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THE DESIGN OF SPECIAL WORKPLACE WITH FANUC DELTA ROBOT

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ABSTRACT
Two models of Delta robots have been developed by FANUC Robotics, M-1iA and M-3iA. These robots are ideal to automate tasks which so far were too fast and too complex for robots. In addition, this new family of robot series offers the motion flexibility of a human wrist, fast cycle times, ultra compact arm and precision. It is also possible to support intelligent functions using iRVision.
The workplace has been designed at University of Zilina. The frame, as the main structure, has been analysed carefully (including static and dynamic analysis) to develop a wide range of tasks requiring high accuracy. Furthermore, 5 tasks and their pallets have been designed to show the abilities of the FANUC M-1iA 0.5A. These tasks have also been thought to be programmed by the students thus the difficulty increases.
Keywords: robot, parallel kinematic structure, delta robot, high speed robot

1. INTRODUCTION
The parallel manipulator is a closed-loop kinematic chain mechanism whose end-effector is linked to the base by several independent kinematic chains [3].
Parallel robots are interesting due to their large stiffness and high positioning accuracy compared to serial robots. This kind of robots can be used in many fields but most of them are used as robots or as numerical controlled machine tools. Specific applications such as spatial, medical, joysticks and simulators are also possible.
Reymond Clavel, professor at École polytechnique Fédérale de Lausanne, comes up with the brilliant idea of using parallelograms to build a parallel robot with three translational and one rotational degree of freedom in the early 80's. His inspiration was truly original. The latter calls his creation the Delta robot, without suspecting that at the turn of the century, it will establish itself as one of the most successful parallel robot designs, with several hundred active robots worldwide [1].

2. THE IDEA OF DELTA ROBOT
The basic idea behind the Delta parallel robot design is the use of parallelograms. A parallelogram allows an output link to remain at a fixed orientation with respect to an input link. The use of three such parallelograms restrains completely the orientation of the mobile platform which remains only with three purely translational degrees of freedom. The input links of the three parallelograms are mounted on rotating levers via revolute joints. The revolute joints of the rotating levers are actuated in two different ways: with rotational (DC or AC servo) motors or with linear actuators. Finally, a

mechanism is used to transmit rotary motion from the base to an end-effector mounted on the mobile platform.
The use of base-mounted actuators and low-mass links allow the mobile platform to achieve large accelerations up to 50 times the gravity (G) in experimental environments and 15 G in industrial applications.
There are two kinds of Delta Robot: *high-speed robot* (objects that weight up to 1 kg) and *robots to handle heavy objects*. Both of them have a low inertia structure.
Delta robots are also famous for easy dismounting and mounting, for their low maintenance and for their flexibility, that is to say, changing the end-effector a Delta robot can carry out a wide range of actions [1].

3. FANUC ROBOTICS DELTA ROBOTS

In 1956 FUJITSU Fanuc was founded as a subsidiary of FUJITSU LTP to develop numerical controls. In 1972, FUJITSU LTD spun off FUJITSU Fanuc and the name was changed to FUJITSU FANUC LTD. The first industrial robot was developed and installed in 1974. The company grew rapidly, changed its name and, USA and EUROPE FANUC were established in 1977 and 1978 respectively. Nowadays, FANUC Robotics has installed over 200,000 robots in all over the world and it is the world leader in industrial robotics.
Two models of Delta robots have been developed by FANUC Robotics, **M-1iA** with 6 or 4 DOF and **M-3iA** also with 6 or 4 DOF. These robots are ideal to automate tasks which so far were too fast and too complex for robots. In addition, this new family of robot series offers the motion flexibility of a human wrist, fast cycle times, ultra compact arm and precision. It is also possible to support intelligent functions using iRVision.

4. THE DEVELOPMENT OF WORKPLACE WITH FANUC DELTA ROBOT

4.1 The Fanuc Delta Robot M-1iA/0.5A

The Delta robot FANUC M-1iA 0.5A (Fig. 1) at the University of Zilina is a novel lightweight robot for electronics, measuring device and other precision industries. It is extremely useful for ultra compact production cells thanks to the compact and lightweight arm and the compact and powerful Mate Open Air Controller.

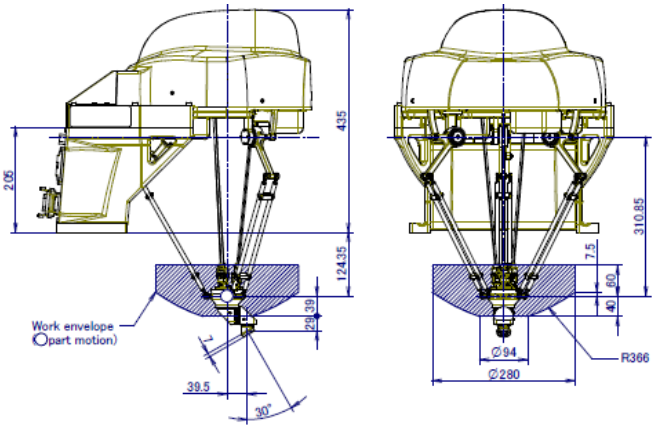

Figure 1. Dimensions of Delta robot FANUC M-1iA 0.5A [5]

This new robot provides a higher productivity for assembly and picking applications, a lightweight mechanism with better cycle times and a unique 6-axes parallel link arm mechanism that allows automate difficult tasks such as complex insertion, gluing and more. However, FANUC M-1iA 0.5A will be used at the laboratories of the University of Zilina to prove the advantages of parallel robots, and to show the students how a robot can be programmed and utilized.
In addition, FANUC M-1iA 0.5A is a compact and intelligent controller thanks to the integrated iRVision which can locate and check work pieces for flexible parts feeding applications and other

intelligent tasks. This vision system allows four possible processes: normal 2D Vision, depalletising 2 ½ D Vision (includes a calculation of Z-height and some special depalletising functions), 2D Multiview Vision and Visual Line Tracking 2D Vision [2].

4.2 The design of workplace

The workplace has been designed for education in robotics at University of Zilina [7]. The frame, as the main structure, has been analyzed carefully (including static and dynamic analysis) to develop a wide range of tasks requiring high accuracy. With respect to the dynamics of the robot motion, the table is fixed to the floor with four screws (Fig. 2).

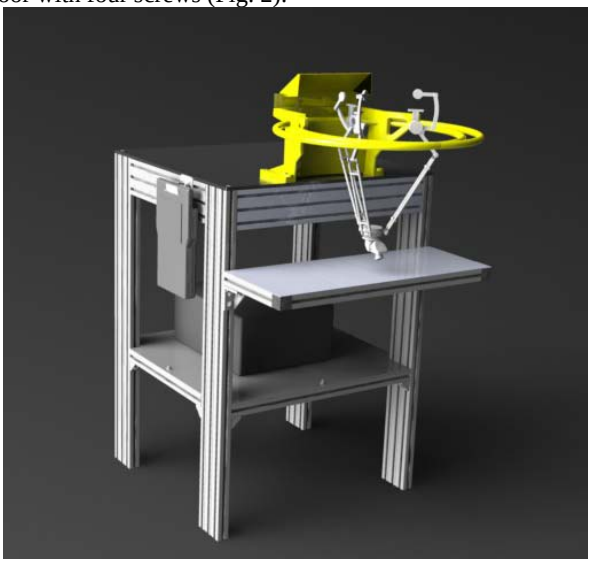

Figure 2. The design of workplace with Delta robot M-1iA FANUC Robotics [7]

4.3 Design of Delta robot application tasks

The workplace will be specially designed to carry out five different tasks at the laboratories of University of Zilina [7]. The end-effector and the pallet must be changed depending on the task.

The first task is oriented on high manipulation with small objects – the balls are replacing as fast as possible in order to prove the agility of the robot.

The second task: 8 cubes are saved to the magazine in order to show the dimensions of the workspace and the dexterity of the robot.

The third task is centred on robot application in automatic assembly without Computer Vision (CV) system application.

Further task is oriented on objects high speed sorting in magazine with CV application (Fig. 3).

In the last task are the keys assembled to sloping keyboard by using CV system.

The tasks have been designed to be programmed by the students and thus the difficulty of these tasks increases.

4.4 Task: objects high speed sorting in magazine with CV system application.

For example we five 4. task (Fig. 3).

Characteristics:

- End-effector: Vacuum end-effector
- iRVision: Yes
- Objects: 3 square-shaped and 3 round-shaped pieces made in metal sheet
- Initial object position: Unknown (random stacked pieces in a magazine)
- Objective: Stack the square-shaped pieces in magazine A and the round-shaped ones in magazine B, in order to prove the reliability of the iRVision.
- Degrees of freedom: 4

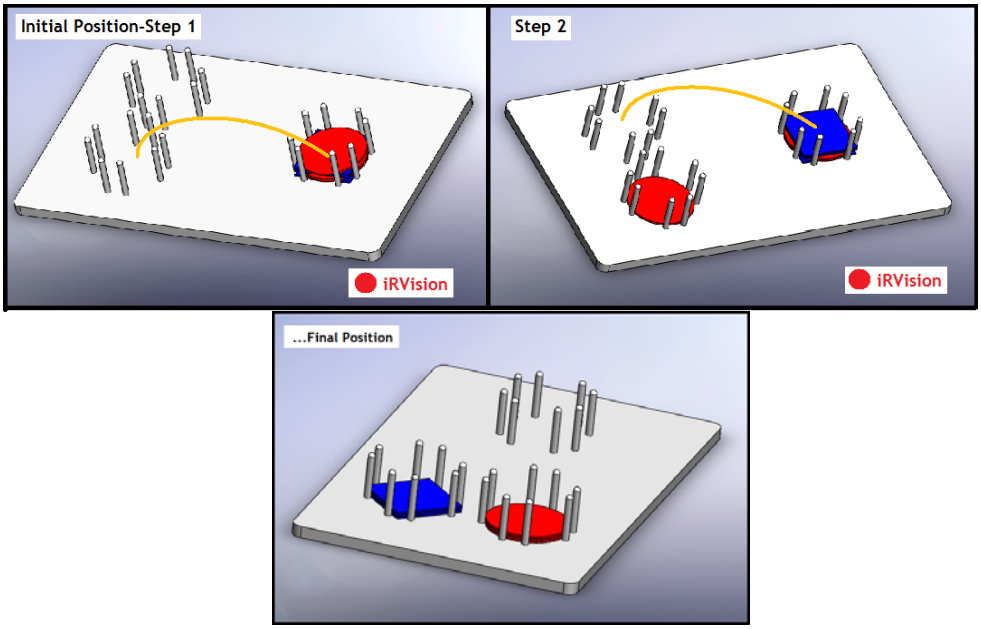

Figure 3. Objects sorting with Computer Vision system application [7]

5. CONCLUSIONS

Two models of Delta robots have been developed by FANUC Robotics, M-1iA and M-3iA. These robots are ideal to automate tasks which so far were too fast and too complex for robots. In addition, this new family of robot series offers the motion flexibility of a human wrist, fast cycle times, ultra compact arm and precision. It is also possible to support intelligent functions using Computer Vision System (iRVision).

The workplace with Delta robot M-1iA FANUC Robotics has been designed at University of Zilina. The frame, as the main structure, has been analyzed carefully (including static and dynamic analysis) to develop a wide range of tasks requiring high accuracy.

Furthermore, 5 tasks and their pallets have been designed to show the abilities of the FANUC M-1iA 0.5A. These tasks have also been thought to be programmed by the students thus the difficulty increases. Finally, a magazine has been designed to store the current task pallets and it has been created to house for ten pallets.

6. ACKNOWLEDGEMENT

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