Fundamental on Robotics: Palletization operation using Mitsubishi RV-M1

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I. Introduction

The aim of this laboratory is to be familiar with the robot Mitsubishi RV-M1. The activity asked is a palletization. We will present first the specification of the robot. Then, we will introduce the positions recording during the manipulation. Finally, we will present the scheme and the program implemented to carry the palletization.

II. Specification of the robot

In this section, we will present every degree of freedom and the Cartesian coordinate system of the Mitsubishi RV-MV1.

A. Degree of freedom

Figure 1 presents all degrees of freedom of the robot. The Mitsubishi RV-M1 is composed of five degrees of freedom. All degree of freedom are rotational joints.

Referring to the figure 1, the degrees of freedom are:

- J_1: Waist - rotational joint of $300°$. The positive direction is clockwise as viewed from A arrow.
- J_2: Shoulder - rotational joint of $130°$.
- J_3: Elbow - rotational joint of $110°$.

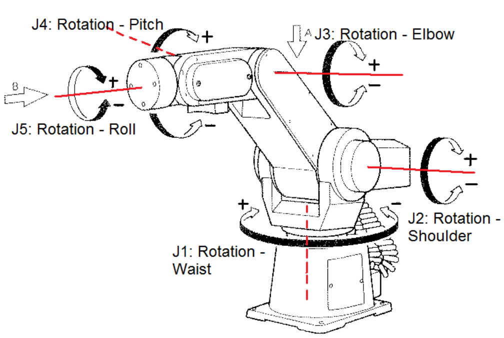

Figure 1. Presentation of degree of freedom

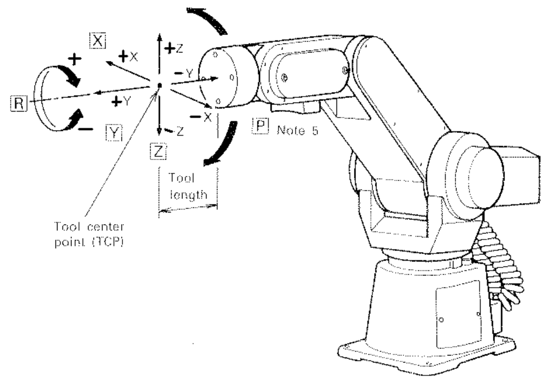

Figure 2. Cartesian coordinate system

- J_4: Wrist pitch - rotational joint of $\pm 90°$.
- J_5: Wrist roll - rotational joint of $\pm 180°$. The positive direction is clockwise as viewed from B arrow.

B. Cartesian coordinate system

Figure 2 presents the Cartesian coordinate system defined for the Mitsubishi RV-M1 robot.

III. Acquisition position

In order to perform the palletization, the first work to do is to save different position useful to carry out the different tasks. The different positions saved are the following:

```
PD 1,57.7,285.1,188.7,-89.8,83.3

PD 20,-48.3,357.7,22.7,-88.5,83.3
PD 21,152.7,310.6,20.2,-88.5,83.3
PD 22,-60.6,301.9,21.4,-88.5,83.3
PD 23,134.3,250.4,18.2,-88.5,83.3

PD 40,-172.7,281.7,110.9,-88.5,83.3
PD 41,-172.6,283.1,21.6,-88.5,83.3
```

```
PD 50,−83.8,415.2,132.2,−46.3,93.8

PD 60,156.3,340.4,198.5,−94.1,83.3
PD 61,180.9,394.0,136.4,−82.2,83.3
```

These different positions correspond to:

- Position 1: Home position.
- Position 20: Top-left corner of the pallet.
- Position 21: Top-right corner of the pallet.
- Position 22: Bottom-left corner of the pallet.
- Position 23: Bottom-right corner of the pallet.
- Position 40: Approach object grip.
- Position 41: Grip object position.
- Position 50: Sensor.
- Position 60: Approach garbage.
- position 61: Garbage position.

IV. Scheme and program

A. Description of the task

So to perform the manipulation, these different steps have to be executed:

- Step 1: Calibration.
- Step 2: Definition of the pallet.
- Step 3: Routine to give an object to grab it later.
- Step 4: Routine to grab the object and test it
  - Step 5-1: If the object is metallic, bring it to the garbage. Return to the step 3.
  - Step 5-2: If the object is plastic, put on the pallet to the actual position. Go to step 6.
- Step 6: Compute the new position on the pallet. If the palletization is not finish go to the step 3.

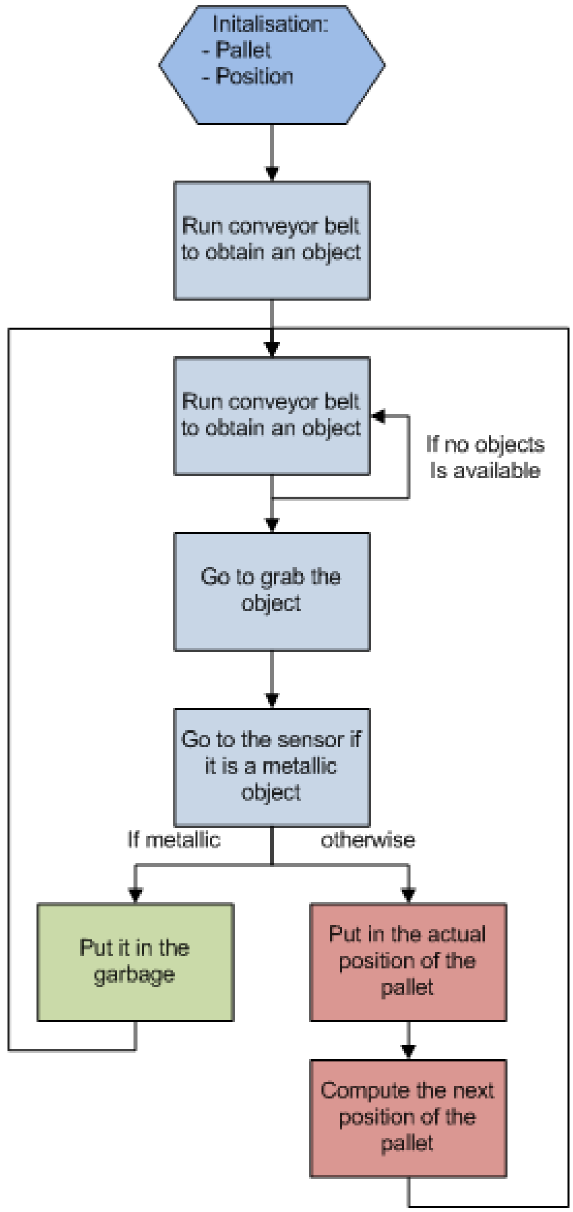

Figure 3. Scheme of the program

B. Scheme

The previous step describe in the previous section are shown on the figure 3.

C. Program and description

So in this section, we will present the code which to implement the palletization:

```
01 //Define positions
PD 40,−172.7,281.7,110.9,−88.5,83.3
PD 41,−172.6,283.1,21.6,−88.5,83.3
PD 22,−60.6,301.9,21.4,−88.5,83.3
PD 20,−48.3,357.7,22.7,−88.5,83.3
PD 21,152.7,310.6,20.2,−88.5,83.3
PD 23,134.3,250.4,18.2,−88.5,83.3
PD 60,156.3,340.4,198.5,−94.1,83.3
PD 61,180.9,394.0,136.4,−82.2,83.3
PD 1,57.7,285.1,188.7,−89.8,83.3
PD 50,−83.8,415.2,132.2,−46.3,93.8
```

To avoid any problem with positions files, the positions presented in the previous part are included in the *MRL* program.

```
02 //Calibrate the robot
03 NT
```

Then, the first motion carry out is to calibrate the robot.

```
05 //Define the corners of the pallet
10 PL 90, 20
20 PL 91, 21
30 PL 92, 22
40 PL 93, 23
```

Four corners of the pallet are defined to compute automatically each position of the pallet.

```
50 //Go to Home position
51 MO 1
52 //Put the speed at 3
53 SP 3
```

The robot will move first in the HOME position and the speed will be setup up at 3 over 9.

```
55 //Create the pallet
60 PA 9,3,2

70 //Set row an column counter
80 SC 91,1
90 SC 92,1
```

The pallet is created knowing the type (PA 9) and the number of column and row.

```
100 //Start the program here
101 //Go for the conveyor belt
105 GT 300
```

The sub routine of the line 300 is called.

```
299 //Routine to give a cube with the
    conveyor
300 OB +1
301 ID
310 TB +2,301
320 OB −1
330 GT 110
```

The code above implement the sub routine to import an object at the of the conveyor. The line 300 start the conveyor belt. The line 301 allows to update the intern register while the line 310 check the bit 2 of intern register to know if an object have reached the end of the conveyor. If not, the program returns to the command to update the intern register. Otherwise, the conveyor belt is stopped and the program return in the main routine at the line 110.

```
109 //Routine grab and place
110 MO 1
120 MO 40
130 MO 41,O
140 GC
145 TI 15
150 MO 40,C
```

The robot moves to the approach position of the conveyor and go to grab the object and close the grip. Wait 1.5 seconds before to move to the approach position to stabilized.

```
151 //Check if it's metal piece
152 MT 50,−50,C
153 MO 50,C
154 TI 15
155 ID
156 TI 15
157 TB −1,700
```

First the robot will approach the sensor, and then go near of the sensor. The intern register will be updated and after 1.5 seconds of temporization, the bit 1 of the intern register is checked. If the value is a 0 logic, the program jump to the line 700 and the object is considered as a metal object. Otherwise, the program continues usually and the object is considered as a plastic object.

```
700 //Put the pice in the garbage
701 MT 50,−50,C
710 MO 1,C
720 MO 60,C
730 MO 61,C
740 GO
750 MO 60
760 MO 1
770 GT 105
```

If the object is an metal object, the robot will deposit the object inside the garbage. That is why, the robot go first to the HOME position (line 710) before to approach the garbage (line 720) and let the object (lines 730 and 740). Then, the robot go back to the HOME position before to execute the code of the line 105.

```
159 //Put on the palet
160 MT 50,−50,C
161 MO 1,C
170 PT 9
```

```
180 MT 9,−50,C
190 MO 9,C
200 GO
205 TI 5
210 MT 9,−50
220 GT 500
```

If the object is detected as a plastic object, the robot will place it on the pallet at the current position computed line 170. Then, the robot temporized 0.5 seconds. Then, the program will go to a routine to increment the position of the pallet.

```

449 //Counter column
500 IC 91
510 CP 91
515 EQ 4,530
520 GT 105

529 //Counter row
530 SC 91,1
550 IC 92
570 CP 92
575 EQ 3,900
580 GT 105

900 MO 1
1000 ED
```

The aim of this part is to increment the position of the pallet. The counter for column is incremented until the moment that the counter exceeds the number of column (from line 500 to 520). When the counter for the column exceeds the number of column, we reset this counter and increment the counter for the row (from line 530 to 580). The program go to the line 105 until the moment where the counter of the row exceeds the number of row. At this moment, the program stops.

V. Conclusion

In this paper, we presented an example of palletization using the Mitsubishi RV-M1. First, we presented the specifications of this robot. Then, we introduce the position stored in order to perform the palletization. Finally, we described the program allowing the palletization.

Appendix A
Code

All the comments using this char ”’” are replace by this char ”//”

```
01 //Define positions
PD 40,−172.7,281.7,110.9,−88.5,83.3
PD 41,−172.6,283.1,21.6,−88.5,83.3
PD 22,−60.6,301.9,21.4,−88.5,83.3
PD 20,−48.3,357.7,22.7,−88.5,83.3
PD 21,152.7,310.6,20.2,−88.5,83.3
PD 23,134.3,250.4,18.2,−88.5,83.3
PD 60,156.3,340.4,198.5,−94.1,83.3
PD 61,180.9,394.0,136.4,−82.2,83.3
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PD 50,−83.8,415.2,132.2,−46.3,93.8

02 //Calibrate the robot
03 NT

05 //Define the corners of the palet
10 PL 90, 20
20 PL 91, 21
30 PL 92, 22
40 PL 93, 23

50 //Go to Home position
51 MO 1
52 //Put the speed at 3
53 SP 3

55 //Create the palet
60 PA 9,3,2

70 //Set row an column counter
80 SC 91,1
90 SC 92,1

100 //Start the program here
101 //Go for the convoyor belt
105 GT 300



115 //Routine grab and place
116 MO 1
120 MO 40
130 MO 41,O
140 GC
145 TI 15
150 MO 40,C
151 //Check if it's metal piece
152 MT 50,−50,C
153 MO 50,C
154 TI 15
155 ID
156 TI 15
157 TB −1,700
```

```
159 //Put on the palet
160 MT 50,-50,C
161 MO 1,C
170 PT 9
180 MT 9,-50,C
190 MO 9,C
200 GO
205 TI 5
210 MT 9,-50
220 GT 500



299 //Routine to give a cube with the convoyor
300 OB +1
301 ID
310 TB +2,301
320 OB -1
330 GT 110


449 //Counter Column
500 IC 91
510 CP 91
515 EQ 4,530
520 GT 105

529 //Counter Row
530 SC 91,1
550 IC 92
570 CP 92
575 EQ 3,900
580 GT 105


700 //Put the pice in the garbage
701 MT 50,-50,C
710 MO 1,C
720 MO 60,C
730 MO 61,C
740 GO
750 MO 60
760 MO 1
770 GT 105


900 MO 1
1000 ED
```