10th International Scientific Conference
Technics, Informatics, and Education – TIE 2024
20-22 September 2024

Session: *Engineering Education and Practice*
Professional paper
DOI: 10.46793/TIE24.336V

Simulation of a Chess Game with an Industrial Robot

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Abstract: *This paper presents a simulation of a chess game with an industrial robot designed for educational purposes, focusing on the integration of automation in various industries. By using the FANUC ER-4iA robot in a FANUC educational cell, we explore the robot's ability to perform precise and complex movements that are important for the chess game. The simulation is carried out using the ROBOGUIDE software, which enables detailed programming and visualization of the robot's movements. The process includes configuring the coordinate system, defining the robot's gripper parameters and programming the robot to precisely manipulate the chess pieces on a virtual chessboard. The results show that the robot performs the set tasks efficiently and demonstrates its educational potential in teaching robotics concepts and programming skills. Although the simulated application showed high precision in motion execution, certain limitations were noted in automation has become a key factor in increasing efficiency and productivity in various industries. Industrial robots have established themselves as indispensable tools in this process, enabling the automation of complex and repetitive tasks with a high degree of precision and reliability. This paper explores the application of industrial robots for educational purposes terms of the robot's reach and carrying capacity.*

Keywords: *industrial robot; FANUC ER-4iA; education; ROBOGUIDE*

1. INTRODUCTION

Nowadays, automation has become a key factor in increasing efficiency and productivity in various industries. Industrial robots have established themselves as indispensable tools in this process, enabling the automation of complex and repetitive tasks with a high degree of precision and reliability. This paper explores the application of industrial robots for educational purposes by simulating a game of chess with a robot with six degrees of freedom. [1, 2, 3]

Chess, a game that requires strategic thinking and planning, is an ideal framework for demonstrating the capabilities of robotic systems. In this study, the FANUC educational cell is used to simulate a game of chess and demonstrate the robot's ability to perform precise and complex operations. Using the ROBOGUIDE software, which allows detailed programming and simulation of robot movements, the potential of robots to simulate this complex game is analyzed. The process begins with the placement of the chessboard in the simulation space, followed by the addition of the chess pieces. The coordinate system is configured to match the required robot movements, using the "Joint" system to control individual robot axes. After setting up the board and pieces, the robot gripper parameters are defined to simulate the interaction with the chess pieces.

The main objective of this paper is to demonstrate the practical application of industrial robots in education and to explore the possibilities of their further development and implementation in various industrial sectors. The paper contributes to a better understanding of the capabilities of industrial robots and illustrates their potential not only in manufacturing processes but also in the educational context, where they can serve as powerful tools for the training of future engineers and technicians.

2. FANUC EDUCATIONAL CELL

FANUC has developed an educational cell that includes the very popular FANUC ER-4iA standard industrial robot. The FANUC ER-4iA industrial robot is compact and precise and is therefore very suitable for education and training. The educational cell is primarily designed for educational institutions such as schools, universities or training centers and is aimed at students, providing them with an excellent robotics training package. With this educational cell, users can develop skills such as programming the robot and processes, controlling movements and familiarizing themselves with the basic concepts of robotics, while also offering insights into safety aspects. The content of the cell is highly relevant to modern industrial applications and contains everything students need to acquire comprehensive knowledge. This educational cell can also be integrated with FANUC's ROBOGUIDE software, which enables advanced learning and research in robotics. The software allows users to virtually create their work cells, set up and program robots, and simulate and analyze workflows. This enables users to visualize how the robots will work in the real world, identify and solve potential problems and optimize workflows before they are used in a production environment. In addition, the educational cell offers the option of using a machine vision camera for component recognition and detection, which is mounted on top of the cell to detect components. The educational cell consists of the following components:

- FANUC ER-4iA robot
- R-30iB Plus controller
- iPendant hand controller
- Educational cell (mobile structure with a table)

Figure 1. *3D model of Fanuc educational cell*

3. CHESS GAME SIMULATION

The simulation is carried out with the ROBOGUIDE software from FANUC. It is necessary to determine and configure the coordinate system, but the "Joint" coordinate system is preset in the learning cell, so no additional configuration is required. The "Joint" coordinate system represents the coordinate system of the individual robot axes, with each joint rotating around its central axis. In addition to the "Joint" coordinate system, there are also Cartesian coordinate systems, which are represented by displacements along the X, Y and Z axes and by rotations around the W, P and R axes. There is also the "World" coordinate system, which is predefined and cannot be changed. The "User" and "Jog" coordinate systems are defined on the basis of this coordinate system. The "User" coordinate system refers to the tool and defines its center and rotation relative to the "World" coordinate system, while the "Jog" coordinate system is defined by the user and is generally used to facilitate robot movement in manual mode.

The first step in the chess simulation process is to import the necessary 3D models into the program. This is achieved by selecting the "Fixtures" tab from the drop-down menu on the left-hand side, right-click on "Fixtures"," select the "Add Fixtures" option and then select "Single CAD File" for the chessboard and "Multiple CAD File" for the pieces. A window will then open in which the 3D model of the chessboard that was previously created in Fusion360 must be located. Once the board is inserted into the workspace, it must be positioned accurately to ensure that the work cell is set up correctly.

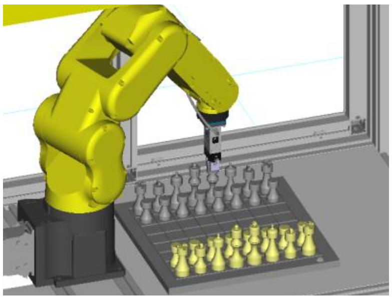

Figure 2. *Work cell after importing chessboard and chess pieces*

In the next step, it is necessary to define how the gripper holds the chess pieces during the simulation. In the drop-down menu under the "Tooling" tab, select the option "UT: 1 (Gripper)" to open the gripper settings. In the newly opened window, select the "Parts" tab. Select the chess piece in the opened window, click on "Apply" and then select "Edit Part Offset" to position the piece in the gripper. After positioning, deselect the options "Visible at Run Time" and "Visible at Teach Time," and confirm again with "Apply" Repeat this process for all chess pieces.

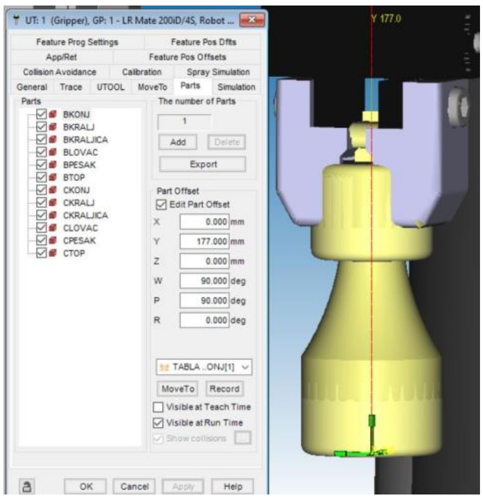

Figure 3. *Position of chess piece in gripper*

Programming the movement of a single chess piece begins with finding the previously created program in the Teach Pendant. To access the program, press the “Select” button and select the desired program using the arrow keys on the keyboard, followed by confirming the selection by pressing the "Enter" key Next, you must insert the appropriate number of lines of code by using the "EDCMD" option and selecting "Insert" The number of lines added does not have to be exact, as lines can be added or deleted later as needed.

The next step is to define the tools and coordinate systems. Use the arrow keys to position the cursor on the first line of code, select the "INST" option and go through the menu until you reach "Offset/Frame"," where the "UFRAME_NUM=" option is set. Enter the number of the coordinate system, e.g. the "Joint" system, and confirm the selection. The same procedure is repeated for selecting the tool by selecting "UTOOL_NUM="," where in this case the tool is the gripper, so that the corresponding number is entered in the code.

The robot is then moved to the "Home" position and the gripper is opened with the "CALL program" subroutine, selecting "AA_HOME" to return the robot to the home position and "HAND_OPEN" to open the gripper. Then the robot is positioned above the desired chess piece to be moved by selecting the "Move To" option in the program tree. Once the robot is positioned above the piece, the "POSN" option is used to adjust the coordinates of the robot, especially the Z-axis, to position the robot at the desired height above the piece. When the positioning is complete, the position is saved in the code by pressing "SHIFT", "F1" and "POINT".

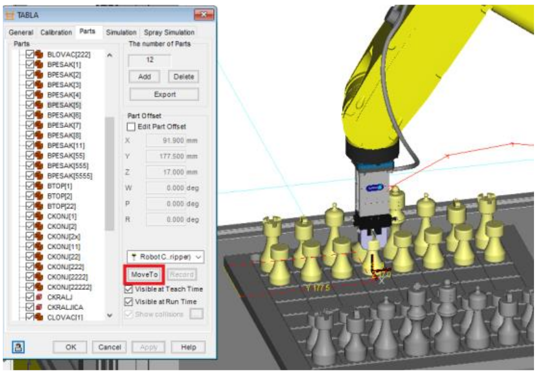

Figure 4. *Point and path definition*

Finally, the robot is lowered to the exact position to grip the piece using a linear movement defined in the code. Once the robot is in the correct position, the gripper is closed with the "Macro" program "HAND_CLOSE" successfully gripping the piece, which is then ready to be moved. This process is repeated for all subsequent movements.

```
PARTIJA_SAHA
232:L  P[104] 50mm/sec FINE
233:  CALL HAND_CLOSE
234:  CALL PICK_CLOVAC
235:L  P[105] 50mm/sec FINE
236:L  P[106] 50mm/sec FINE
237:L  P[107] 50mm/sec FINE
238:  CALL HAND_OPEN
239:  CALL PLACE_CLOVAC
240:L  P[108] 50mm/sec FINE
241:L  P[109] 50mm/sec FINE
242:L  P[110] 50mm/sec FINE
243:  CALL HAND_CLOSE
244:  CALL PICK_BKONJ
245:L  P[111] 50mm/sec FINE
246:L  P[112] 50mm/sec FINE
247:L  P[113] 50mm/sec FINE
248:  CALL HAND_OPEN
249:  CALL PLACE_BKONJ
250:L  P[114] 50mm/sec FINE
251:  CALL AA_HOME
[End]
```

Figure 5. *Program part*

In order to visualize the movement of the chess pieces in the simulation, it is necessary to create simulation programs for opening and closing the gripper, which should be called after the line in which the gripper is actually closed. The simulation program is created by right-clicking on the "Programs" tab in the tree on the left-hand side and selecting the "Add Simulation Program" option. A name is entered in the new program, for example "PICKBPIJUN".

By running the simulation of the robot, you can test the application. Once the application has been tested, it is transferred to the physical robot controller and the robot is put into operation. In order for the program to work on the physical controller, you must delete the simulation programs. The program is then transferred from ROBOGUIDE to a USB drive and then from the USB drive to the robot controller.

When the USB drive is connected, press the "MENU" button, select the "FILE" option in the next window and then "File" again. If you press the "F1" key, the "Type" menu opens, in which you select the ".TP" option for easier searching. A menu will then open with the programs available on the USB drive. Position the cursor on the desired program and load it by selecting the "LOAD" option or pressing the "F3" key.

Figure 6. *Chess game on physical robot*

4. CONCLUSION

This study successfully created a basic version of a pick-and-place application on the robot, which represents the first step in the programming of industrial robots. The simulation showed a high degree of precision in the manipulation of the chess pieces. However, limitations were identified in terms of working range and payload, which could be improved by using a robot with a higher payload capacity or better suited to certain tasks.

In addition, the integration of software tools such as ROBOGUIDE enables efficient planning and simulation of complex tasks before they are transferred to the real environment. The FANUC ER-4iA robot accurately executed all the prescribed moves on the chessboard, demonstrating its ability for precise positioning and repeatability of movements.

Future studies could explore the integration of advanced artificial intelligence systems to enable more autonomous interaction between the robot and its environment, potentially allowing the robot to play a game of chess against a human opponent. The results indicate a high level of precision and reliability, suggesting the potential for further applications of such systems in both education and industry.

ACKNOWLEDGEMENTS

Research presented in this paper was partially funded by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia, contract No. 451-03-66/2024-03/200132, implemented by the Faculty of Technical Sciences in Cacak - University of Kragujevac.

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