Camera tracking and trajectory planning with manipulator Mitsubishi MELFA

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Abstract **– This project presents the development of a 2 different application of trajectory planning, first where the objective is to draw the logo of a national football team qualified to WC 2018 in a sheet of paper using the manipulator Melfa RV 3SQB available in the Automation Lab. The first step is to get the points to draw and to define a work area for the robot. After this, it is necessary to select the command of movement for the robot, in this case it is Mvs. The second application is to develop a source code that catches points by hand movement tracking using a camera and the project writes the code in the MELFA language with the trajectory which is loaded to the manipulator. The tracking system is made with Matlab and generates the code to load in the MELFA with all the commands needed.**

Keywords **— Manipulator, Trajectory, Tracking, Singularity.**

INTRODUCTION

Industrial manipulators are normally controlled by means of a pre-established programming that allows them to carry out routines, this loading of routines can be carried out in various ways, some of these are: through Matlab, SolidWorks, etc. But in some cases the robots (manipulators) can be controlled in real time by means of Matlab complemented by Microsoft Kinect or 3D Cam Systems, for correct operation a direct IP connection must be made. [1]

During the last few decades, few new application fields have been developed for industrial robotics, although exploiting the state of the art in (industrial) robotics research can open up a plethora of new applications in industrial manufacturing and other areas.. [2]

Each industrial manipulator contains a controller that calculates the kinematics, currents and torques for each of the movements. That device driver is loaded with the program to do all the calculations and function optimally. [3]

Not only the manipulators are taken into account, the tasks carried out by the operator are also important, since they must know each of the functions and processes carried out by the robot.[4]

Figure 1: *MELFA RV 3SQB Manipulator [4]*

In addition, the main connection instruments with which they work must be taken into account, such as the HMI screens that allow the configuration to be configured directly on the robot and, as usual, they must contain a visible and easily accessible emergency stop button.

Figure 2 *: Teaching Pendant R56TB[4]*

The risks of manipulators and their use in industry 4.0 must also be taken into account, which, although they are not occupational or fatal risks, have an impact on the employment offered to the operators of these machines, which replace human labor with automated machines it has reduced the opportunities of many people who were developing in this area, and it is that in this type of industry even everything is developed digitally and by artificial intelligence. [5]

One of the characteristics of the programming lines of the manipulators is that they are efficient and precise for industrial processes, that is why, through the use of CAD systems such as Solidworks, trajectories have been designed and manipulators programmed offline before being placed. in progress in a plant, in order to be able to identify characteristics of the process and possible changes to be made. [6]

It is always important to take into account the work area of a robot, since it is on which the movement it performs will be carried out, and also when 2 robots are combined, such as a mobile robot and a manipulator, such as the case of a helicopter that has an integrated manipulator attached to its lower part and that adds a degree of freedom to its kinematics. Where both robots work complemented to be a single robot of 8 DOF. [7]

Figure 3*: Mobile robot with manipulator 8 DOF [7]*

These industrial manipulators already have all their commands standardized, and their direct and inverse kinematics defined, however other methods have been developed to carry out and solve these problems using artificial intelligence. Artificial intelligence allows the robot to make a better decision in the face of a common problem, such as plotting points with greater precision and correcting possible position errors. It is observed in figure 4 on which AI is performed in the inverse kinematics of a robot, obtaining a lower mean square error in the final position after training the point in a neural network so that the motors have the exact displacement.[8]

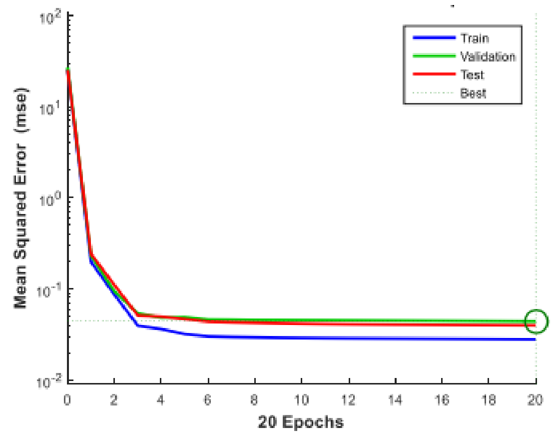

Figure 4 *: Position error VS Epochs, on a manipulator with AI [8]*

METHODS

- **Planning for the football logo.**

For the development of the practice, first the trajectory that the manipulator must carry out is identified, the teacher randomly assigns a different logo for every class group,, in this case the logo of the Australian Football Federation must be drawn on paper as shown in figure 5.

Figure 5 *: Australian Football Federation Logo*

Using the Solidworks software, the image of the shield is inserted and from there the points are located on the contours of the shield that are to be defined, and the workspace defined for the manipulator must also be taken into account, which will be on the X axis from 50mm to 250mm and on the Y axis from -460mm to -280mm. After having all these points, an excel file is generated where all the points obtained are organized, and the command to use in the manipulator must also be indicated.

For this case, you want to make points that are not totally straight lines, that is why the Mvs command is used, which allows the software to interpolate 2 points and make a curved path between these two. Having said this, the .PRG extension code is loaded into the manipulator so that it can carry out the programmed trajectory.

- **Tracking method**

For the handheld tracking system, the MATLAB software is used, in which the webcam integrated in the computer is used as a data input device, in this case a circumference is presented to the computer's webcam from which the program via a command finds the center of the circle and stores its position in a position vector. The position of the center is the coordinate in pixels of the point, the resolution of the camera is 640x480, but in this practice a different work area is defined, that is why a linear interpolation is made that allows converting the pixel values of the camera to values that are within the working area of the manipulator.

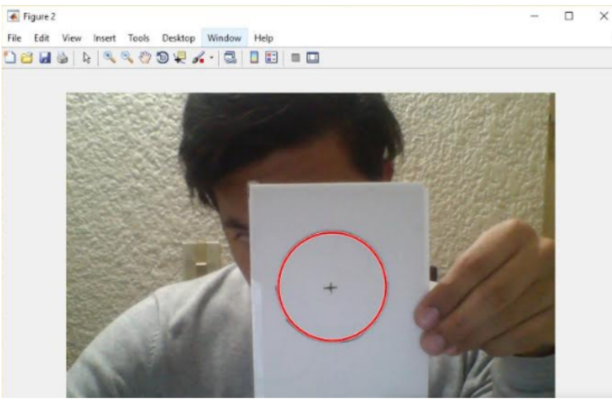

***Figure 6**: Circle recognition on MATLAB*

When it recognizes a circular contour, it colors it red, indicating that the identification is correct, as shown in figure 6.

And taking into account the center of the circle, the desired trajectory can be made while observing the camera in the interface. The center will be the one that defines the trajectory, it was decided to take the circle as a reference object since it can be left within a white background, making it easy to recognize at any level of light in the environment.

MATERIALS

-Manipulator MELFA RV-3SQB

-Matlab R2017a

-Solidworks

RESULTS

Using Solidworks, it was possible to obtain the entire set of points for the graphing of the shield, resulting in the image of figure 7. In total there were 1223 points.

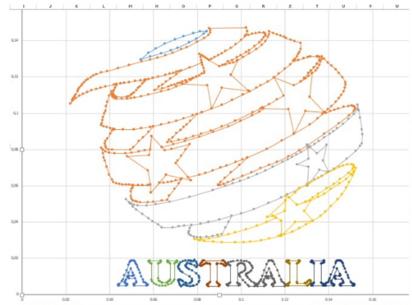

***Figure 7** :Obtained points by Solidworks*

For the tracking system and after plotting the points on the interface using the center of the circle, the plot function is used, and the plotted points are obtained, as shown in figure 8.

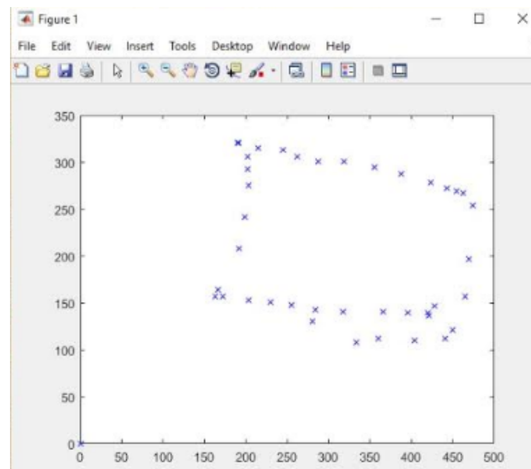

***Figure 8** :Points obtained by tracking (camera)*

After this, the code in Matlab generates all the necessary code for the manipulator, and that must first be simulated to verify that the trajectory that it will carry out is the one programmed. The result of the simulation carried out can be found in figure 9.

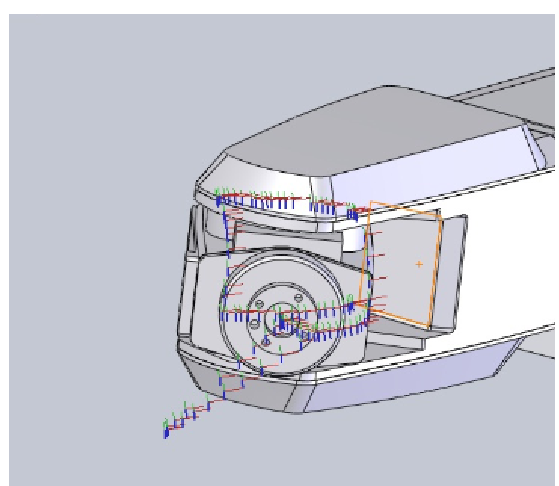

***Figure 9** :Simulation of tracked trajectory by camera*

Where it is observed that it performs the same trajectory that appears in the MATLAB result. Starting from a zero start point, which is the corner of the work area.

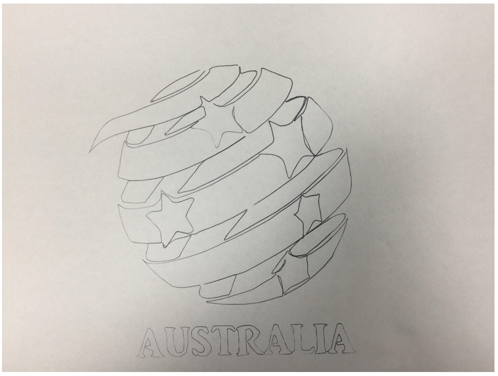

Figure 10 *:Result of the trajectory made in the laboratory manipulator.*

CONCLUSIONS

In modernity it is expected that as the machines continue to take over the industry, the personnel in the plant would be reduced, however the manipulators need an expert operator who knows how to control each variable, sensor, movement and action that he performs, In this case, it can be even more expensive to hire an operator for this machine than an entire staff to carry out the process, taking into account that each robot needs periodic maintenance.

REFERENCES

[1]T. Wruetz, J. Golz, R. Biesenbach, “A Wireless Multi-robot Network Approach for Industry 4.0 using RoBO2L”, IEEE 14th International Multi-Conference on Systems, Signals & Devices(SSD), pp 661-664, 2017.

[2]A. Muxfeldt, D. Kubus, F. Wahl, “Developing New Application Fields for Industrial Robots - Four Examples for Academia-Industry Collaboration”, IEEE 20th Conference on Emerging Technologies & Factory Automation (ETFA), 2015.

[3]Mitsubishi Industrial Robot SQ Series Special Specifications Manual, MITSUBISHI, Ratingen, GER.

[4]A. Moniz, “Organisational Challenges of Human-Robot Interaction Systems in Industry”, Springer ed, 2014.

[5]Z. Rajnai, I. Kocsis,“Labor Market Risks of Industry 4.0, Digitalization, Robots and AI ”, IEEE 15th International Symposium on Intelligent systems and informatics, pp343-346 2017.

[6]H. Wu, H. Deng, C. Yang, Y. Guan, H. Zhang, H. Li, “A robotic Off-Line programming system based on Solidworks”, IEEE Conference on Robotics and Biomimetics”, pp1711-1716, 2016.

[7]K. Kondak, F. Huber, M. Schwarzbach, M. Laiacker, D. Sommer, M. Bejar, A. Ollero, “Aerial manipulation robot composed of an autonomous helicopter and a 7 degrees of freedom industrial manipulator”, IEEE International Conference on Robotics & Automation (ICRA), pp2107-2112, 2014.

[8]N. Lathifah, A. Handayani, H. Herwanto, S. Sendari,”Solving Inverse Kinematics Trajectory Tracking of Planar Manipulator using Neural Network”, IEEE International Conference on Information and Communications Technology (ICOIACT), pp 483-488, 2018.