

# The off-line programming and simulation software for the Mitsubishi Movemaster RV-M1 robot

J. Świder <sup>a</sup>, K. Foit <sup>a,\*</sup>, G. Wszolek <sup>a</sup>, D. Mastrowski <sup>b</sup>

<sup>a</sup> Faculty of Mechanical Engineering, Institute of Engineering Processes Automation and Integrated Manufacturing Systems, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland

<sup>b</sup> Former MSc student at Faculty of Mechanical Engineering, Institute of Engineering Processes Automation and Integrated Manufacturing Systems, Silesian University of Technology, ul. Konarskiego 18a, 44-100 Gliwice, Poland

\* Corresponding author: E-mail address: krzysztof.foit@polsl.pl

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## Manufacturing and processing

### ABSTRACT

**Purpose:** Contemporary robotics requires modern instruments for programming, control and supervising of robots' work. It becomes necessary to strictly adjust the robot in its working environment after tests on a virtual model of the robot and its surroundings. The aim of present work is a presentation of preliminary version of the system for off-line programming, simulation and remote supervision of the Mitsubishi Movemaster RV-M1 robot.

**Design/methodology/approach:** The robot installed in institute's laboratory has been used in research work. Attention has been focused on creating of universal software, which could be developed in the future.

**Findings:** In result of carried work a first version of the software has been developed. It has network oriented modular structure.

**Research limitations/implications:** The code of the software has been developed in high level programming in such manner, that allows further translation and transfer to the other system platform. Far-reaching plans include creation of universal form of the software, which could be applied to majority of system platforms and can operate with different types of robots.

**Practical implications:** Created software has presently didactic character and it is used during conduction of laboratory classes.

**Originality/value:** Conducted works have in view a creation of universal and modular software. Existing commercial solutions are usually dedicated to a concrete type of robot.

**Keywords:** Automation engineering processes; Robotics; Simulation; Remote supervision of robot; Education

## 1. Introduction

Modern applications of robotics require new solutions in the field of programming, control and supervision of robots. Nowadays application of a robot is not already sufficient, but it is necessary to adjust it in its working environment. It is connected not only with selection of the proper equipment, but also with proper tests of a program.

Transcending the boundaries of industrial application, robots often substitute human activity in dangerous or inaccessible environments, acting as an extension of operator's limbs and substituting senses of sight and hearing, but on the other hand they retain at least partial autonomy in acting. As an example there can be mentioned mobile robots for debris and explosion-threatened territory inspection, robots taking part in space missions or working in laboratories, where chemical contamination or

harmful radiation is occurred [1,2]. The issues concerning remote control of robots are the subjects of telerobotics, which is a part of robotics.

Application of telerobotics in industrial solutions is, until now, relatively small. Start-up of production process with use of the robots is preceded by off-line tests executed in virtual reality on a virtual model of a robot, then on-line tests directly on manufacturing line or in robot's cell. A supervision of working units is often limited to simple inspection, without possibility of interference to movements of a manipulator or to change the code of the program [3-11].

The goal of the work, which preliminary results are presented in this paper, is creation of an universal and modular system that can allow remote programming and supervision of a robot, after previous test of the program on a virtual model created in virtual environment. The software has been developed for educational and investigative purposes so far. Expedience of conduct of the research confirms a fact, that systems of these types, being presently available on the market, are characterized by complexity and high price, but overall cost of their exploitations is even greater due to necessity of buying proper computer equipment and instructing of employee. On the other hand, there is a lack of simple, platform-independent software, allowing remote supervision of the working robot with ability to change its program. The elaboration of the current version of the system has been conducted with participation of a student.

A similar project to the one presented here is the JRobot system, which is also developed on Mitsubishi Movemaster RV-M1. It should be mentioned here, that the idea of the created system is not connected in any way with JRobot – it is an independent project [12].

In the further part of the paper general assumptions and the present state of work will be presented.

## **2. Overall description of the system**

### **2.1. Description of used laboratory equipment**

In the course of conduction work on software development, the attention has been paid to adaptation to operation with Mitsubishi Movemaster RV-M1 robot due to its availability in the Institute's laboratory and simplicity of programming

Mitsubishi Movemaster RV-M1 robot has five-axis manipulator with 1,2 kg lifting capacity. In spite of small size, the robot is a typical industrial machine [13]. Controller of the robot has ability of communication with external devices through array of inputs and outputs, as well as possibility to connect it to a computer using Centronics or RS-232 port. Programming of the robot can be proceeded by using a teachbox or a personal computer. In case of using a computer, program is prepared in MELFA BASIC language, which has very simple syntax and allows fast writing of the code in any text editor. It is also possible to use the batch mode, when command has been executed immediately after sending it to a robot's controller. Described properties of the MELFA BASIC language allow an user to quickly create its own communication unit for cooperation with the robot.

### **2.2. The development of the system**

The first idea, from which the work on system's creation has started, was an intention of creation of an application, which would generate program for the robot on a base of a drawing containing a trajectory, created in CAD type application, taking into consideration consecutive positions of the gripper and its state (open or close) [14,15]. The translating program has its own dictionary, which can be modified by an user, giving possibility of adapting the application for the other type a of robot or reading of the other input data formats.

The next stage has been an idea to realize the transfer of the program from a computer to the robot installed in the other room [14,15]. Because the robot's controller has not possibility to connect it to the computer network, it was necessary to use an additional computer that fulfills the role of a server. Such solution created the possibility to observe the robot's environment using an USB camera and to transmit the picture to the client computer. Two solutions have been considered in order to achieve the aim: the use of WWW server and CGI or scripting languages or use of JAVA Virtual Machine. The second one is more elastic in reference to use the system on different platforms and enables the possibility to setup the link for real-time data transfer.

In the case of sending the program code to the remote robot, it is very important to make sure that it will be executed in a proper manner and no element on workplace would be damaged by a manipulator. Such test can be conducted in a virtual reality, where all elements of the real robot environment have been modelled. This conclusion has led to creation of the simulation module [14,15,16].

The project is still in development phase. Individual stages will be discussed in further part of this paper.

## **3. Stages of development**

### **3.1. Translation software**

The first result of the work on the system has been a simple application making translation of the trajectory coded in AutoCAD to the source code of the robot's program [16]. The principle of working has been based on the use of a dictionary file, which could be modified by a program operator. The application has been dedicated to the Mitsubishi Movemaster RV-M1 robot, so only elements responsible for decoding the drawing file and finding the parameters needed for creation of the trajectory has been located in the dictionary. In the application, also a possibility of checking propriety of decoded coordinates and editing of a generated program has been implemented. The creation of the trajectory is done in AutoCAD program. The application has been also equipped with a simple interface, which allows providing communication with the robot via RS-232 port. The main window of the CAD TO RV-M1 program is shown in Figure 1.

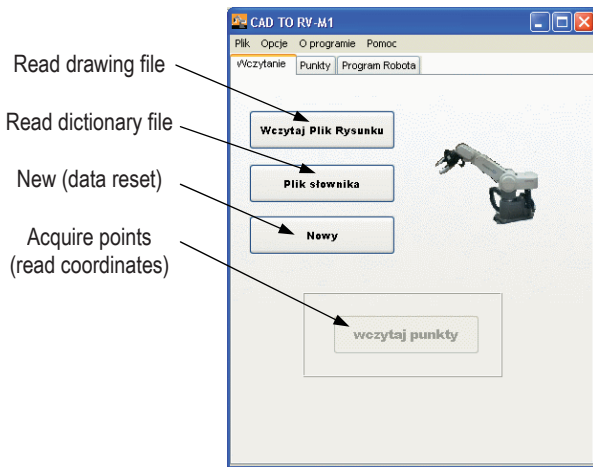


Fig. 1. Main window of the CAD TO RV-M1 program

### 3.2. Simulation software

As it was mentioned earlier, the transfer of the program and its execution on the robot installed in the other room can cause safety problems, which could lead to damages on the robot's workplace. The possibility of testing the program on a virtual model of the robot considerably minimizes the risk connected with dangerous situations. In order to achieve this goal, the next stage of the project has been connected with creation of the proper simulating software, dedicated for the Movemaster RV-M1 robot [15,15,16]. The application named ROBO has been patterned after Denford Virtual Robot software – a virtual room with the robot's workplace has been introduced. The program has been also equipped with a control panel, which combines a virtual robot positioning, a program editor, and simulation management tools. The part of the program, which is responsible for visualization, has been based on the OpenGL engine. At that stage of the project development, the ROBO application had not a capability of communication with the robot, so the code had to be created directly in the program editor or imported from CAD drawing.

### 3.3. Current stage of development

The prototype of the system has been based on ROBO application, which has been equipped with additional simulation capabilities and network communication [15,16]. Moreover, two modules have been developed: KAMROB and SERWER [15,16]. First of them fulfills the role of a mediate program between the robot and the ROBO application and, in addition, sends the video stream from an internet camera to the client station. The SERWER application integrates KAMROB and ROBO by means of network communication – it is a server program. Such division is assumed only to ensure modularity and flexibility of the system. The software has been developed in high level programming language and compiled on Windows platform.

## 4. Prototype of the system

The system has been designed to be the most flexible in use. Particularly, the pressure has been put on the possibility to use the system in education process, where usually only one robot and many client stations are installed. The simulation module can be also executed individually, without necessity to connect it to a real robot.

### 4.1. Simulation module (program ROBO)

The ROBO application has preserved all properties of the previous version, described in section 3.2. In the developed version, a visualization module has been improved and, in addition, new elements of workplace have been introduced: tables and racks [15,16]. The other novelty is a possibility to define an object of manipulation and ability to locate up to five virtual robots working in parallel (this limitation has been introduced only due to graphics engine efficiency). Moreover, it is possible to set the position of the virtual camera using cursor keys. The main window of the ROBO program is shown in Figure 2.

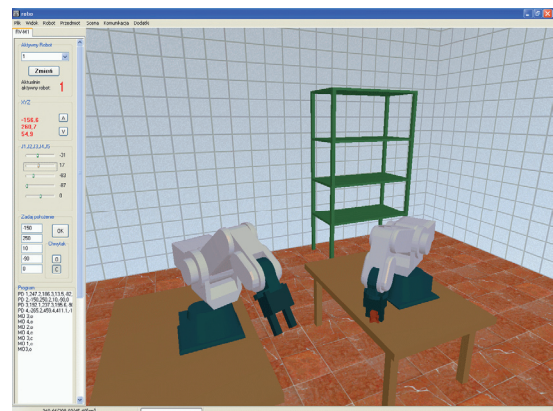


Fig. 2. The main window of the ROBO program

A very important and interesting property is a possibility to locate up to five robots on the workplace and to use a special configuration of ROBO applications, executed on different computers in that manner, each of them controls the other virtual robot. It is also possible to execute a mixed mode, in which one of the robots is connected with the real robot. The example of such configuration is shown in Figure 3.

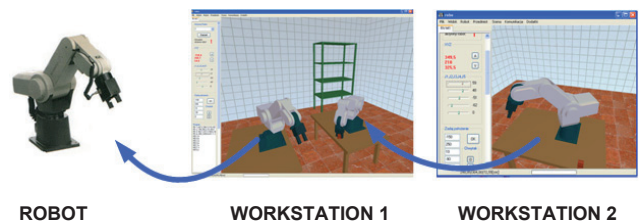


Fig. 3. Workstation 1 operating in mixed mode

The ROBO application has also an ability to send data to the robot in real time, when every change of a virtual robot arm position executes adequate change of a real manipulator. Additionally, it can show the video stream from a remote internet camera. To enable communication between several ROBO applications it is needed to execute the SERWER program on any of the network stations, whereas for communication with camera and the robot the KAMROB application is additionally needed.

#### **4.2. Robot and camera control module (program KAMROB)**

The KAMROB program is the module responsible for communication between a server and a real robot [15,16]. The second function of the program is to transmit video stream from the camera. This application should be executed directly on the computer located juxtapose to the robot's workplace, which is connected to controller via RS-232 port. To the same computer an internet camera should be connected.

#### **4.3. Server module (program SERWER)**

The SERWER application realizes the network communication among ROBO applications and the KAMROB program [15,16]. The SERWER application does not require any additional configuration. To work in the proper manner it needs three network ports, which are assigned to video transmission, network communication for ROBO and KAMROB and for diagnostic messages including errors during communication with the real robot.

There is no objection to assemble the server and robot communication program in the future, but current solution allows more flexibility in network configuration.

### **5. Conclusions**

Developed prototype of the system has allowed conduction of tests of correctness of the structure. In the future, it is planned to develop more new, unrealized functions, mentioned in section 2. Very important is also the didactic aspect of the system, connected with use of it during laboratory classes. For the near future, it is scheduled to modify the software that could handle other types of robots.

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