

Experiments Steps

1 Automated Solubility with N9

1. The N9 robot picks up a vial from the deck and places it on the on-deck gripper.
2. The N9 robot picks up the vial.
3. The Quantos door opens.
4. The Arduino stepper Motor moves up, in case it is not all the way up already.
5. The N9 robot places the vial inside the quantos.
6. The Quantos measures the weight of the empty vial.
7. The N9 robot removes vial from the Quantos and places it on the on-deck gripper.
8. The Quantos door closes.
9. The N9 robot uncaps the vials and places the cap on the on-deck caper.
10. The N9 robot picks up the vial.
11. The Quantos door opens.
12. The N9 robot places the vial inside the quantos.
13. The Arduino Stepper Motor moves down towards the vial.
14. The Quantos door closes.
15. The Quantos starts the dosing of the solid and records the dosed amount.
16. Once dosing is done, the Arduino Stepper Motor assembled on the handle of the Quantos moves the dosing head up.
17. The Quantos door opens.
18. The N9 robot picks up the vial.
19. The Quantos door closes.
20. The N9 robot places the vial on the on-deck gripper.
21. The N9 caps the vial bac.
22. The N9 robot moves the slider to open position on the vision station : a platform with a camera on the stir plate, where the vial is going to be placed.
23. The N9 robot picks up the vial and places on the magnetic stirrer, inside the vision station.
24. The N9 robot closes the slider.
25. The N9 robot goes to the needle station, picks up the needle and removes the lid. A camera detects whether needle was properly picked up and uncapped. If it is not the case, it will attempt to get a needle again.
26. N9 robot moves to the liquid dosing station, a bank of 10 different solvents.
27. The Tecan Cavro draws a specified volume of the liquid.
28. The N9 robot moves to the vial.
29. The Tecan Cavro dispenses liquid inside the vial.
30. The Magnetic Stirrer starts.
31. The Magnetic Stirrer stirs the mixture of the vial.
32. The camera on the deck takes a picture of the vial to check the turbidity of the solution.
33. The steps from 26 to 32 are repeated until the mixture is dissolved.
34. Once the experiment is done which is determined if the solution dissolved or reached the maximum volume of the vial without dissolution.
35. The N9 robot arm discards the needle.
36. The N9 opens the slider on the vision station.
37. The N9 robot arm picks the vial.
38. The Quantos door opens.
39. The N9 robot places the vial inside.
40. The Quantos measures the weight.
41. The N9 robot picks the vial from Quantos.
42. The N9 robot places the vial solution on the vial tray.

2 Automated Solubility with N9 and UR3e

1. The Quantos Balance checks the solid inside the Quantos and compares with the solid name specified by the user in the script.
2. If it is different from the one that is required for the experiment, the solid is replaced with the one mentioned by the user in the script.
3. To replace the solid, the Arduino Stepper Motor moves down bringing the Quantos dosing gun with it so it is reachable by the arm.
4. The UR3e robot moves to the Quantos.
5. UR3e robot removes the solid tube from the Quantos dosing gun and places it to the on-wall positions of the tubes.
6. UR3e robot picks up the correct one from the on-wall position and moves towards the Quantos.
7. UR3e robot fixes the correct solid tube on the Quantos.
8. The Arduino Stepper Motor moves back up.
9. The N9 robot picks up a vial from the deck and places it on the on-deck gripper.
10. The N9 robot picks up the vial.
11. The Quantos door opens.
12. The Arduino stepper Motor moves up, in case it is not all the way up already.
13. The N9 robot places the vial inside the quantos.
14. The Quantos measures the weight of the empty vial.
15. The N9 robot removes vial from the Quantos and places it on the on-deck gripper.
16. The Quantos door closes.
17. The N9 robot uncaps the vials and places the cap on the on-deck caper.
18. The N9 robot picks up the vial.
19. The Quantos door opens.
20. The N9 robot places the vial inside the quantos.
21. The Arduino Stepper Motor moves down towards the vial.
22. The Quantos door closes.
23. The Quantos starts the dosing of the solid and records the dosed amount.
24. Once dosing is done, the Arduino Stepper Motor assembled on the handle of the Quantos moves the dosing head up.
25. The Quantos door opens.
26. The N9 robot picks up the vial.
27. The Quantos door closes.
28. The N9 robot places the vial on the on-deck gripper.
29. The N9 caps the vial bac.
30. The N9 robot moves the slider to open position on the vision station : a platform with a camera on the stir plate, where the vial is going to be placed.
31. The N9 robot picks up the vial and places on the magnetic stirrer, inside the vision station.
32. The N9 robot closes the slider.
33. The N9 robot goes to the needle station, picks up the needle and removes the lid. A camera detects whether needle was properly picked up and uncapped. If it is not the case, it will attempt to get a needle again.
34. N9 robot moves to the liquid dosing station, a bank of 10 different solvents.
35. The Tecan Cavro draws a specified volume of the liquid.
36. The N9 robot moves to the vial.
37. The Tecan Cavro dispenses liquid inside the vial.
38. The Magnetic Stirrer starts.
39. The Magnetic Stirrer stirs the mixture of the vial.
40. The camera on the deck takes a picture of the vial to check the turbidity of the solution.
41. The steps from 34 to 40 are repeated until the mixture is dissolved.

42. Once the experiment is done which is determined if the solution dissolved or reached the maximum volume of the vial without dissolution.
43. The N9 robot arm discards the needle.
44. The N9 opens the slider on the vision station.
45. The N9 robot arm picks the vial.
46. The Quantos door opens.
47. The N9 robot places the vial inside.
48. The Quantos measures the weight.
49. The N9 robot picks the vial from Quantos.
50. The N9 robot places the vial solution on the vial tray.

3 Crystal Solubility Profiling

1. The N9 Arm picks up a tube with a filter from the deck and opens its cap.
2. The N9 Arm removes the filter from the tube and puts the filter in the filter holder.
3. The N9 robot picks up the tube.
4. The Quantos door opens.
5. The N9 robot places it inside the quantos.
6. The Arduino Stepper Motor moves the dosing head down.
7. The Quantos door closes.
8. The Quantos starts dosing of the solid and records the dosed amount.
9. Once dosing is done, Arduino Stepper Motor moves the dosing head up.
10. The Quantos door opens.
11. The N9 Arm picks up the tube and moves out of Quantos.
12. The Quantos door closes.
13. The N9 Arm places the tube in vial tray, removes filter from holder and places the filter in tube
14. The N9 Arm goes to the needle station, picks up the needle and removes the lid.
15. The N9 Arm moves to the liquid dosing station.
16. The Tecan Cavro pumps the liquid.
17. The N9 Arm moves to the tube.
18. The Tecan Cavro dispenses liquid inside the tube.
19. The N9 Arm closes the tube cap and transfers it to the Magnetic Stirrer.
20. The Magnetic Stirrer stirs the solution.
21. The N9 Arm picks up the tube and puts it on the mini tube tray.
22. The N9 Arm moves away.
23. The UR3e Arm picks up the cap of the centrifuge and places the cap on the deck.
24. The camera checks the centrifuge position.
25. The UR3e Arm picks up a rod, adjusts centrifuge position and places the rod back.
26. The UR3e Arm then picks up the vial and puts it inside the centrifuge.
27. The Centrifuge then puts the cap back.
28. The Centrifuge is started to filter the solid from liquid.
29. Once this is done, the UR3e Arm picks up the cap and places it on the deck.
30. The Camera checks the centrifuge position, picks up the rod, adjusts centrifuge position and places the rod back.
31. The UR3e Arm picks up the tube from the Centrifuge and places it on the station.
32. The UR3e Arm places the cap back.
33. The N9 Arm picks up the tube, opens the tube cap and sends the tube to the vial tray.
34. The N9 Arm picks up the new tube from the tube tray and uncaps the new tube.
35. The N9 removes the filter from the old tube, sends the filter to the new tube.
36. The steps are repeated for the filter (steps 14 to 35) depending on the specified number of filter washes.

4 Joystick

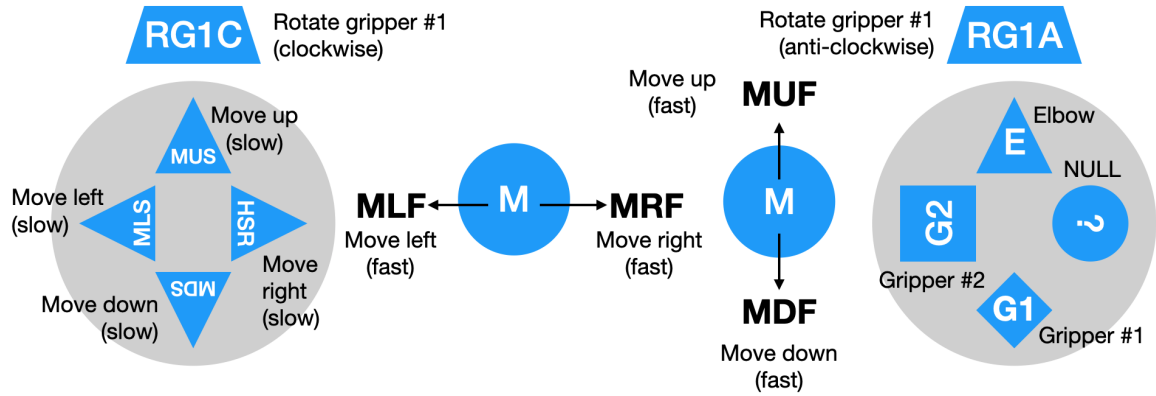


Figure 1: Mapping between joystick buttons and N9 actions

Fig. 1 illustrates the different actions for which the joystick buttons are programmed. Table 1 shows six experiments that were performed using Joystick in two modes on the middlebox: DIRECT or REMOTE. The DIRECT mode is used to collect the tracing data whereas the REMOTE mode is used to collect the tracing data along with sending the commands to the robots.

Name	Experiment Steps
EXP1	Start by moving the arm up and down using MDF and MUF. Repeatedly move the arm left and right by pressing MLF and MRF.
EXP2	Bring the arm to a valid position. Repeatedly move the arm up and down using MDF and MUF. Repeatedly open and close both grippers using G2 and G1.
EXP3	Move arm very slowly to the left using MLS. Move arm very slowly to the right using MRS.
EXP4	Move arm very slowly upward using MUS. Move arm very slowly downward using MDS. Repeatedly toggle the elbow position using E. Adjust the arm slightly using MLF and MRF. Repeatedly toggle the elbow position using E.
EXP5	Move arm near the vial. Pick the vial using gripper and take it to the on-deck gripper. Open the arm gripper, let the vial fall, close the on-deck gripper. Few more things.
EXP6	Rotate arm gripper clockwise for some time using RG1C. Rotate arm gripper anti-clockwise for some time using RG1A. Close the arm gripper using G1. Rotate arm gripper clockwise for some time using RG1C. Rotate arm gripper anti-clockwise for some time using RG1A.

Table 1: Joystick Experiments