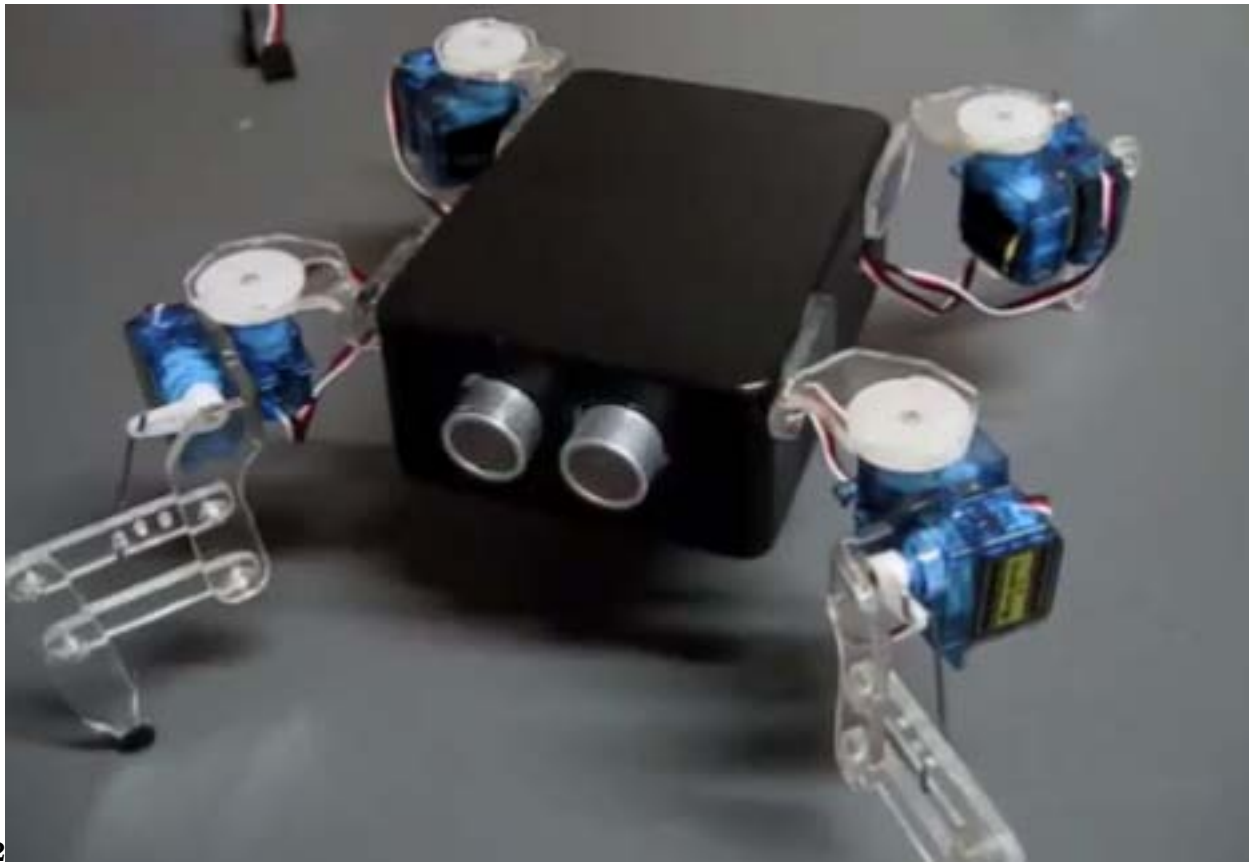
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Figure 8: Figure 2 . 9 :



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Figure 9: Figure 2 . 11 :



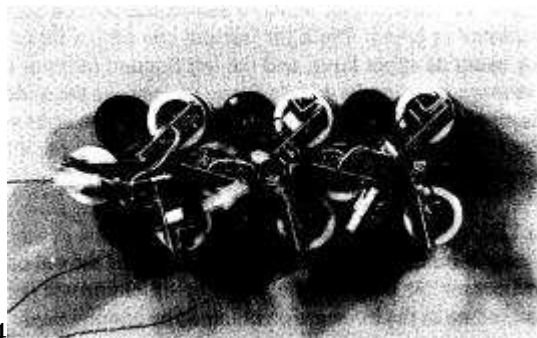
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Figure 10: Figure 2 .



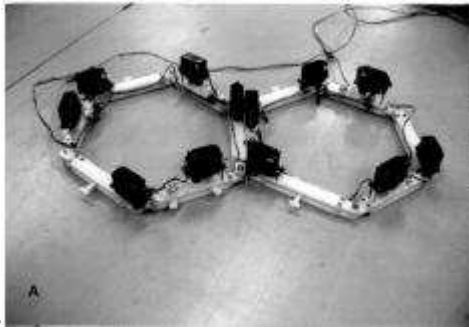
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Figure 11: Figure 2 .



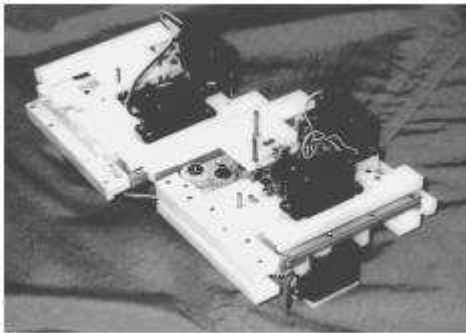
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Figure 12: Figure 2 . 14 :



3

Figure 13: Figure 3



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Figure 14: Figure 3 .Figure 3 . 3 FFigure 3 . 5 :Figure 3 . 6 :

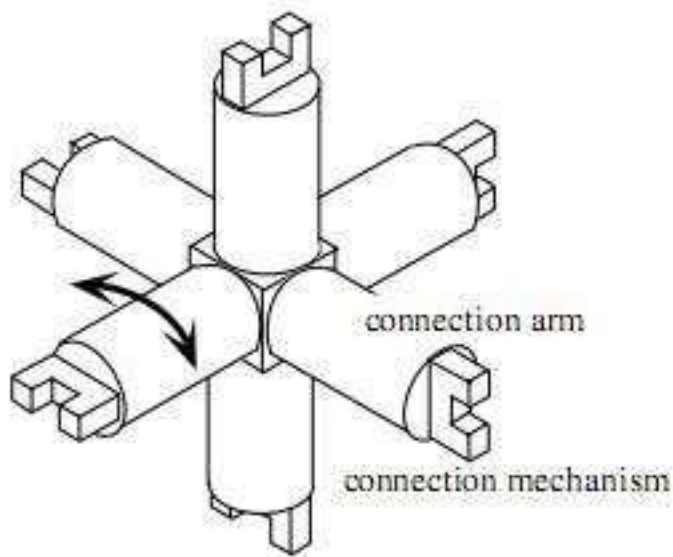


Figure 15:

1

Research issue concerning self reconfigurable	robot	
The part and the whole diversity	Self-similar structure, boundary of a multifunctionality; adaptable to change according to environment.	flexibility,
Morphogenesis	Logic of growth from homogeneity to heterogeneity; computational complexity	
Robustness	Self-repair, graceful degradation, scalability	
Self-reproduction evolution	Driving force of evolution, novel method of production co-evolution between morphology and motion; acceleration of evolution	
System architecture	Centralized/decentralized, homogeneous/heterogenous, local/global communication	

Figure 16: Table 1 :

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