Assisted Creative Robot Arm Assembly and Control Program Design

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Abstract: - Applied techniques in smart robots implicates various basic and applied courses in different fields, activities relating to education on high-tech smart robots are good methods to inspire students to become outstanding technological personnel. Thus, this study used training activities based on the creative DIY Lego robot block combination designs, and in turn, used the program design to control the robotic arm actions of Lego robots in order to cultivate student ability in understanding and applying principles of robotic movement and control. This study intended that students would apply creative, inventive abilities to solve problems, produce innovative ideas, and new design methods for games.

This study aimed to teach students to learn the basic principles of robotic movement, the writing, and design of Java code, and in turn, complete repetitive works for controlling robotic arms to pick up objects at fixed points, move them, and place them. These activities can inspire student concepts in using robots to replace human resources and related applied technologies, and is intended to educating students to engage in new beneficial research relating to robots.

Key-Words:- Robots, Robot arms, Creative combination, Assisted computer programming language instruction, Java

1. Introduction

Automation technology has long been one of the focal points of development in contemporary science and industry. Smart robots, developed from automation technology as a basis, are further used by the United States and Japan for disaster rescue in special terrains, such as in the Fukushima nuclear disaster, and in the form of home care android robots. Smart robots are multifunctional, multi-axial fully, or semi-automatic machinery devices [1, 2], and have automatic manipulation and mobility functions for various types of work, which have become common processes and practices [3]. It is also possible for them to use programmed actions to engage in various productive activities, provide services, or interact with people [4]. Furthermore, combined with applications of artificial intelligence or sensory detection technology, they provide services in terms of living, health, security, and entertainment. The smart robotics industry involves technologies in many aspects, including computer computations, artificial intelligence, sensory and detection technology, precise instruments, control of machinery and electronics, mobility platforms, power technology, system integration, and formal design. The related industries include electrical engineering, mechanics, automation, information, communication, electronics, optics, security systems, energy and materials, and creative content. These are star industries, with high technical integration, correlation, and added value, with broad applications in the future, including industrial robots, and even expand to service robots in various fields, such as home care, entertainment services, and information integration. The robotics industry has great research and developmental value and direction for hardware and software in Taiwan [5].

Since applied techniques in smart robots implicate various basic and applied courses in different fields, activities relating to education on high-tech smart robots are good methods to inspire students to become outstanding technological personnel. If it is possible to assist students in learning how to control robot mobility and sensory functions through writing computer programming language, students can demonstrate their intelligence and display their abilities. Since each precise action to be completed by robots are controlled by computer programs, in the process of learning to write computer programs students can use various commands to control each robot action. Thus, in the process of learning to encode and manipulate, this would effectively elevate student abilities in logical thinking and determination relating to robotic actions and sequential programming.

Education in smart robots can cultivate student interest in science. If robotic education can be carried out with a high level of interest, during knowledge transmission, student abilities in creative inventions can be inspired and innovative abilities can be elevated.

2. Research Motives and Purposes

Based on the importance of education in smart robots, this project proposes a seed student training activity in creative DIY Lego robot block combination design, which uses programing design to control the movements of the Lego robotic arm, in order to cultivate student abilities in understanding and applying the principles of robotic movement and control. It intends that students would apply creative and inventive abilities to solve problems, produce innovative ideas, and create design methods for games.

This study designs a type of linkage Lego robotic arm, which uses turning gears to control the creative assembly of the opening and closing motions the arm. Then, the Java program code is used through annotations to explain how students can easily learn to control robotic actions through program writing and design. This study teaches students to learn the basic principles of robotic movement, writing and design of Java code, and in turn complete repetitive works of controlling robotic arms to pick up objects at fixed points, move them, and place them. This can inspire student concepts in using robots to replace human resources and related applied technologies, and is intended to educate students to engage in new beneficial research relating to robots.

3. Robots

Robots are the common name for automatic control machines, which include all machinery that can simulate human behavior or thought, or other organisms, such as robot dogs and cats. In contemporary industries, robots refer to artificial machinery devices that can automatically execute tasks, which can replace or assist labor forces [6].

Robotic science is a subject that is highly interdisciplinary, and represents the high-tech development standards of a country. In 2005, the Aichi World Expo in Japan used robots as the theme and displayed various new smart robots, which inspired a great response and observations from the rest of the world. Japanese robotics will be developed into a national core industry [7]), and it was predicted that, by 2010 robots can be applied in business environments, and by 2020, people will be able to live with robots [8]. Such information changes public thoughts and impressions regarding robots, and there is significant potential in imagination and future development. The smart robotics technology and industry have become new technological industries, with priority development by various countries of the world. For instance, Japan has listed smart robots as one of the seven major strategic fields in their top level industries [9], and Korea has listed it among the ten new age developmental motivation industries [10], and both have devoted massive amounts of capital and human resources for its development. In order to promote industrial development, in Taiwan's Industry and Technology Strategy Review Board Meeting [11], the industry of smart robots was listed as an emerging focus industry for economic development in 2015 [12], thus, smart robots will become the next wave of industrial development [13].

Narrowly defined robotics learning is focused on allowing learners to interact with programs and machines that are highly automated and reactive, which allows learners to learn specific capabilities and knowledge, as well as receive corresponding assistance and information. Robotics learning is a learning model that can stimulate a high degree of interest. Through the interactions and designs of robots, learners can interact with, respond to, and understand causal relationships relating to robots, which are applicable to learning in different fields, such as science, mathematics, engineering, and physics. Robotics learning is also a learning method suitable for team cooperation and the establishment of personal learning interest and confidence [5].

3.1 Creative robot arms assembly

Smart robots primarily combine different components and system modules in an industry that requires a high degree of integration [14-16]. In order to accelerate the output of commercialized smart robot products, there should be a creative DIY development for component assembly, software design integration, and application in the Taiwanese smart robotics industry. Cultivation of integrated technology and personnel that have management capabilities will provide the necessary human resources for industrial development, which in turn is used to increase industrial scope and production value. Such activities will be the keys to success for a smart robotics industry.

Due to flexibility of the Lego robot components, they can be developed, designed, and assembled by the user into various Lego robot models, thus, such applications have frequently been used in teaching, as they allow users to design robots of different types and functions through Lego assemblies. Figure 1 shows a robot arm with six links and seven joints developed by using Lego robot components [17]. It could be expressed as a (6,7) robot arm. Figure 2 shows the corresponding schematic diagram of the (6,7) robot arm. The topological structure of the (6,7) robot arm is concluded as follows:

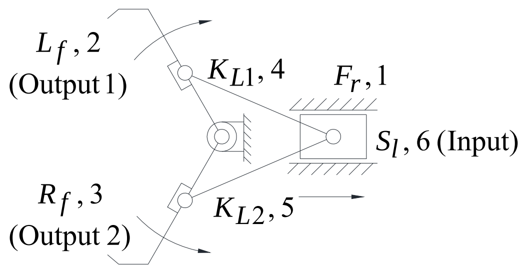
1. It consists of six links and seven joints.
2. It has one ground link (F_r, member 1), one left finger (L_f, member 2), one right finger (R_f, member 3), two link (K_{L1} and K_{L2}, member 4 and member 5), and one input link (slider link S_l, member 6).
3. It has seven revolute joints (J_R) and one prismatic joint (J_P).
4. It is a planar mechanism with one degree of freedom.

Figure 3 and 4 show a robot arm with four links and four joints developed by using Lego robot components [17] and its corresponding schematic diagram. It could be expressed as a (4, 4) robot arm. The topological structure of the (4, 4) robot arm is concluded as follows:

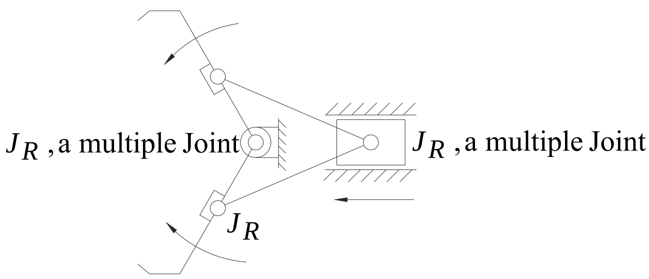
1. It consists of four links and four joints.
2. It has one ground link (F_r, member 1), one left finger (L_f, member 2), one right finger (R_f, member 3), and one input link (slider link S_l, member 4).
3. It has three revolute joints (J_R) and one prismatic joint (J_P).
4. It is a planar mechanism with one degree of freedom.

(a) opening arm (b) closing arm

Figure 1 A (6,7) robot arm [17]

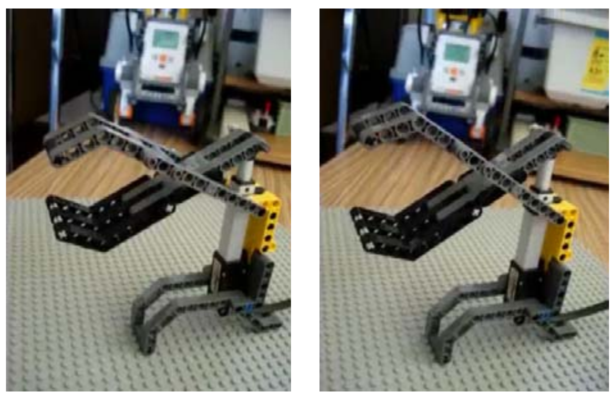


(a) opening arm



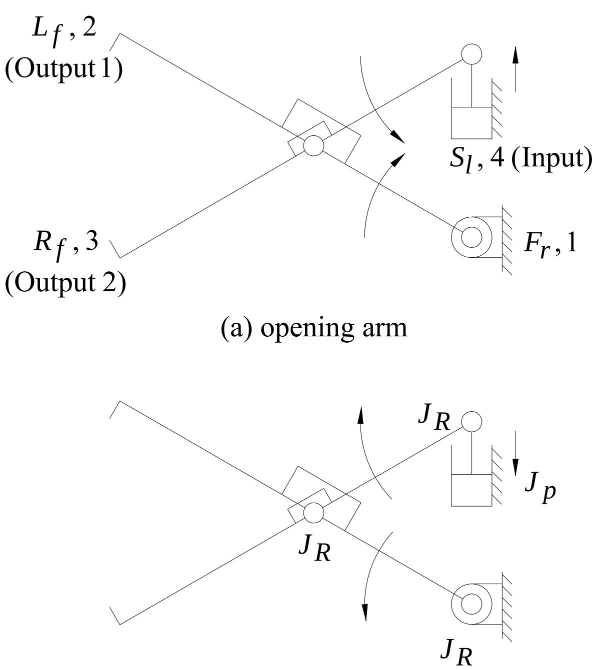
(b) closing arm

Figure 2 Schematic diagram of a (6,7) robot arm



(a) opening arm (b) closing arm

Figure 3 A (4,4) robot arm [17]



(a) opening arm

(b) closing arm

Figure 4 Schematic diagram of a (4,4) robot arm

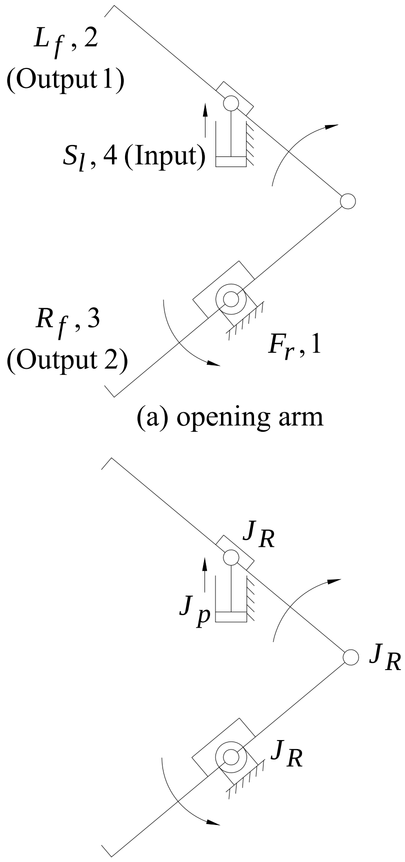
Another (4,4) robot arm developed by using Lego robot components [17] and its corresponding schematic diagram are shown as Figure 5 and 6, respectively. Though the topological structures of the two (4,4) robot arms are the same. But change the locations of joints of the two (4,4) robot arms, the user can create various Lego robot arm models.

Additionally, the users can use the Lego gear components not like as sliders, they can create a different Lego robot arm model [18] shown as Figure 7. It is a (3,3) robot arm. Figure 8 shows the corresponding schematic diagram of the (3,3) robot arm. The topological structure of the (3,3) robot arm is concluded as follows:

1. It consists of three links and three joints.

(a) opening arm (b) closing arm

Figure 5 another (4,4) robot arm [17]

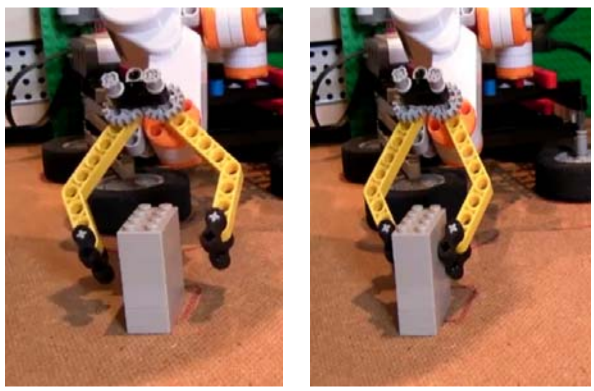


(a) opening arm

(b) closing arm

Figure 6 Schematic diagram of another (4,4) robot arm

2. It has one ground link (F_r , member 1), one left finger (L_f , member 2 is a gear, G_{e1} and is the input link), and one right finger (R_f , member 3 is another gear 3, G_{e2}).
3. It has two revolute joints (J_R) and one gear joint (J_G).
4. It is a planar mechanism with one degree of freedom.



(a) opening arm (b) closing arm

Figure 7 a (3,3) robot arm [18]

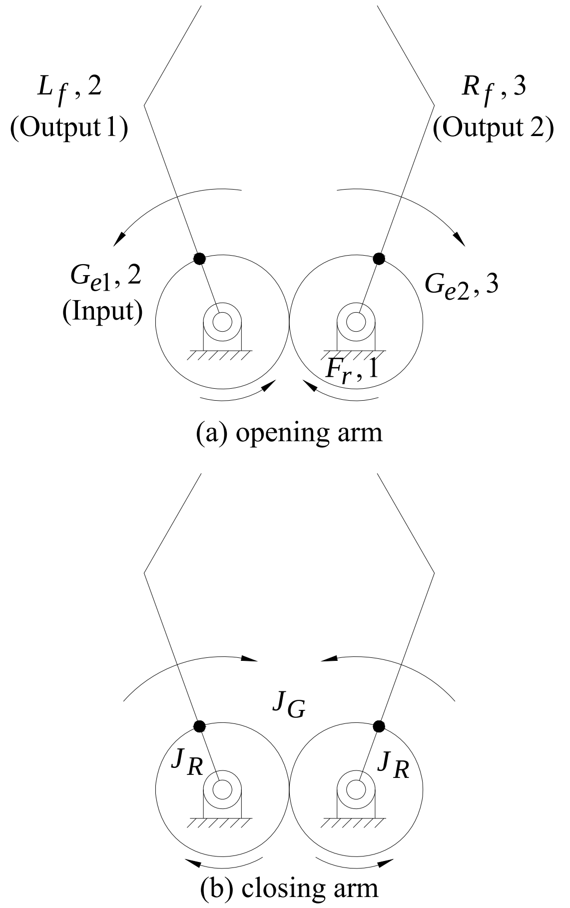


Figure 8 Schematic diagram of a (3,3) robot arm

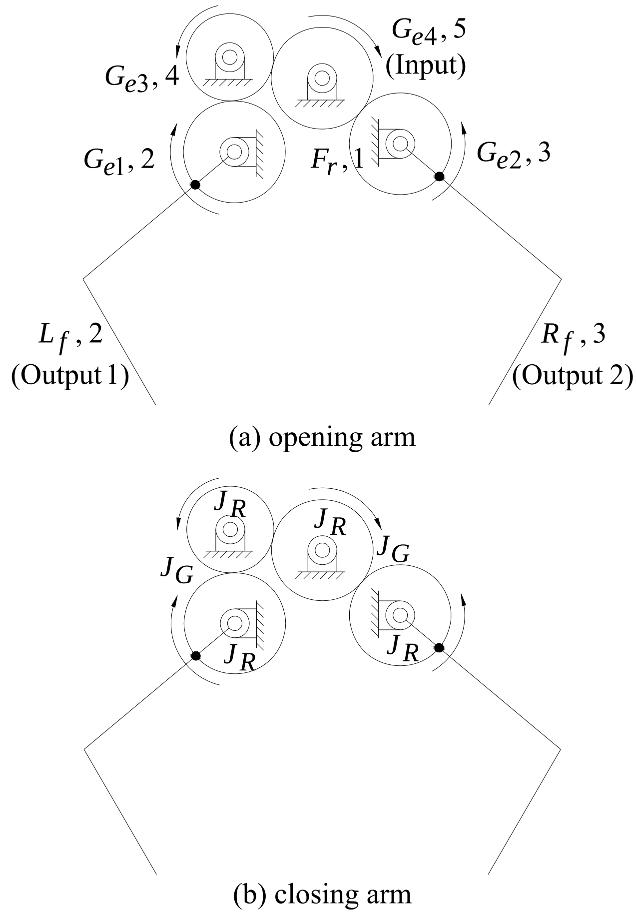


Figure 9 Schematic diagram of a new (5,7) robot arm

Furthermore, based on the design concept of the (3,3) robot arm, the users can use four Lego gear components to create a new Lego robot arm model shown as Figure 9. It is a (5,7) robot arm. The topological structure is concluded as follows:

1. It consists of five links and seven joints.
2. It has one ground link (F_r, member 1), one left finger (L_f, member 2 is a gear, G_{e1}), one right finger (R_f, member 3 is another gear 3, G_{e2}), the other gear (G_{e3}, member 4), the last gear is also the input link (G_{e4}, member 5).
3. It has four revolute joints (J_R) and three gear joints (J_G).
4. It is a planar mechanism with one degree of freedom.

This study uses Lego robot components to engage in science education relating to robot DIY creative combinations, based on machine fixture arm design and assembly.

3.2 Principles of robotic arm design

This study uses Lego robot components to carry out DIY creative assembly of robots, designing linkage Lego machine fixture arms, which use the turns of gears to control the creative assembly of the opening and closing motions of the arms. Then, through annotations, the Java program code is used to explain how students can easily learn to control robotic action through program writing and design.

The core of Lego robot components is a programmable block called RCX, with various different connector ports that allow users to conduct connections and development of creative mechanisms. Through Java program writing and input, such as in Chart 1, the core RCX portion conducts programming computations to control corresponding opening and closing actions of the arms. Through the external signal connections of the connector ports, the user is able to transmit action commands to the robot models, which are creatively designed, developed, and assembled by students, meeting the objective of robot movement control.

4. Combination control

The researcher hopes to train students to use their minds and hands to create combinations of different robotic arms, then, through training of the Java programming language design, to use a computer to control the opening and closing of the machine arms, achieving the objective of obtaining abilities in theory and practice.

This study uses Lego robot component training of students to engage in DIY assembly of robotic arms, intended to satisfy student curiosity in controlling robots, and promote their problem-solving techniques. As they undergo the steps of design, testing, and modification, students further learn how to apply technological knowledge.

4.1 Creative design and science technical education

This study uses design of curricular activities, in which teachers assist students to plan for tasks to be completed by a robotic arm. [19] developed electrical systems for smart robots, and at the same time, developed digital learning systems regarding smart robots for applications of digital learning.

4.2 Easy teaching and learning of programming code

When most students in non-English speaking nations are learning programming languages, they often do not know the purpose of learning the programming language, as they are unfamiliar with English and abstract programming language, and because they are uninterested in the samples used it results in a lack of sufficient learning motivation. Thus, their learning accomplishments are lacking. Therefore, programming language has long been an obstacle to student learning. In order to avoid this obstacle, this study uses the world's most popular instructional robot tool, Mindstorms NXT, to conduct programming language instruction. NXT is primarily formed by different Lego blocks, such as a controller, motor, detector, and other forms. The controller core uses an ARM7 32-bit microprocessor, which can be connected to four input devices that simultaneously receive input signals from four detectors; it is externally connected to three output devices that simultaneously power three motors for various actions. It also provides one LCD monitor, a built-in speaker, and supports USB and Bluetooth data transmission methods. This study uses Java object-oriented programming language, matched with LEJOS (Java for LEGO Mindstorms) program components, in order that students could use Java programming code to control the motions of robots.

This study conducts suitable program design, based on action tasks to be completed, to transmit a downloaded program to the "brain" of the robots in order to proceed with designing the actions of robots. A suitable programming language is used in instructional assistance, which is applied to the tools controlling the robot movement. This interesting instructional method can help students enjoy their learning of the programming language. To help students learn with greater convenience, this study provides Chinese program code annotations for Taiwanese students, which helps students to easily learn the Java programming language for robots, lower their stress in learning the programming language, and in turn, instills the desire to get close to robots and use programming language to control the actions of the robots.

For achieving the above purpose, the authors establish a simple Lego robot arm shown as Figure10. The flowchart of steps for controlling the movement of robots and robotic arm is shown as Figure 11. Figure 12 shows the various movements of the robot and robotic arms.

The Chinese programming code annotations, as provided by this study, is shown in the following Table 1.

(a) opening arm (b) closing arm

Figure10 Schematic diagram of a simple Lego robot arm

Table 1 Explanation chart of Java programming language with Chinese code annotations

Program language	Program explanation
Car moving forward	
Motor.B.setSpeed(200); //	Set the speed of Motor B to 200(degrees/seconds) wheel
Motor.C.setSpeed(200); //	Set the speed of Motor C to 200(degrees/seconds) wheel
Motor.A.setSpeed(50); //	Set the speed of Motor A to 50(degrees/seconds) arm
while(true){ //	Enter loop
//	Forward
Motor.B.forward(); //	B motor moves forward
Motor.C.forward(); //	C motor moves forward
Delay.msDelay(5000); //	Wait for 5 seconds =5000 milliseconds
//	Stop
Motor.B.stop(); //	B motor moves forward
Motor.C.stop(); //	C motor moves forward
Open and close hand portion	
for (int i=0;i<3;i++){ //	Open and close arm, repeated 3 times
Motor.A.forward(); //	
Delay.msDelay(1000); //	Open
Motor.A.backward(); //	Wait 1 second
Delay.msDelay(1000); //	Retrieve
}	
	Wait 1 second
Turn around	
Motor.B.forward(); //	B motor moves forward
Motor.C.stop(); //	C motor stops
Delay.msDelay(3500); //	Wait 3.5 seconds
//	Forward
Motor.B.forward(); //	Wheels move forward
Motor.C.forward(); //	Wheels move forward
}	
}	
}	

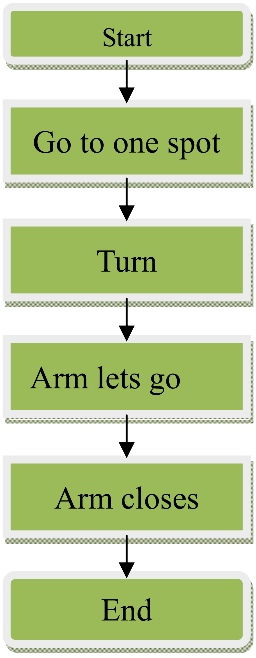


Figure11 Flowchart of steps for controlling the movement of robots and robotic arm

5. Conclusions

For students, research on the science of robots is an interdisciplinary subject. Thus, this study uses the design of actual curricular activities, which allows teachers to assist students to plan and complete creative assembly and movement controls of robotic arms in order to complete the expected movement tasks. This study used Lego robot components for DIY creative assembly of robots, and designed linkage Lego machine fixture arms, which use turning gears to control the creative assembly of arm opening and closing movements. Then, using Java programming code, the annotation method was used to explain and help students to easily learn how to write and design code that controls robot movements.

This study used the supplemental explanations of the program as a reference for teachers in instruction, and for students in learning and understanding. Integrated application of robot programs and controls will be beneficial for students as they engage in work relating to robotic applications in the future. This helps students to have further understanding of actual and potential roles of micro-robots in life, which can effectively increase their interest and scientific literacy regarding micro-robots, leading to increased interest to engage in related research and development work.

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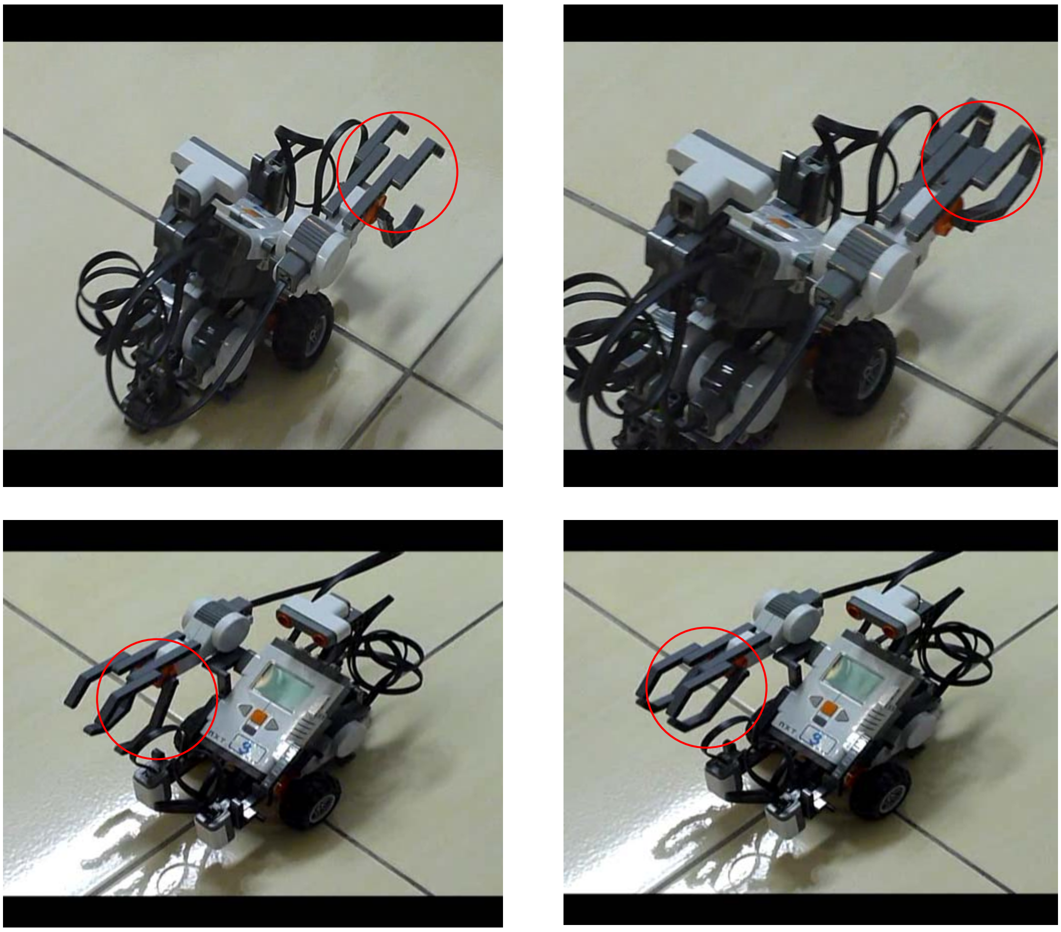
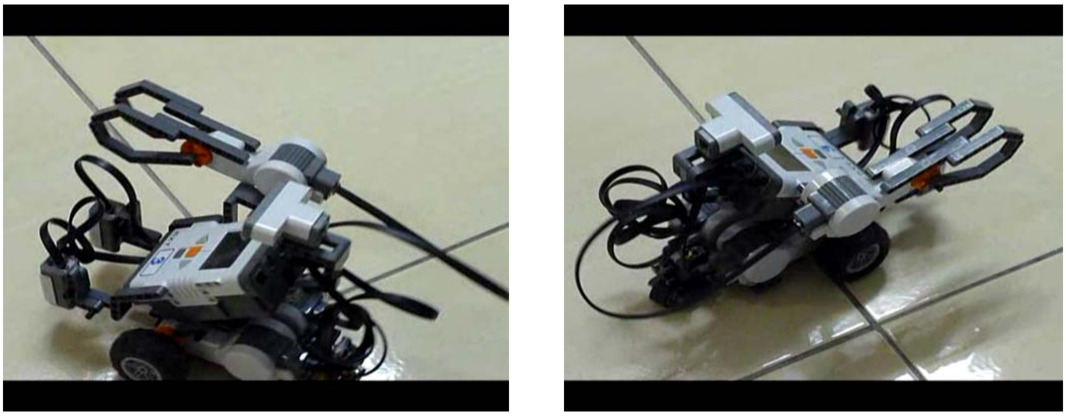


(a) Captured shot of opening and closing arm



(b) Captured shot of movement and turn

Figure 12 Captured shots of various movements of robots and the robotic arm

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