Programming and experimental analysis of MELFA RV-2SDB robot

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Abstract With the development of technology and science, it became clear that robots are starting to have a major role in the modern world. Regardless of whether they're meant to do hard work or just entertain, robotics has changed human life for the better. What makes a robot different from a man is that a robot doesn't have the ability to make decisions by itself, so it needs to have a set of instructions previously written by a man. The topic of this paper is programming and experimental analysis of MELFA RV-2SDB robot's work. The content of this paper is based on development of robotics as a science branch, the structure of a robot, as well as controlling one, with its kinematics and dynamics. That is followed by an explanation of controlling and programming a MELFA RV-2SDB robot. Programming has been done with CIROS Studio tool using MELFA BASIC V programming language. Practical part consists of work analysis and programming of the mentioned robot. Its task is to move LEGO cubes from one place to another, composing a desired form as the result.

Keywords: robot, MELFA RV-2SDB, CIROS Studio, MELFA BASIC V

1. Introduction

Fast development of science has lead man to new discoveries and inventions, which would make life easier for humans, including robots. Robots are considered as machines, which take the role of performing jobs and various tasks that are too hard or dangerous for a man. They have proven very useful in almost every field of industry known to man today. To be able to control a robot, a man must first be thoroughly

aware of the robot's structure, its abilities, as well as the expanse in which it's placed, and can then move onto programming the robot. In case of MELFA robots, the most common programming language is MELFA BASIC V, while the programming is done in CIROS Studio [1].

Robotics as a term is a branch of engineering, which includes mechanical, electrical and computer science, amongst others [2], [3]. Robotics is in charge of design, construction and operations of robots, as well as computer systems needed to control them, information processing and sensory feedback.

The goal of this technology is to develop a machine that would serve as a substitute for a human. There are a lot of dangerous environments in which people work, so to minimize risks to the human life, scientists developed machines that are able to do the same work a man does, for e.g. bomb detection and deactivation. Today's robots are capable of replicating some of the behavior typical for a human, such as walking, lifting, speech, cognition and many others. They can be made in any shape, so the idea behind making robots similar to humans lies in the attempt to get people to accept and get accustomed to robots in their everyday life. The word *robotics* is derived from the word *robot*, which comes from Slavic word *"robota"*, that translates to *"labour"* [4], [5].

With the development of technology and science, it became clear that robots are starting to have a major role in the modern world. Regardless of whether they're meant to do hard work or just entertain, robotics has changed human life for the better.

There are a lot of types of robots, since their application field is unlimited in today's world, but all robots share three similarities when it comes to their construction: metal construction, electrical components and computer programming code. Metal construction is a frame, or a shape designed to achieve a particular task, electrical components purpose is to power and control the machinery, and the computer programming code are actually instructions which the robot follows. For example, a robot whose purpose is to travel across heavy terrain, such as dirt or mud, would need caterpillar tracks which represent the metal construction, power in form of electricity to be able to use those tracks, and lastly the computer programming code which would tell it to move.

2. Robots and types of robots

There are many definitions of robots, but in general we can say robots are machines that can be programmed by a computer and are capable of carrying out complex series of actions automatically. Robots are divided by generations, from the period they were invented, up until today [6].

Null generation robots were robots that couldn't be reprogrammed, and they didn't have a control unit. These robots could've been programmed only once, and are used

as a replacement in manual labor, such as industrial welding robots, shown in the Figure 2.1.

Fig. 2.1. Industrial welding robots

First generation robots have the ability to manage joints, using an independent actuating system. These robots have all the necessary sensors, but very limited intelligence taking in consider that every part is separately programmed and managed. They are used in areas where great precision isn't needed.

Second generation robots work in accordance with the environment in which they are, and have the ability to adapt in accordance with sensors that they have. They also exchange information using the same sensors. Also, they can make logical decisions: yes and no.

Third generation robots are highly intelligent robot systems, and they are most similar to human's characteristics and behavior. They have the ability to make decisions in various situations, as well as learn new behavior.

Robots can be used for military purposes, like weapon systems that provide calculations for accurate predicted fire, or autonomous fighter jets and bombers, for medicinal purposes, such as surgical robots, rehabilitation robots and bio-robots, as well as social and other purposes.
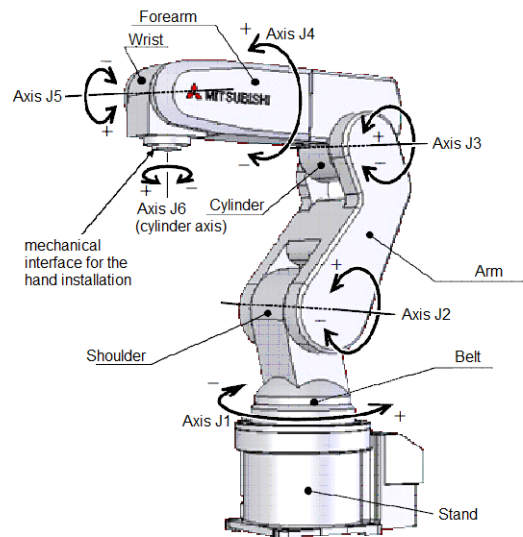
3. MELFA RV-2SDB robot

Mitsubishi MELFA industrial robots are manufactured to work with high speed and relatively high accuracy while working, combining different technology methods. They are divided according to usage, which means some of them are made to perform complex operations, while others are made to perform under high speed or precision.
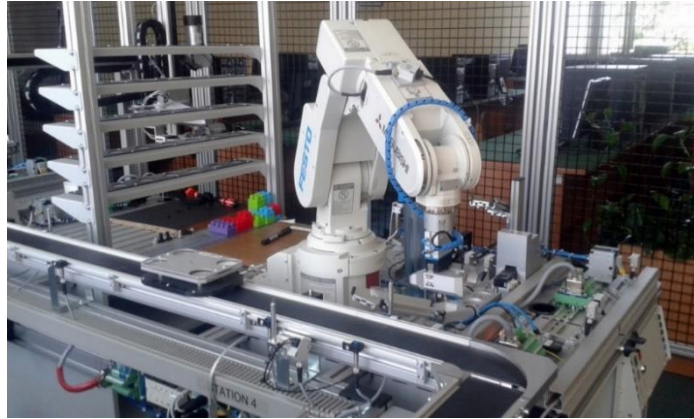
Fig. 3.1. MELFA RV-2SDB robot

MELFA RV-2SDB is a vertical robot type, shown in Figure 3.1 above, whose purpose is to perform complex operations. This type of robot has 6 degrees of freedom [1], [7], [8]. It uses CR1DA-700 controller. Supply voltage for this controller is AC 180 to 230 V. Installed power required is 0.5 kW and the range of operating frequencies is 50-60Hz. Parts of MELFA RV-2SDB are shown in Figure 3.2. MELFA RV-2SDB robot has a capacity of 256 programs. Programming of MELFA is done using MELFA-BASIC IV or MELFA-BASIC V programming language.

Figure 3.2. Parts of MELFA RV-2SDB

The robot can be manually controlled using Teaching Pendant (TP) controller, which is connected to the previously mentioned CR1DA controller. Teaching Pendant has a button to stop the robot even when it's in *automatic* mode, if an error happens.

4. Programming of the MELFA RV-2SDB robot

As previously mentioned, these types of robots are programmed using MELFA-BASIC IV or MELFA-BASIC V programming language, and CIROS Studio interface. CIROS Studio [9],[10] is an integrated development environment (short IDE), for Mitsubishi robots, that supports fast and easy generation of MELFA-BASIC III/IV/V or MOVEMASTER COMMAND programs. After various tests and optimization, program is uploaded onto the robot, using a direct connection between the computer and the robot via network or serial port. CIROS Studio has supervision over the robot while it performs the uploaded code, as well as visualization of movement in 3D graph. The interface of the program is shown in Figure 4.1.
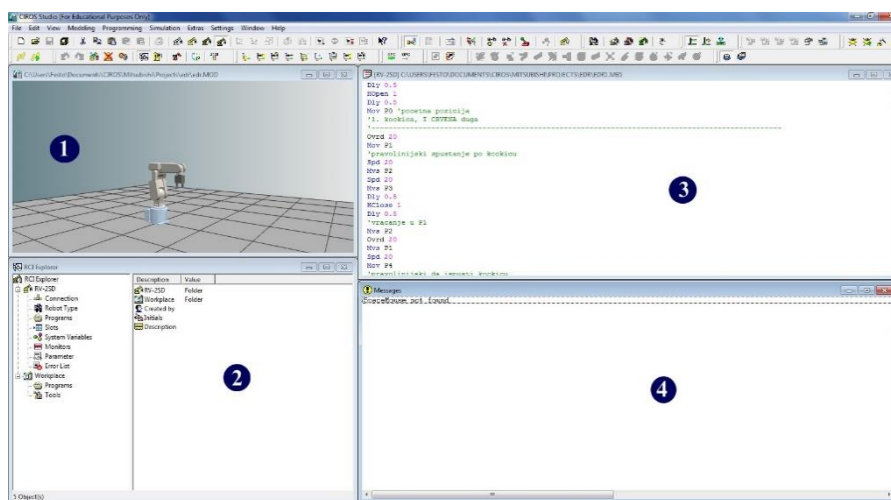

Fig. 4.1. CIROS Studio

Numbers in Figure 4.1 are as follows:
1. visual display of the virtual robot
2. RCI explorer, contains programs, variables, parameters etc.
3. Program editor
4. Messages, warnings, errors

The most common instructions of MELFA BASIC V [11] are as follows:

- *DLY* – wait of 0.5s before executing next instruction,
- *SERVO ON* – turns on the servo,
- *SERVO OFF* – turns off the servo,
- *HOPEN* – opens the hand
- *HCLOSE –* closes the hand.

It's necessary to use instruction DLY before instruction to open the hand (HOPEN) and before closing the hand (HCLOSE).

In order for the robot to do a task it's designed for, there are motion instructions, such as basic motion instructions, instructions for circulatory motion, instructions for relative motion, and instructions for continued motion. Next to mentioned instructions, there are also various instructions for management of I/O data, interrupts and similar.

The control of the MELFA robot is done with predefined order of action. Controlling is done via CR1DA-700 [12] and TP controllers. There are two ways of control, manual and automatic. Automatic control is running previously written code, while manual refers to setting positions. For both types of programming, positions must be inserted and saved via TP controller.

For our experimental analysis (see Figure 4.2), 7 positions of robot's trajectory has been used.
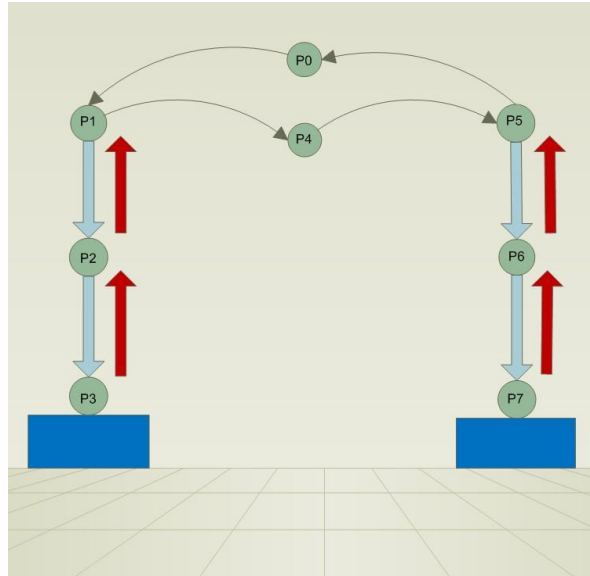
Fig. 4.2. Positions and trajectory of the robot

Using JOG mode, it's necessary to manually place the robot in the desired starting position and save that position using the TP controller's options, and repeat that for all positions needed in the movement trajectory.

After saving the positions, the code is written in MELFA BASIC V programming language [11], which enables the robot to move over the predefined positions. Robot is programmed so that it moves with different speed between different positions, so from P2 to P3, it will move with slower speed so it could precisely grab the LEGO cube, meanwhile between positions P1 and P4, or P4 and P5, it has a curved motion and greater speed.

5. Experimental analysis of MELFA RV-2SDB

In this paper it is explained how MELFA RV-2SDB robot moves objects from one place to another (see Figure 5.1). Taking in consider that this type of robot it limited to the size of the object, LEGO cubes are used, with their width being 3.7 cm, while the length of the object is irrelevant. It is necessary to mention that the better grip the robot has on an object, it will be easier for it to move it without major deviations.


Fig. 5.1. Robot moving a cube

Two boards are needed, one for primary position of cubes, and the other as destination. In this paper it is shown how MELFA RV-2SDB rearranges LEGO cubes from one position to another.
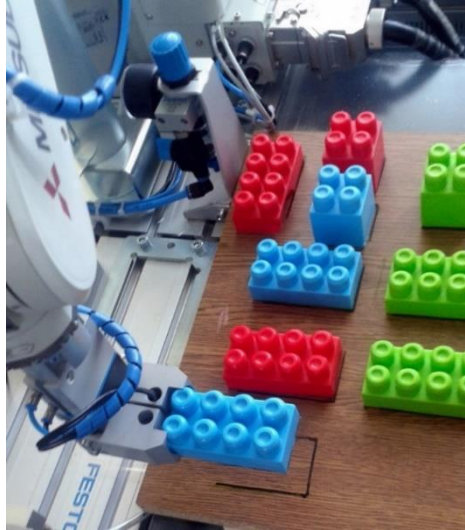
Fig. 5.2. Starting positions of the cubes

On the starting position (Figure 5.2), the cubes are arranged with enough spacing in between to enable unobstructed work for the robot. All cubes have their marked positions, which are saved as positions, as previously explained. Robot takes one cube at a time, in a predefined order, and composes them on the destination board.
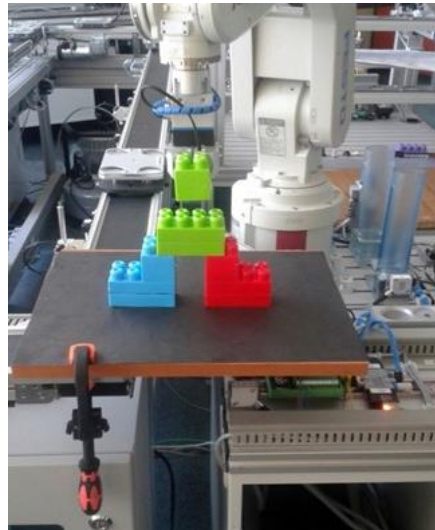
Fig. 5.3. Destination board, final appearance

On the destination board (Figure 5.3), there are fixed wooden dowel pins on which the first two cubes are placed, to prevent slipping or other errors the robot could make during the arrangement.

After the conducted experimental analysis, we can come to the conclusion that even though the task looks easy to do, it is in fact quite hard for the robot. This is because it requires high precision to compose the cubes. The hand of the robot is not flexible so even the slightest deviation, in millimeters, can cause inability of the robot to compose the cubes.

6. Conclusion

Based on experimental analysis of the work of MELFA RV-2SDB robot, it can be concluded that this robot can be used for very complex and precise tasks, performed under high speed. In this paper, the robot successfully managed to do the task of composing the desired form. It can be concluded that MELFA RV-2SDB robot can be used for a wide range of tasks, which demand both high precision and speed.

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