UR5 Robot Quick Start Guide

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Campus: HAW
Building: EN – Robotics Lab EN212

Safety Signage

	**Covered footwear required**	**-**	**Robot to be used by trained operators only**	**-**	**-**

***CAUTION**: The moving robot arm and gripper are a hazard to the operator and observers. The door of the safety cage must be closed during operation. Personnel must not be within the safety cage when the robot is in operation.*

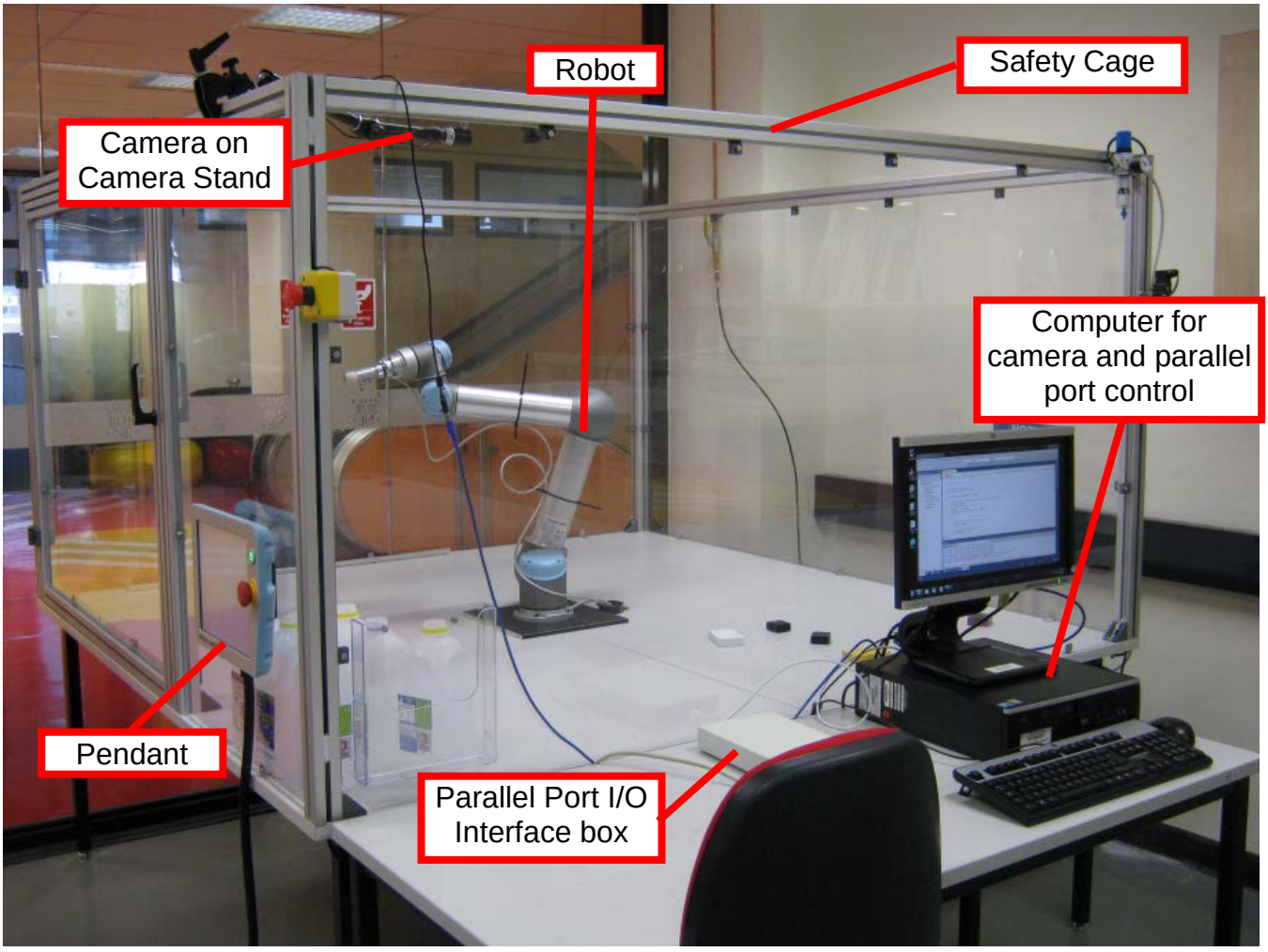

Figure 1 The robot workstation

UR5 Robot Operation

Equipment (see Figure 1 and Figure 2)

- **Controller** – large grey box located under the robot table. Used to power and control the robot.
- **Pendant** – Interface that allows the user to interact with and program the robot.
- **Robot** – a six axis UR5 robot that is fixed to the bench.
- **Computer for Camera and Parallel Port Control** – the computer is located on the desk next to the robot safety cage. The computer can control the camera and the parallel port using C++ code that is provided to students.
- **I/O Interface Box** – the box is located next to the computer that controls this device. It displays the output to the parallel port and can be used for debugging.
- **Camera** – the camera is mounted on an arm on the robot safety cage and is situated to monitor the table in the cage. It can be controlled through software provided to students.
- **Safety Cage** – the robot is located in the safety cage. The safety cage provides a barrier between the operating robot and any observers. There is a lock-out switch located on the door so that the robot cannot operate if the door is open.

Figure 2 The robot – it is fixed to the bench and has six axes of movement.

Emergency Stop – Safety Information

1. In case of emergency, an emergency stop button must be pressed. The emergency stop button is the red button on the robot pendant. There is also an emergency stop button on the safety cage next to the safety cage door. In addition to this, opening the door of the safety cage will trigger the emergency stop in the form of a lock-out.

2. When the emergency stop button has been pressed or the door of the safety cage has been opened, an error message will appear on the pendant screen notifying the user.

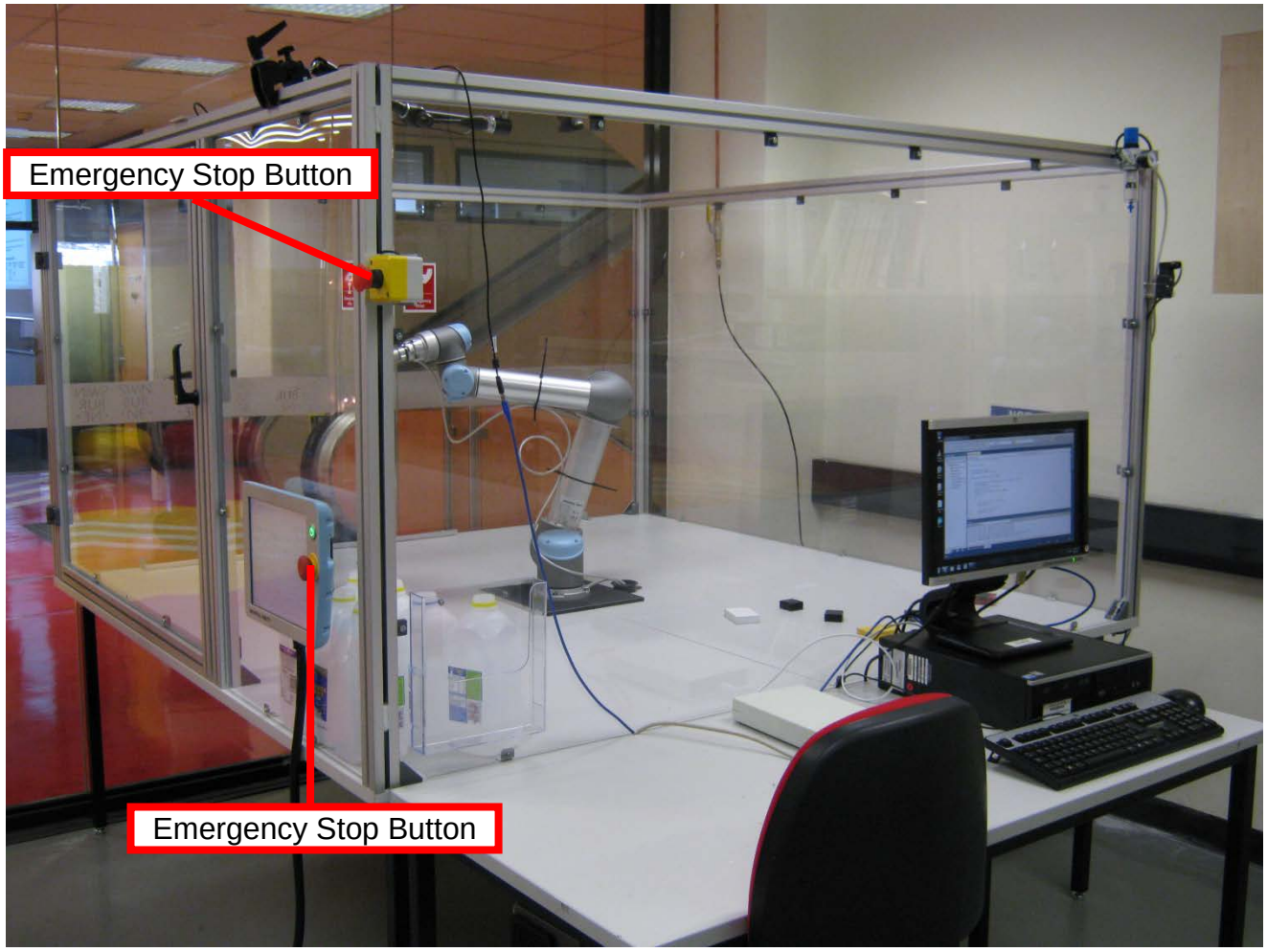

Figure 3 The emergency stop button is the red button on the robot controller and the red button on the side of the safety cage next to the door.

3. Once the danger has passed each emergency stop button may be released by turning the emergency stop button. When the door is closed the lock-out switch will be reset.

Set up the equipment

1. Ensure that the controller and computer connection to main power supply is secure and tight.
2. Verify that all cables are correctly and securely connected.
3. Check that there are no unwanted obstacles in the robot's workspace.
4. Turn on the computer for camera/parallel port control (EN212-006) and log on.
5. Turn on the power to the robot. The button is located on the front of the robot pendant above the E-stop (see Figure 4).

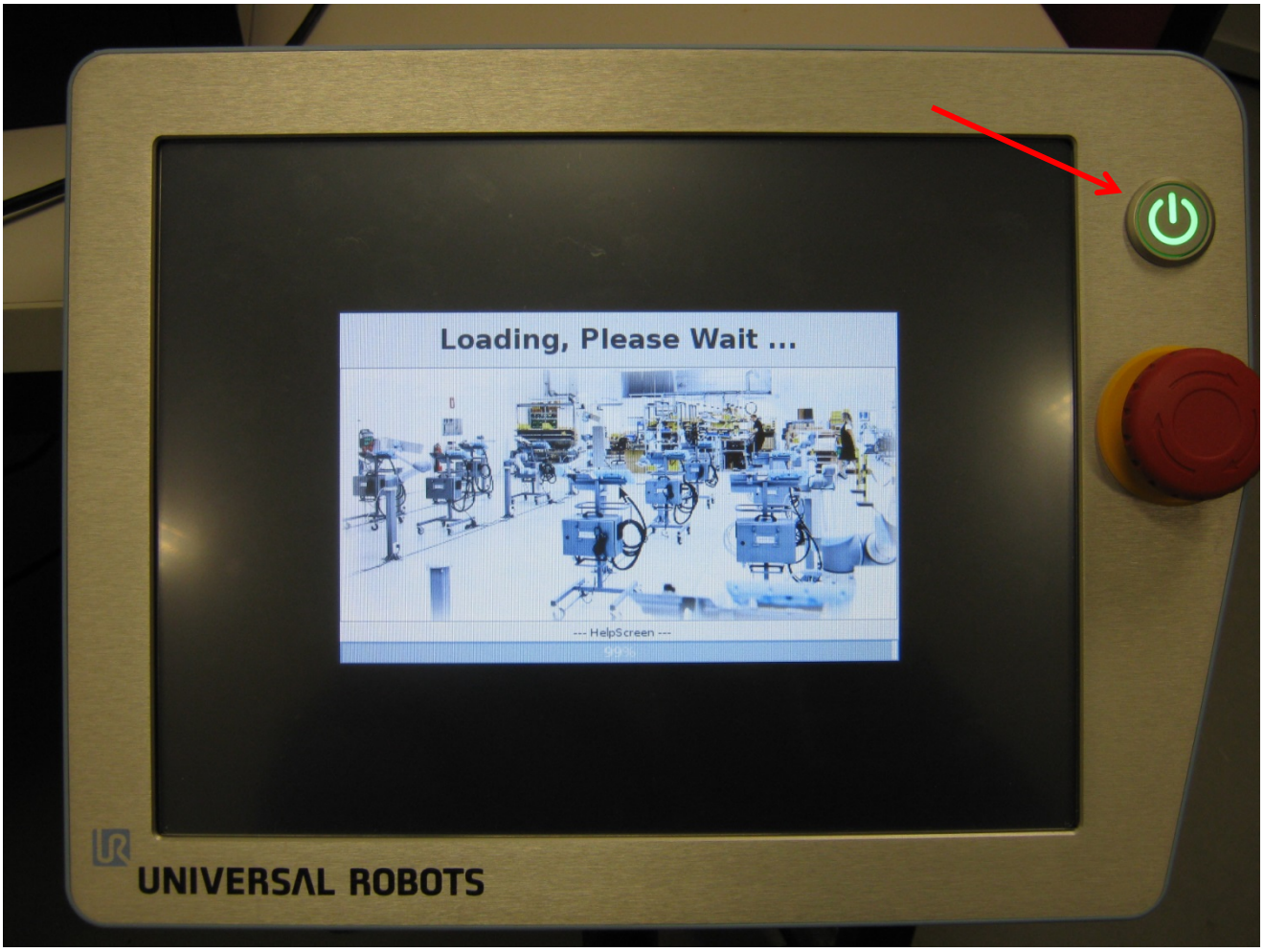

Figure 4 The pendant with the power button shown.

6. Ensure that all emergency stop devices are operating correctly.

7. On the pendant a warning message will be displayed (Figure 5). Press the “To Initalization Screen” button.

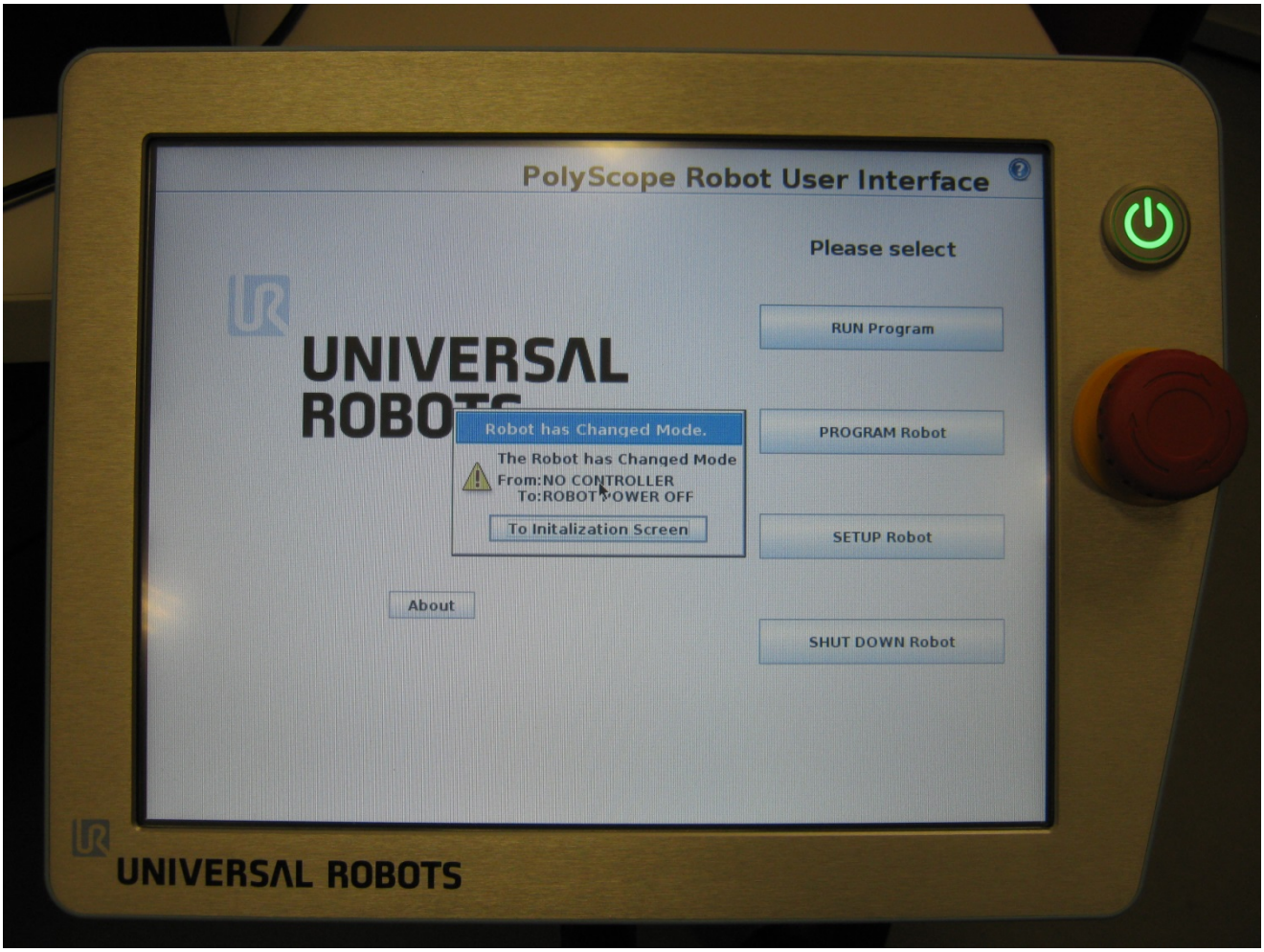

Figure 5 Warning message when robot is first started.

8. The robot does not remember its position when shut down. As such it must be initialised. The first step is to supply power to the robot. Press the “On” button at the top of the Initialise Robot screen (Figure 6). The green indictor button next to “Robot Power” on the pendant screen will illuminate.

9. **Read this entire instruction before beginning the initialisation step.** The robot can be initialised by using a predefined program or by moving each of the joints individually. You may wish to move each joint individually if the robot is an awkward position and is likely to crash into an external object or itself, otherwise using the predefined program is fine. To initialise the robot using the predefined function press the “Auto” button next to “Robot” (Figure 6) keeping your finger on the button. Watch the robot closely as it initialises to check for any collisions. The robot will move each axis individually. If at any time during initialisation the robot looks likely to collide with itself or another object, release the button that you are pressing to stop the robot. If you press the button again the robot will rotate in the direction opposite to the previous direction – this way you can avoid a collision. If you wish to manually initialise the robot you can initialise each joint individually by clicking the Auto button or the arrow buttons associated with each joint (Figure 6).

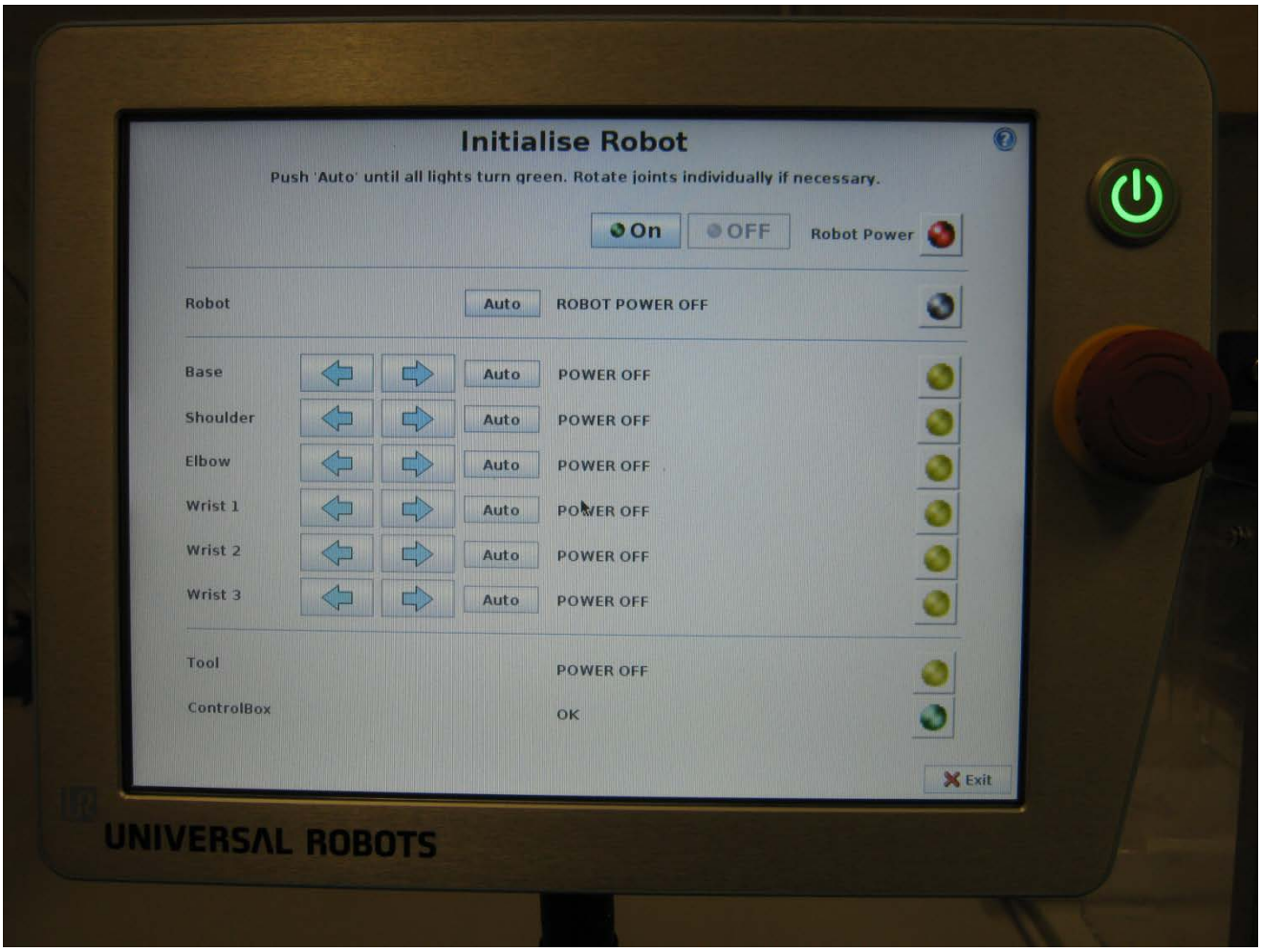

Figure 6 The Initialise Robot screen.

10. Once the robot is initialised all of the joints will have OK written beside them (Figure 7). Press the OK button at the bottom of the screen.

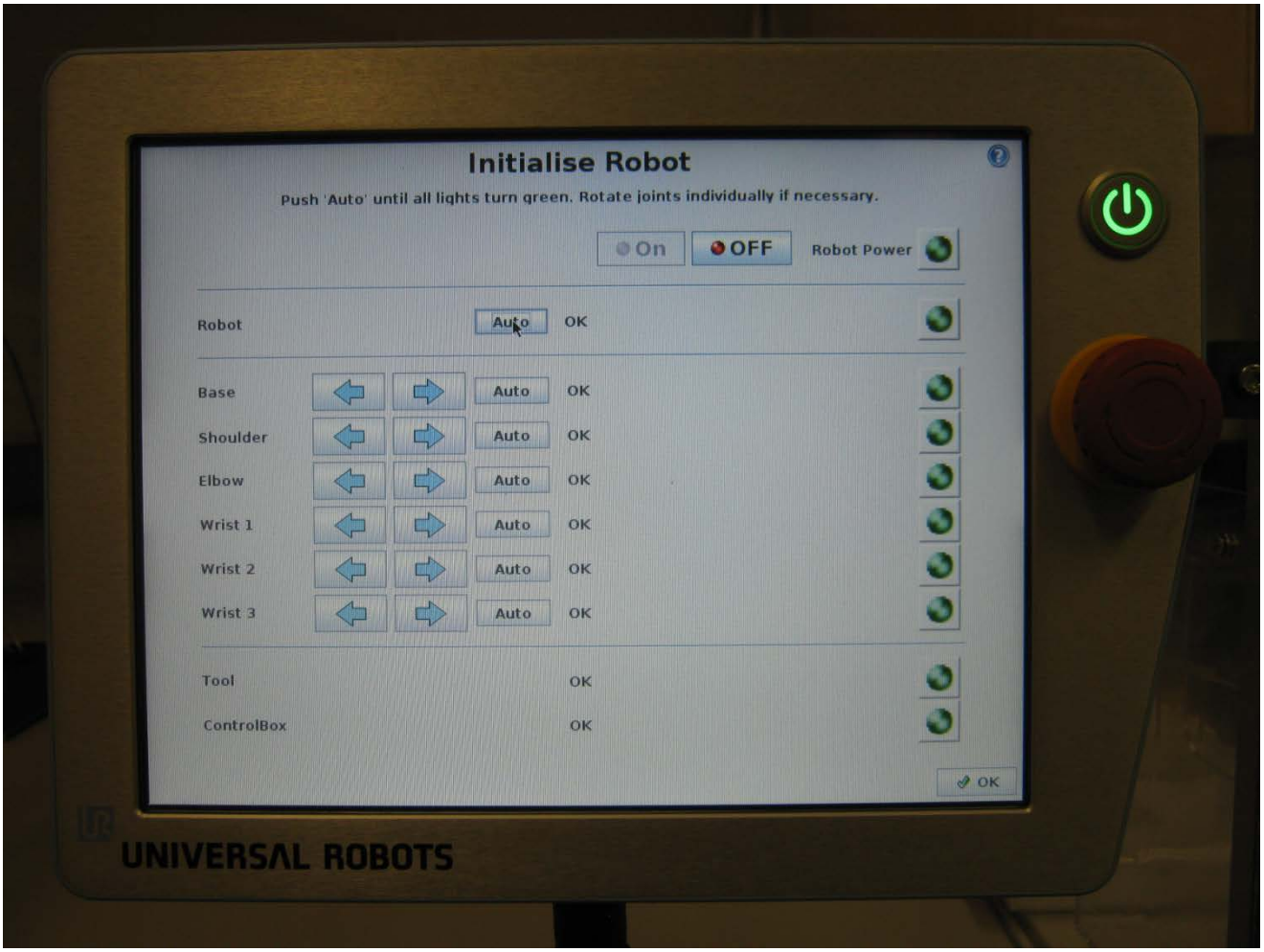

Figure 7 Initialisation is complete

11. The pendant will now show the Welcome screen.

Basic Software Operation

1. To program the robot press the “PROGRAM Robot” button on the Welcome screen (Figure 8).

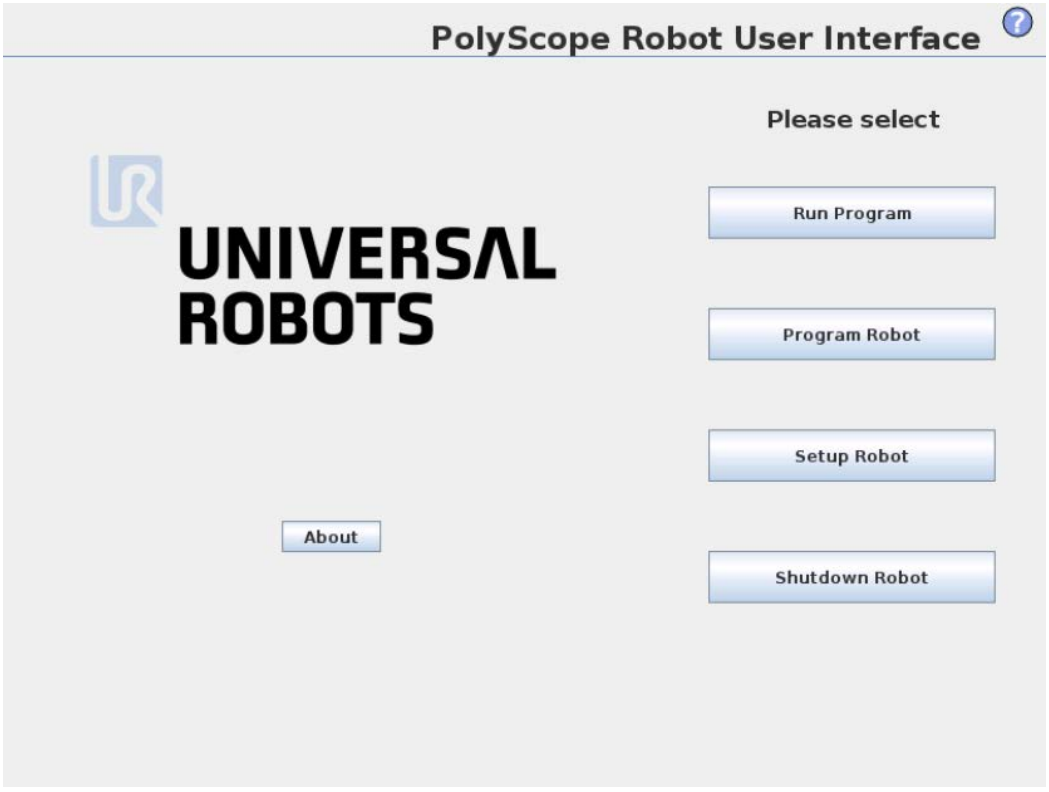

Figure 8 UR5 Welcome screen

2. You will then be asked to load a program, use a predefined program template, or use an empty program (Figure 9). Press the “Empty Program” button.

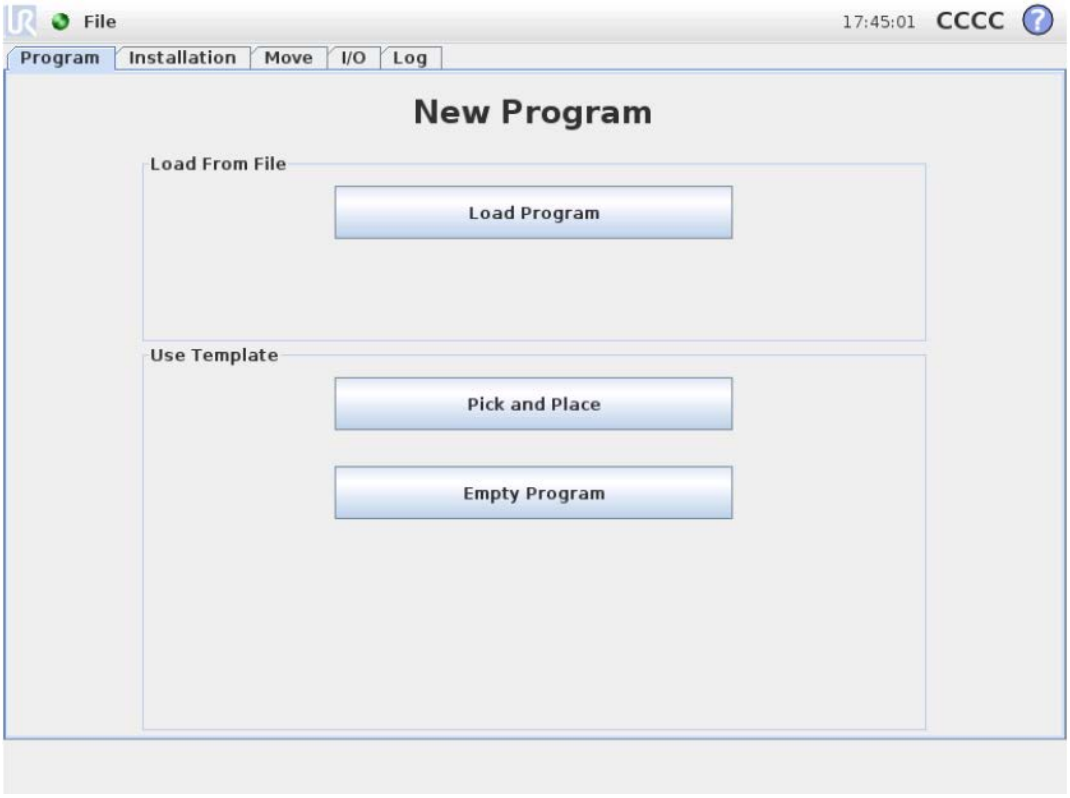

Figure 9 New program screen

3. You will now be taken to the Command tab of an empty program (Figure 10). The left hand panel contains the instructions of our program (currently empty).We will write a simple program of picking up an imaginary object and moving it to another location. The first position is the start position of the robot. The second position is where the robot can pick up the object if the gripper was engaged. The third position is the end position of the robot.

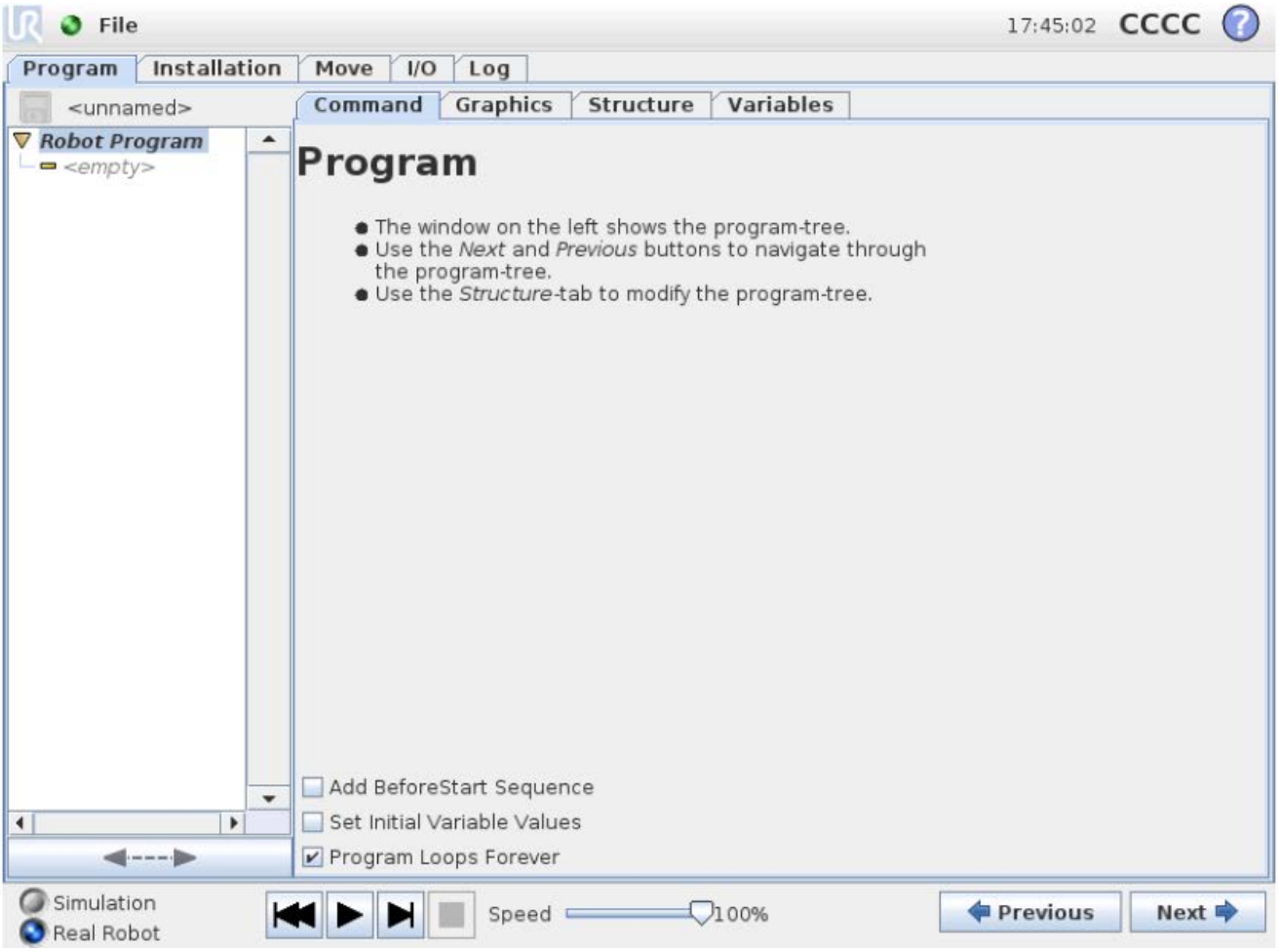

Figure 10 Command tab of a program

4. Press the “Structure’ tab. The following screen will appear (Figure 11).

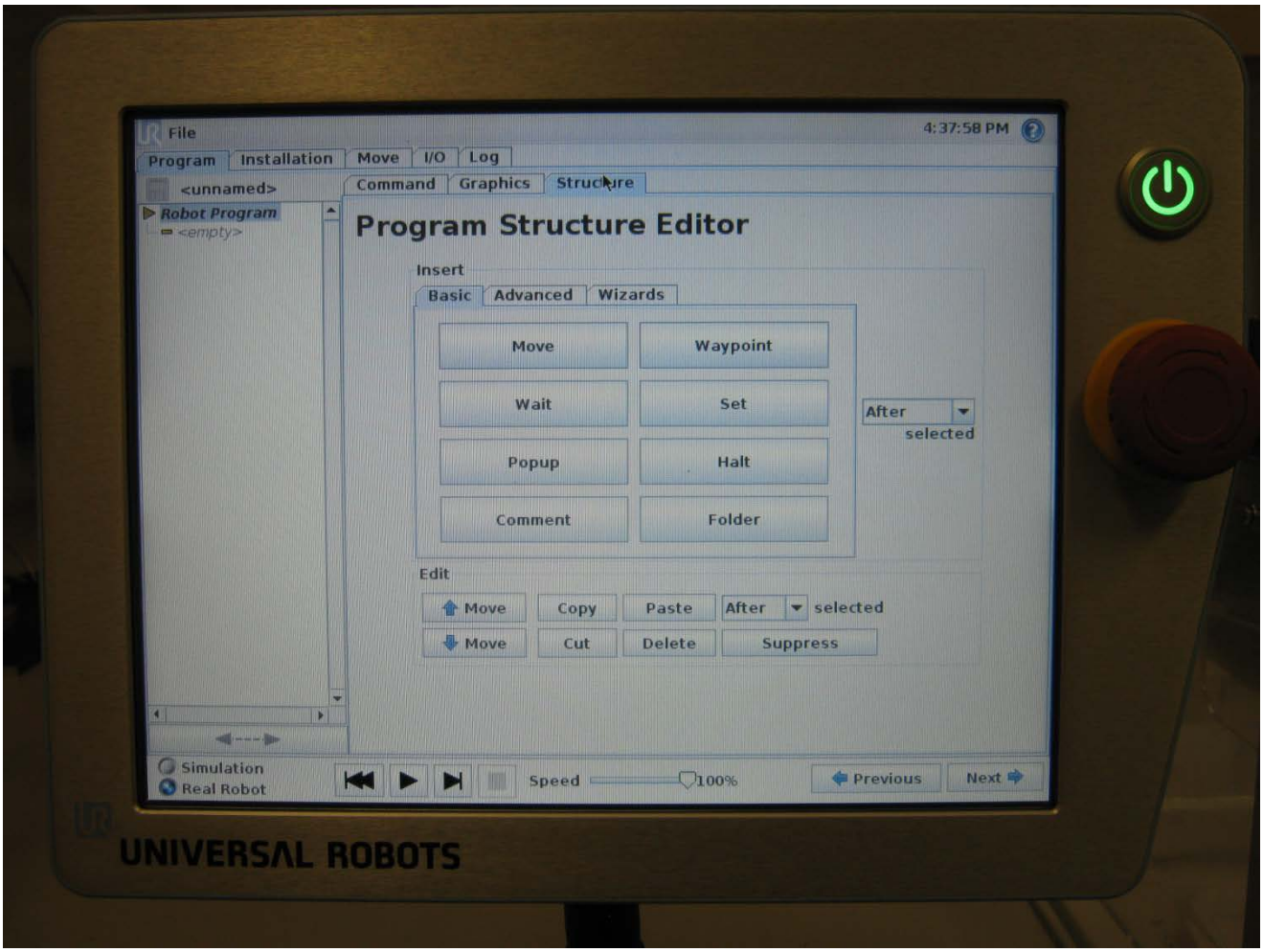

Figure 11 The Program Structure tab

5. Most of our commands will be associated with a Move command, so we will include a “Move”. Press the “Move” button to include the move command. You will notice that “MoveJ” and “Waypoint” has appeared in the list of instructions in the left hand panel (Figure 12). You will also notice that the arrows and circles before the MoveJ and Waypoint instructions are yellow. The yellow colour indicates that the instructions are incomplete and need more information.

6. In the list of instructions in the left hand side panel press “Waypoint” to select it, then click on the Command tab. The following screen will appear (Figure 12).

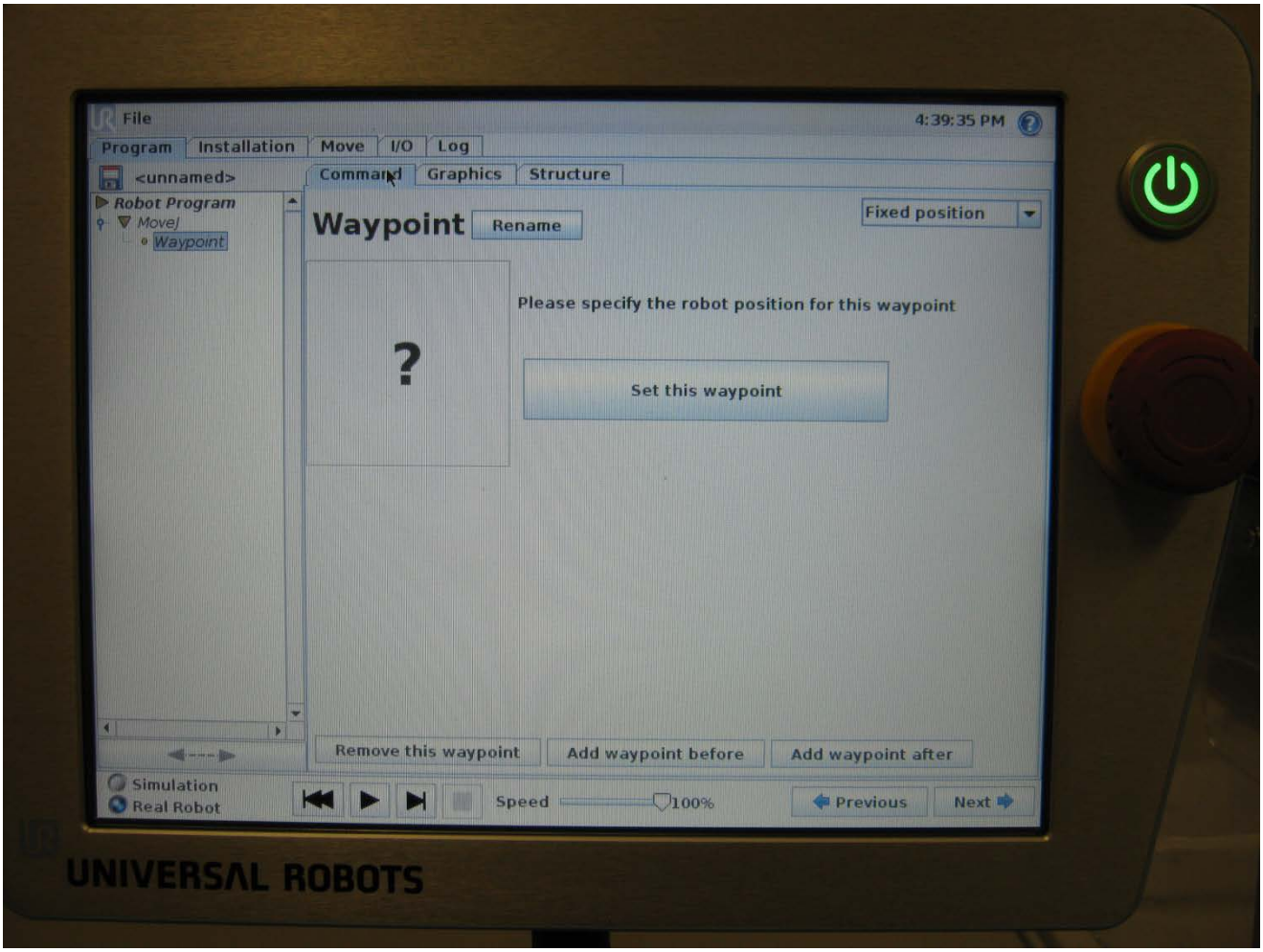

Figure 12 The Command tab for a waypoint

7. On this screen you can rename the waypoint and set the position of the waypoint. To set the position press the “Set this waypoint” button. The Move screen in Figure 13 will appear.

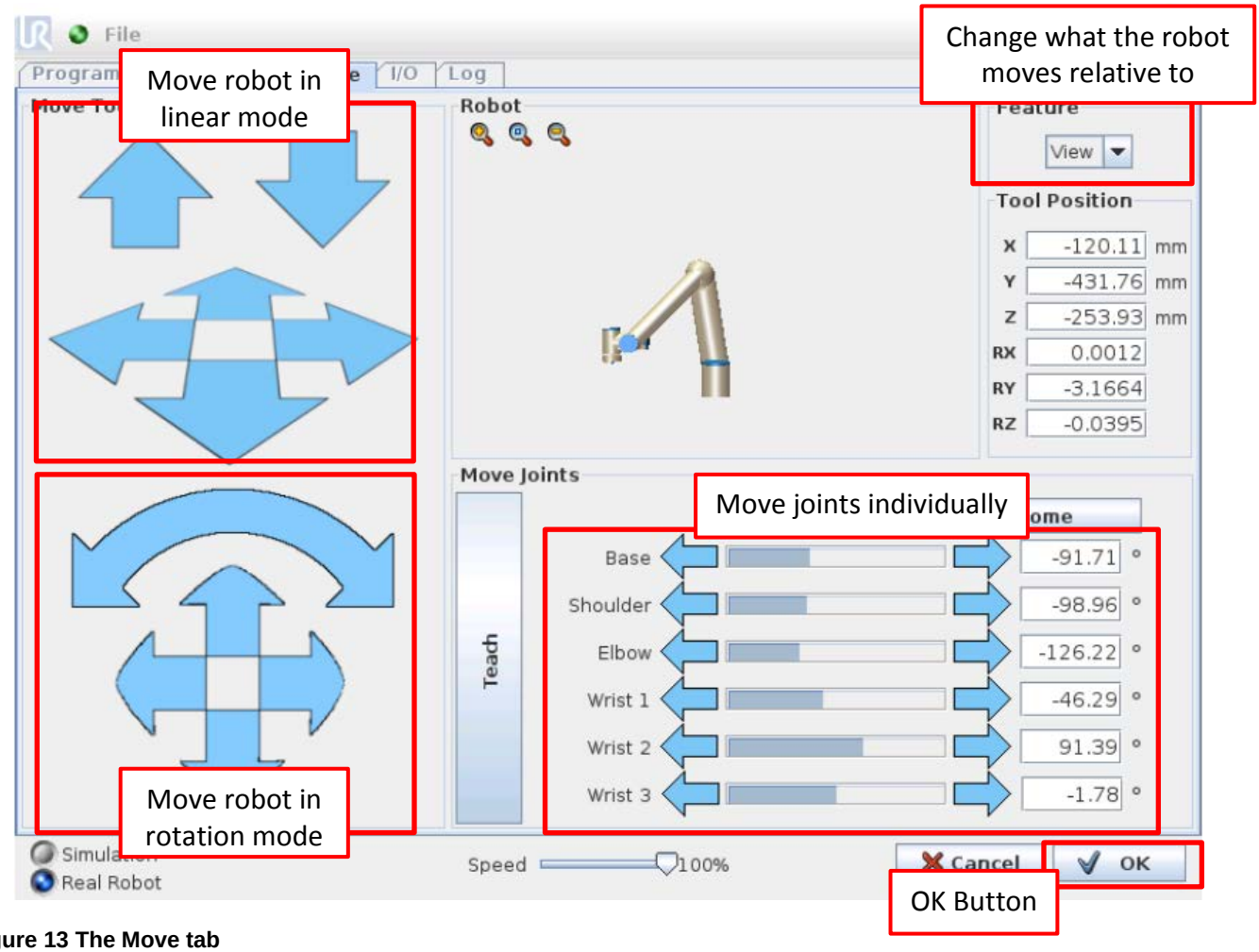

Figure 13 The Move tab

8. There are several ways of moving the robot (see Figure 13).

   a. The top left arrows will move the robot in linear mode, that is, when the robot moves it will move in a straight line

   b. The bottom left arrows move the robot in rotation mode, it will rotate the robot about the head of the robot

   c. The bottom right arrows will move the robot by individual joints

9. The top right box “Feature” (see Figure 13) has three options, “View”, “Base” and “Tool”. Selecting these will change how the left hand arrows affect the robot. For example when using “Tool” mode, the linear arrows will be relative to the direction of the tool tip, so pressing the up arrow will have the robot move along the axis of the tool. The viewpoint also changes how the robot displayed on the screen is shown, for instance pressing ”Tool” will show the robot tool.

10. Move the robot into the first position. Once it is in the correct location press the “OK” button in the lower right hand corner (Figure 13). You have now recorded the first position, notice that the list of instructions on the left hand side now has all green arrows and circles.

11. We can now add another waypoint, in this case the pick-up position of the robot. Press the “Add waypoint after” button at the bottom right hand corner of the screen (see Figure 12). Follow steps 7 to 10 to set the next position.

12. We now want to expand the bellows gripper to pick up the object. To do this press the “Structure” tab and press the “Set” button (see Figure 11), then go to the “Command” tab. A screen similar to Figure 14 will be shown.

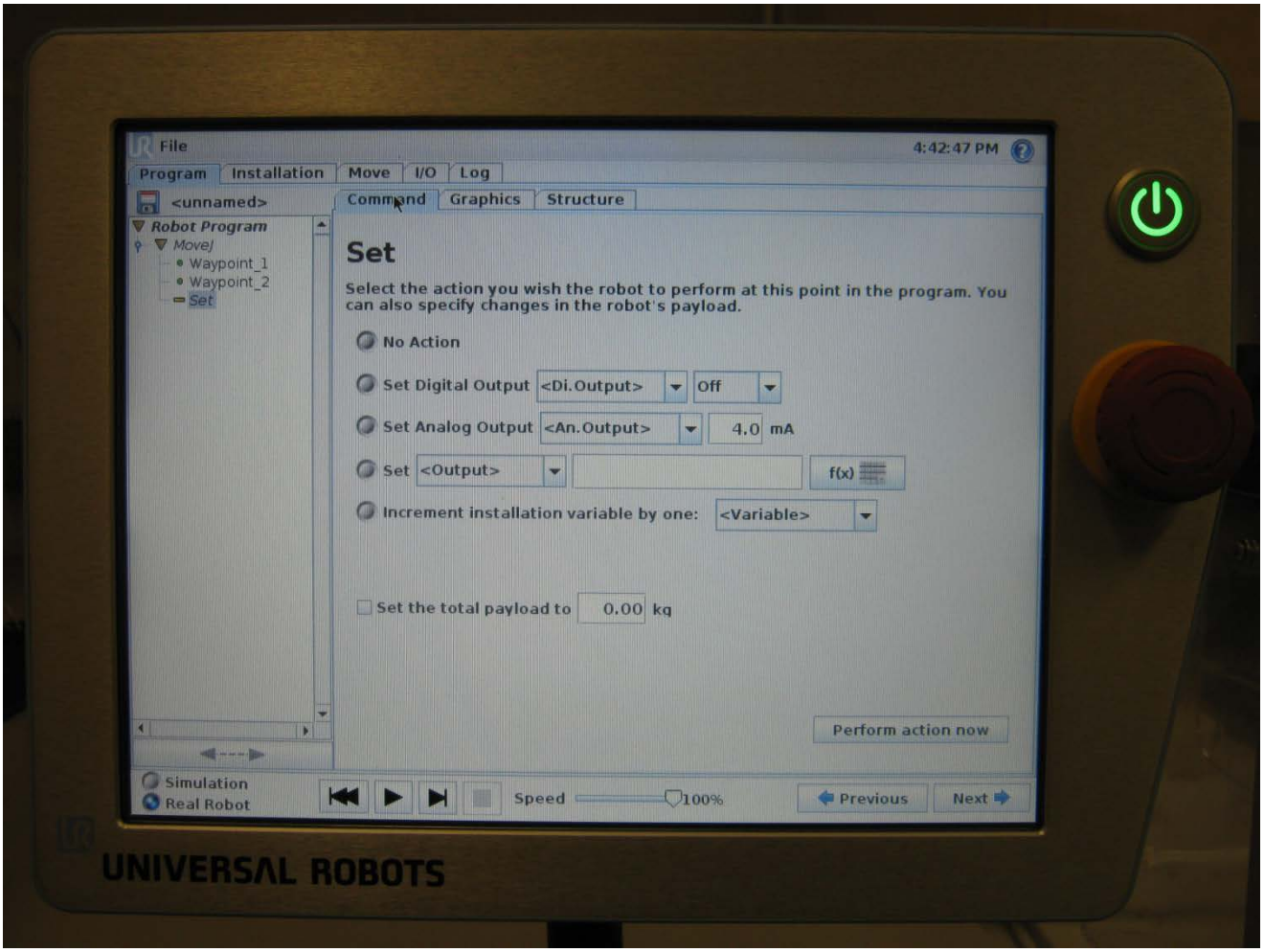

Figure 14 The Command tab for the Set function

13. Select the radio button next to Set Digital Output, select “digital_out[0]” from the first drop down menu and select “On” from the second drop down menu (or “Off” to release the gripper). Press the “Next” button in the bottom right hand corner.

14. Whenever the gripper is set, it is important to include a short “Wait” command to allow the gripper time to turn on or off before the next command. To include a wait command, select the last item in the list of instructions, and then press the “Structure” tab. Press the “Wait” button. You’ll notice that a “Wait” instruction has been added to the instruction list.

15. Press the “Command” tab and then select the radio button next to “Wait” and set the text box to 0.5 seconds. Then press the “Next” button in the bottom right hand corner.

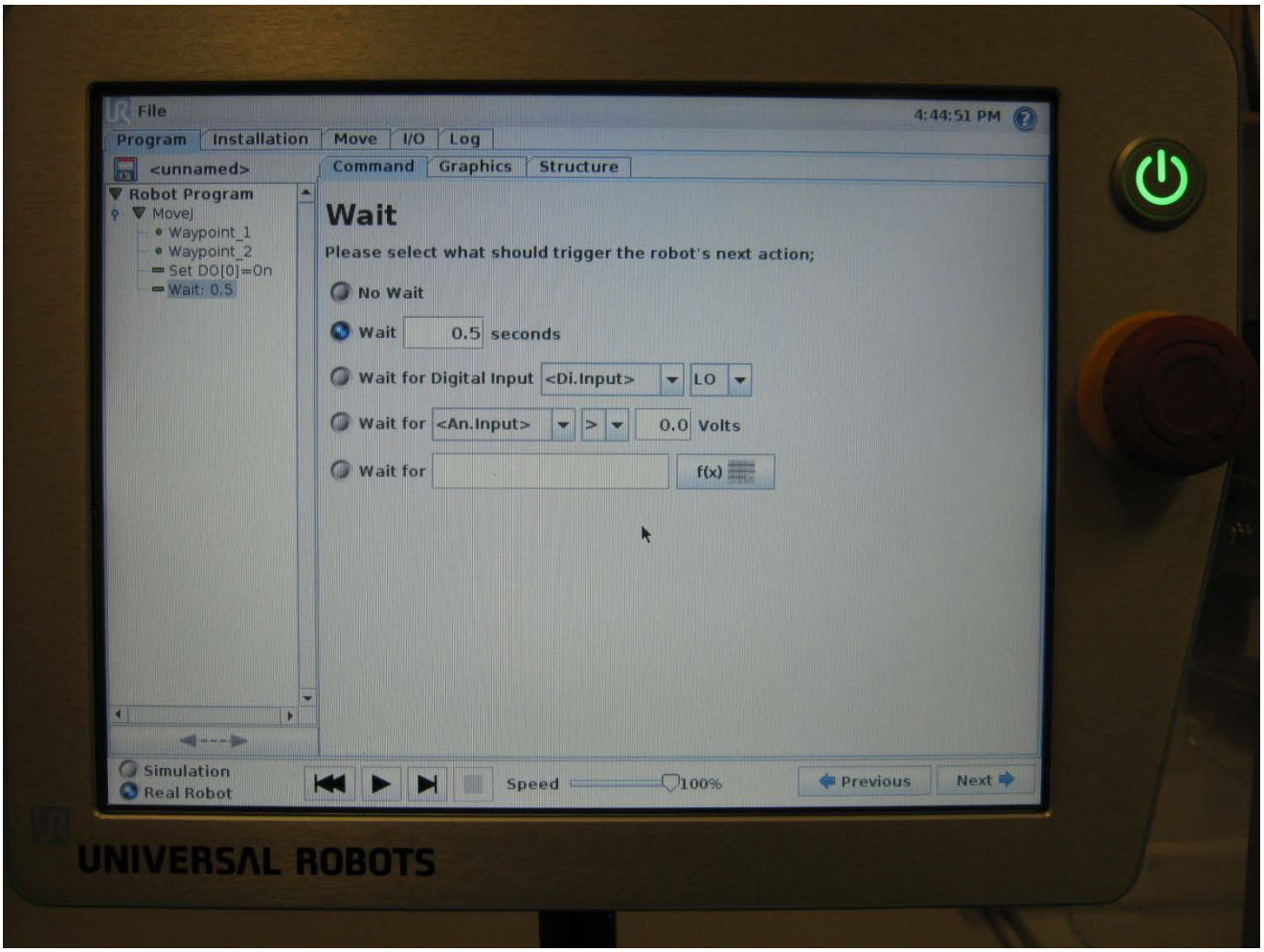

Figure 15 The Command tab for the Wait function

16. Finally we need to robot to move to the drop off location. Click the last command in your list of instructions to include the next step in the correct location. Highlight the last instruction in the list. Click the Structure tab and then click the Waypoint button. Select the Command tab and follow steps 7 to 10 to include the next waypoint.

17. Follow steps 12 to 15 to turn the gripper off.

18. You should have a program that looks similar to the one in Figure 16.

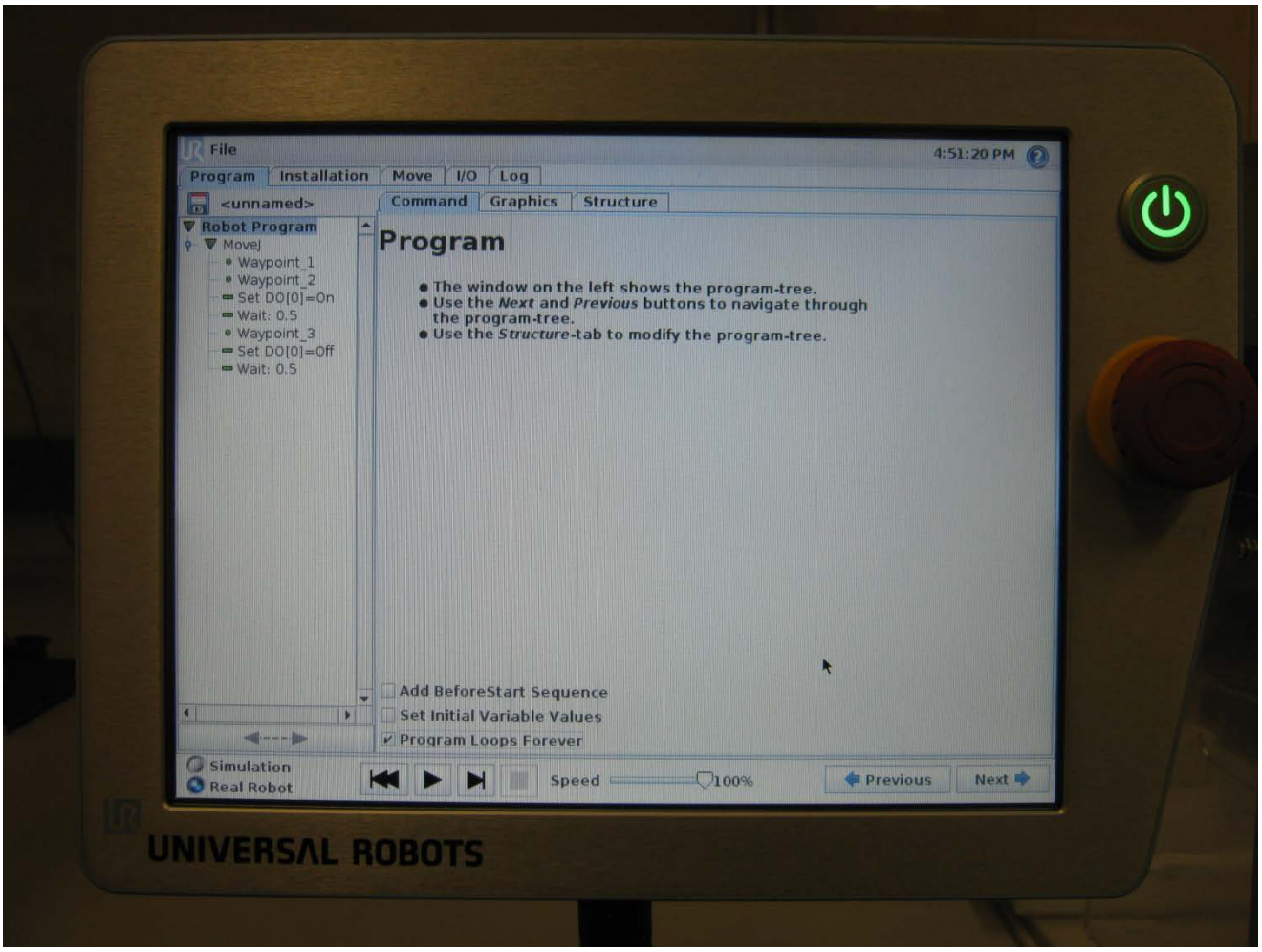

Figure 16 The Command tab for the Robot Program with a completed program

19. We can now run the program. To do this press the run (right pointing arrow) button at the bottom of the screen. The screen in Figure 17 may appear.

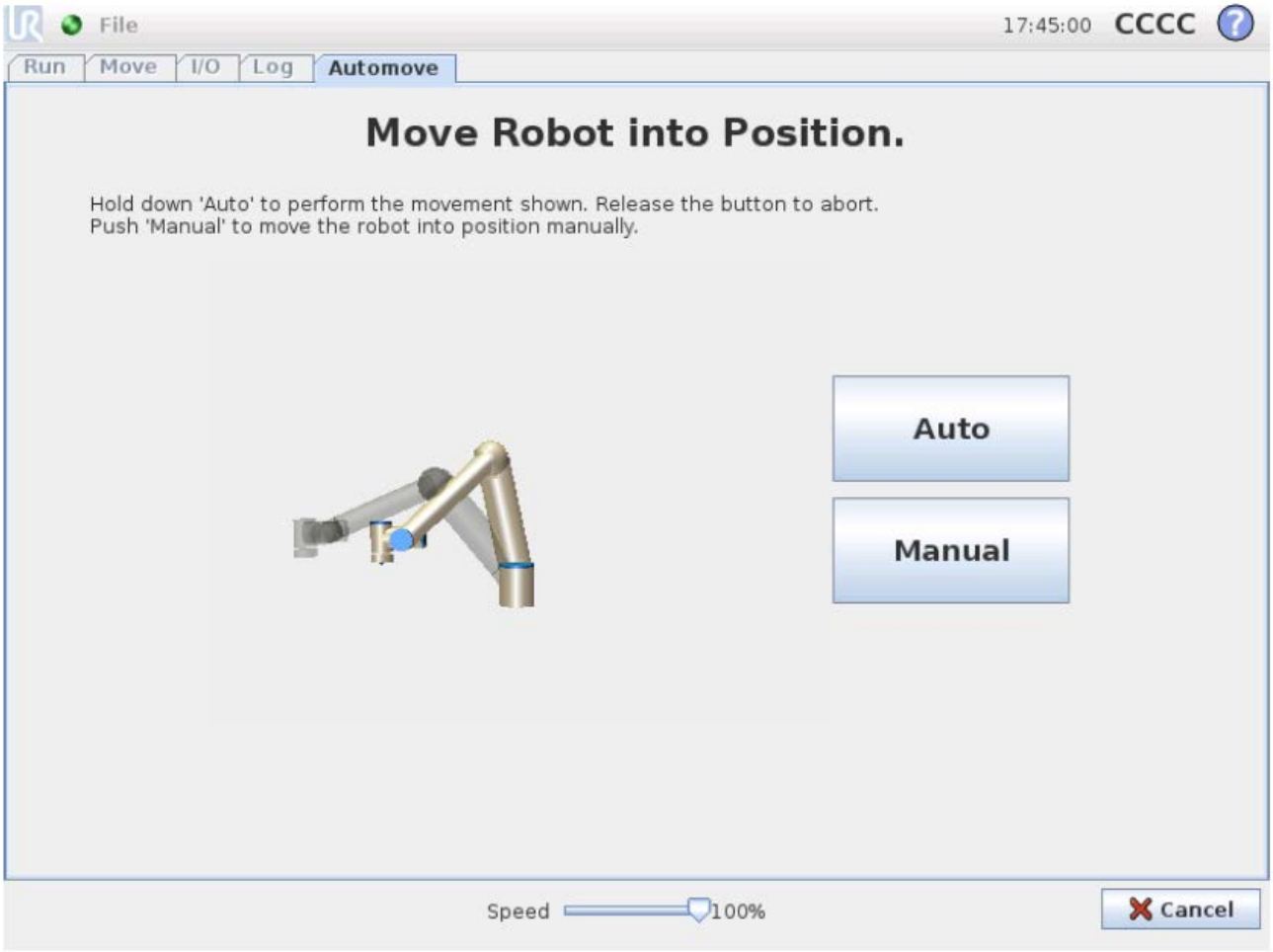

Figure 17 The AutoMove tab

20. The robot needs to be moved to the first position of the program. Press and hold the “Auto” button until the robot is in the first position and the “Auto” button greys out. Press the OK button at the bottom right hand corner of the screen

21. Press the run button again and the robot should execute your program. It will execute the movement repeatedly. Press the Stop button to stop the robot.

22. To have the robot execute the command only once, select “Robot Program” from the program in the left hand panel (see Figure 16). Then press the Command tab.

23. Uncheck the “Program Loops Forever” box.

24. Additional functions are available under the “Structure” tab in the “Basic” and “Advanced” tabs. Information about these functions can be found in the UR5 User Manual.

Controlling and Communicating with the I/O Interface Box

1. The parallel port is controlled by the computer named EN212-006.
2. Plug the USB cable from the computer into the I/O Interface Box.
3. A program (RobotComms.zip) for using the I/O Interface Box is available for use. It will be provided to students on Blackboard.
4. Open the RobotComms project file (RobotComms.sln) in Microsoft Visual Studio.
5. In the Solution Explorer window, expand the Source Files folder and double click on RobotComms.cpp to open it.
6. Go to line 14 and check that the COM port specified is the correct. You can determine which COM port to specify by checking the Device Manager in the Control Panel. The COM port will be associated with either Arduino UNO or USB Serial Port.
7. Go to line 22 (texBufArray[0] = 255;). Replace the 255 with the number that you wish to send to the interface box (and hence the robot).
8. Build the project using the Build RobotComms option on the Build menu.
9. Once it is compiled, run the program by clicking the Run button.
10. If it has carried out the command correctly, the binary form of the number you entered will appear on the display of the I/O Interface Box (Figure 18).
11. If the robot controller is on and the parallel port is connected to the inputs, the binary form of your number will also be displayed on the input display (Figure 18).

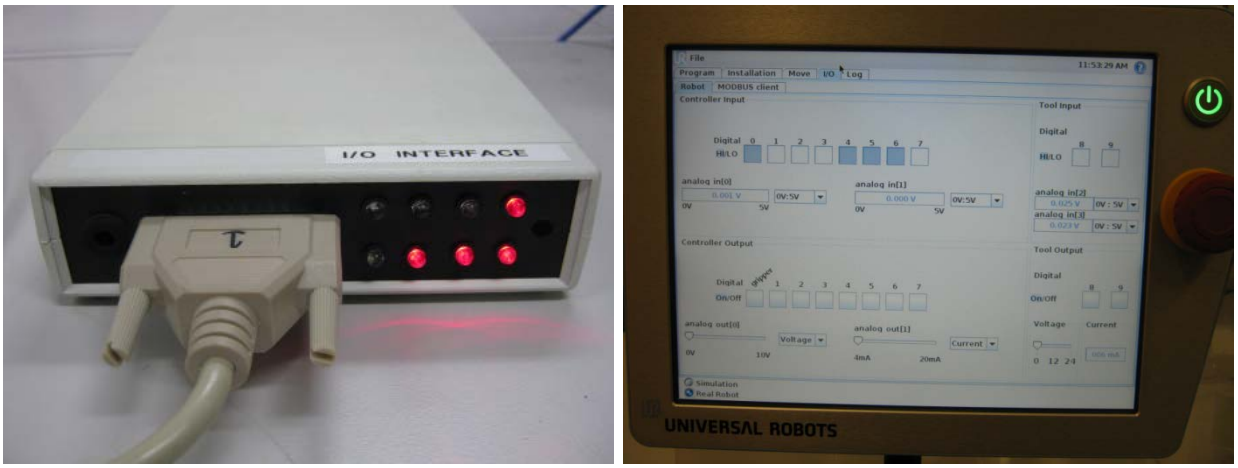

Figure 18 The Parallel Port I/O Interface box showing the number 113 and the robot controller showing the number 113 on the inputs

Using the Camera

1. The camera is controlled by the computer named EN212-006 positioned on the table next to the UR5 robot.

2. The camera is operated using a program developed with OpenCV software. This program is available to student on Blackboard. Download the “Camera Software” file for the UR5 robot.

3. To use it open a new project in Microsoft Visual Studio 2010.

4. In the new project window (see Figure 19) select “Win32 Console Application” and provide a name and location for your project. Then Click OK.

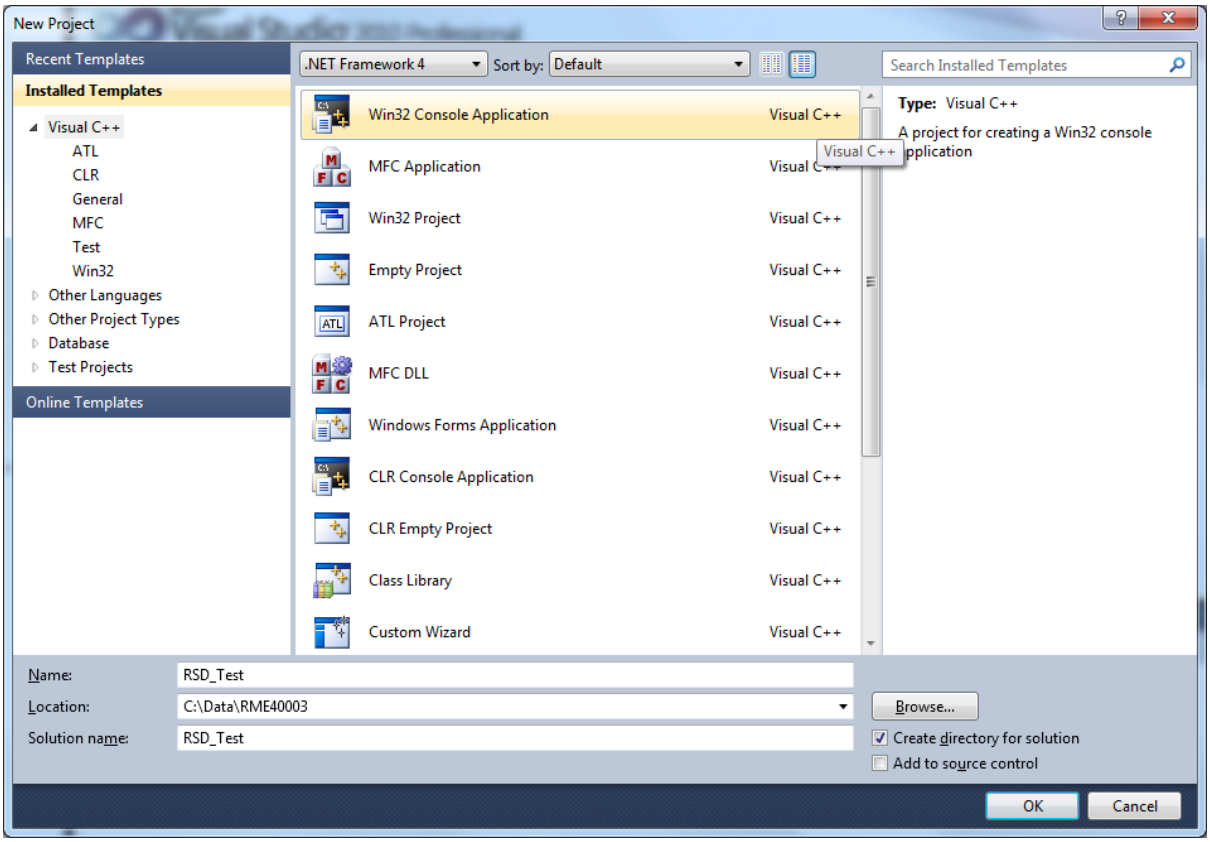

Figure 19 The new project window

5. The Project Wizard will start. Click “Next” on the first screen (Figure 20).

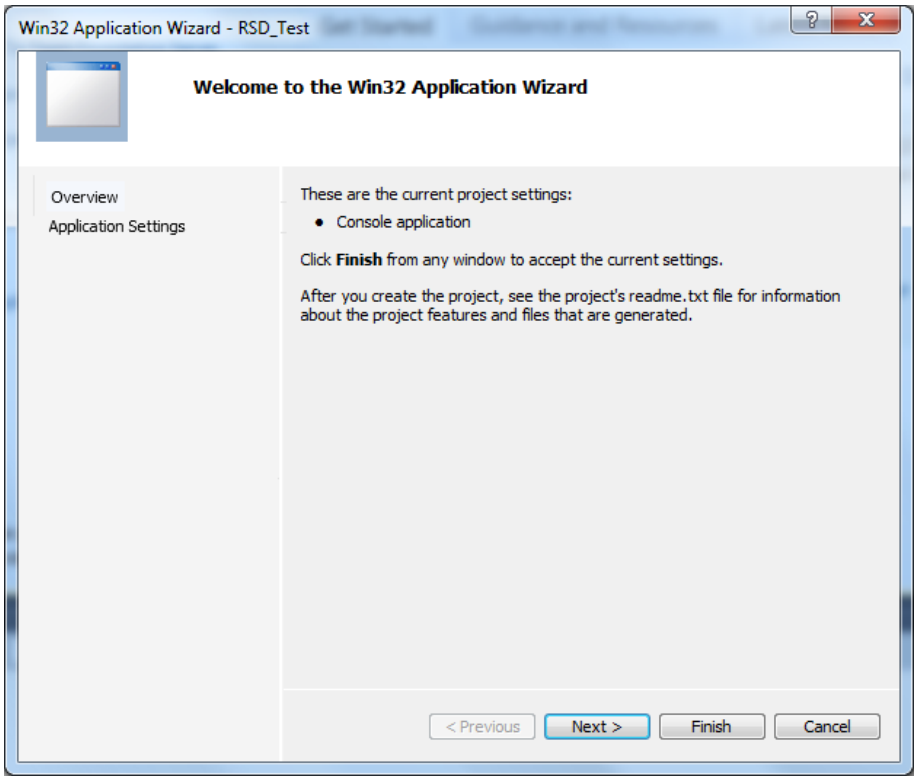

Figure 20 The new Project Win32 Application Wizard – Welcome window

6. For the Application Settings on the next page (Figure 21) select Console Application. Also check the “Empty Project” box under Additional Options. Then click “Finish”.

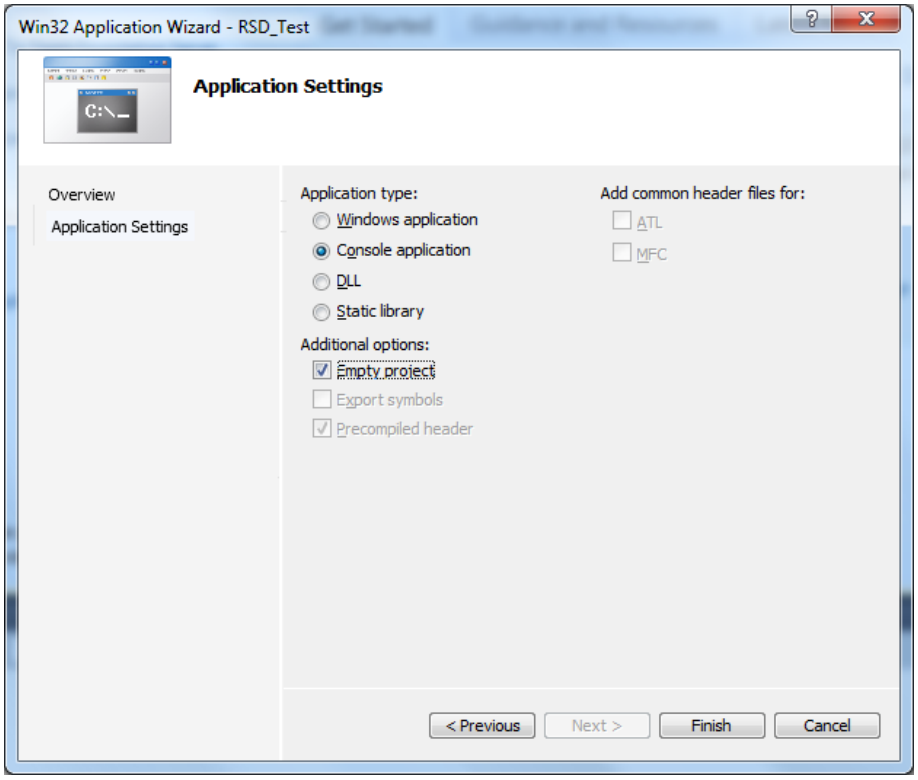

Figure 21 The new Project Win32 Application Wizard – Application Settings window

7. The computer EN212-001 attached to the ER9 robot operates on Windows 7 64-bit. Click on the "Solution Platforms" dropdown list from the toolbar and select "Configuration Manager" (see Figure 22).

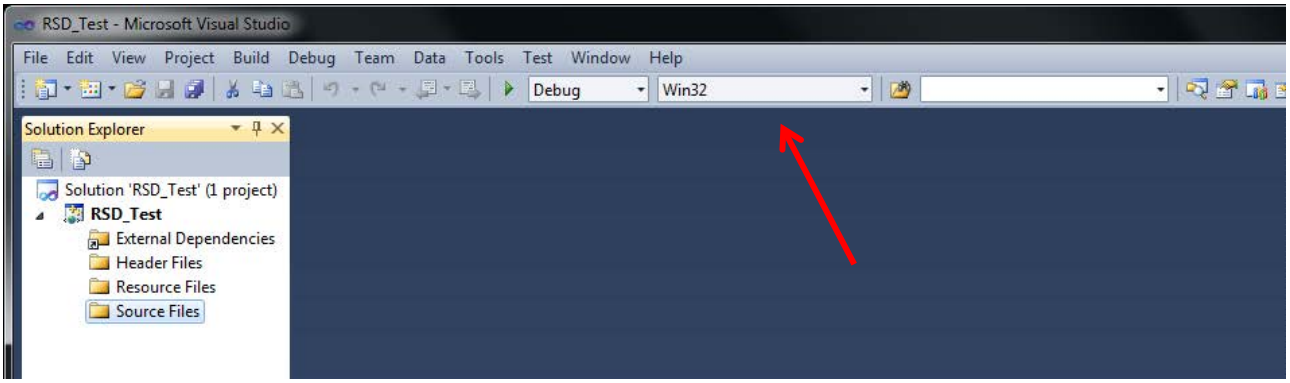

Figure 22 The Solutions Platform dropdown list is shown

8. Select the Platform dropdown list for your project and select "<New…>" (see Figure 23).

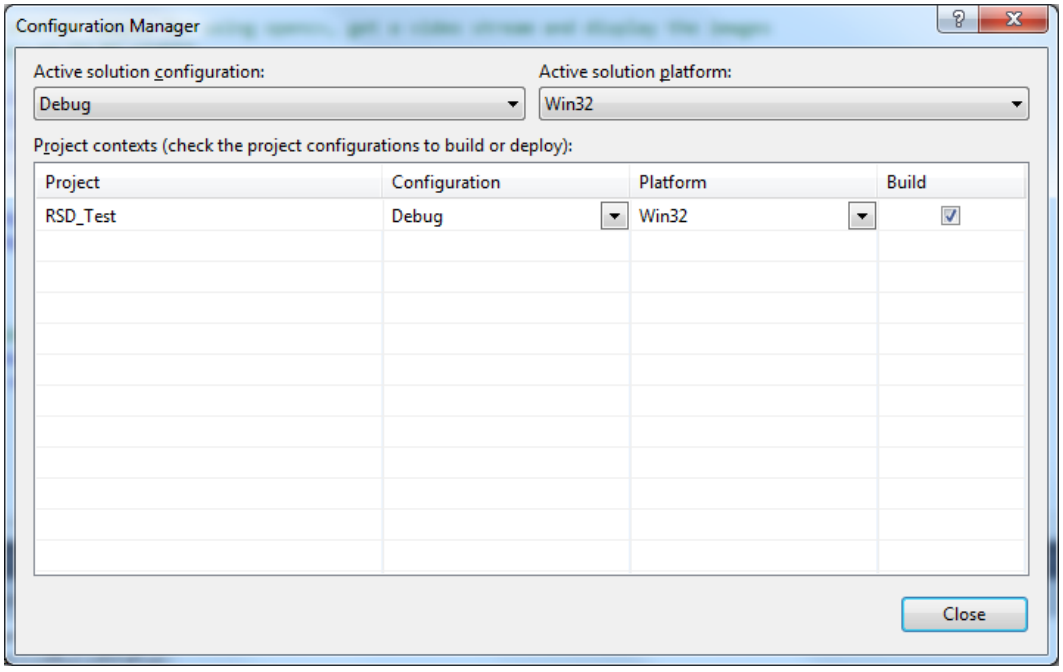

Figure 23 The Platform drop down list is shown

9. Select “x64” as the new platform and click “OK” (see Figure 24). Then click “Close” on the “Configuration Manager” window.

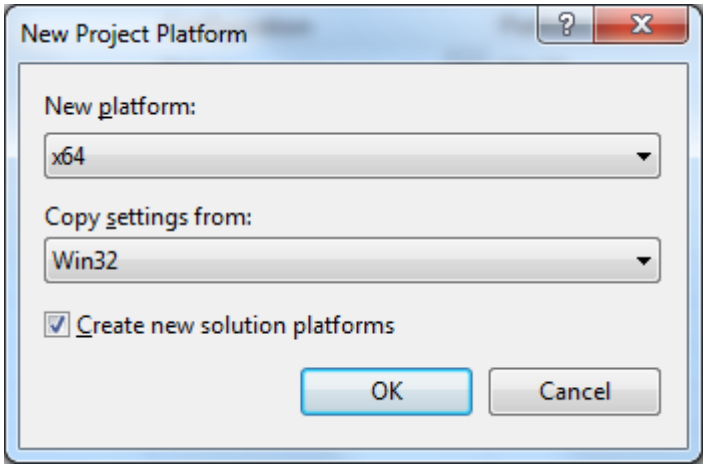

Figure 24 New Project Platform window

10. Expand the project under the Property Manager tab (see Figure 36) and right click on “Debug | x64”. Select “Add Existing Property Sheet” and select the “OpenCV_Debug.pros” file from the VS2010 Build Rules folder in the zip file downloaded in step 2.

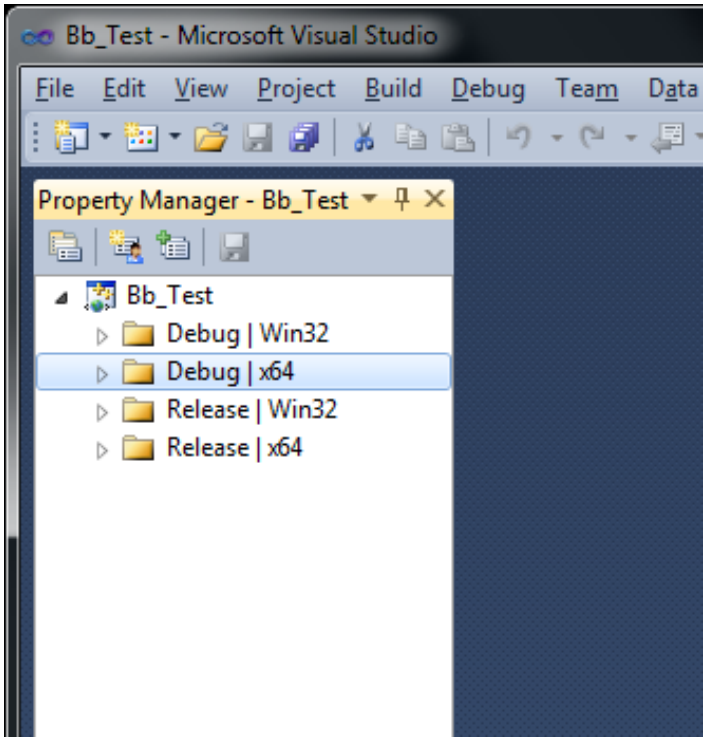

Figure 25 The Property Manager tab

11. While on the Property Manager tab, right click on “Release | x64”. Select “Add Existing Property Sheet” and select the “OpenCV_Release.pros” file from the VS2010 Build Rules folder in the zip file downloaded in step 2.

12. Go to the “Solutions Explorer” tab (see Figure 26) on the left hand panel and expand your project.

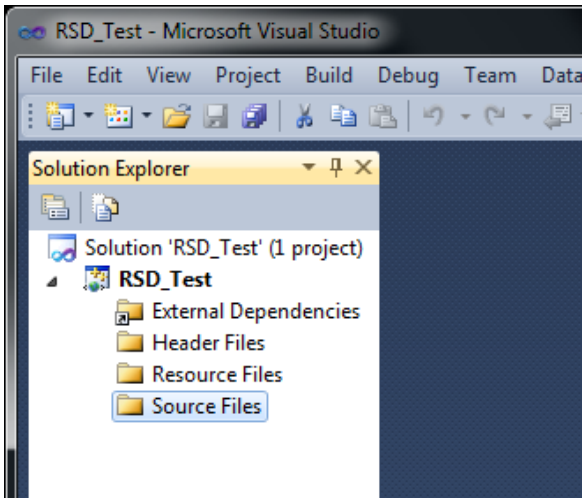

Figure 26 The Solution Explorer tab

13. Right click on “Source Files” and Select Add>Existing Item. Then select the “RSD_starter_video.cpp” file.

14. Right click on the project name “RSD_Test” in the “Solutions Explorer” tab and select Properties. Go to the Configuration Properties tab and set C/C++ >General > Additional Include Directories to “$(OPENCV_DIR)\include”

15. Right click on the project name “RSD_Test” in the “Solutions Explorer” tab and select Properties. Go to the Configuration Properties tab and set Linker >General > Additional Library Directories to “$(OPENCV_DIR)\x64\vc10\lib”

16. Double click on the “RSD_starter_video.cpp” file to open the program. This program has an entry point for Swinburne students at line 58.

17. Build the project.

18. Once it has been successfully built you will need to run your program through the Command Prompt. Open the Command Prompt and navigate to the location of your executable. If your project was called RSD_Test the location is likely to be …\RSD_Test\Debug. See Figure 27 for an example.

19. Type the name of your executable followed by a “0”. For example RSD_Test.exe 0. The zero signifies the device number of the camera which is usually zero if there is only one camera (see Figure 27).

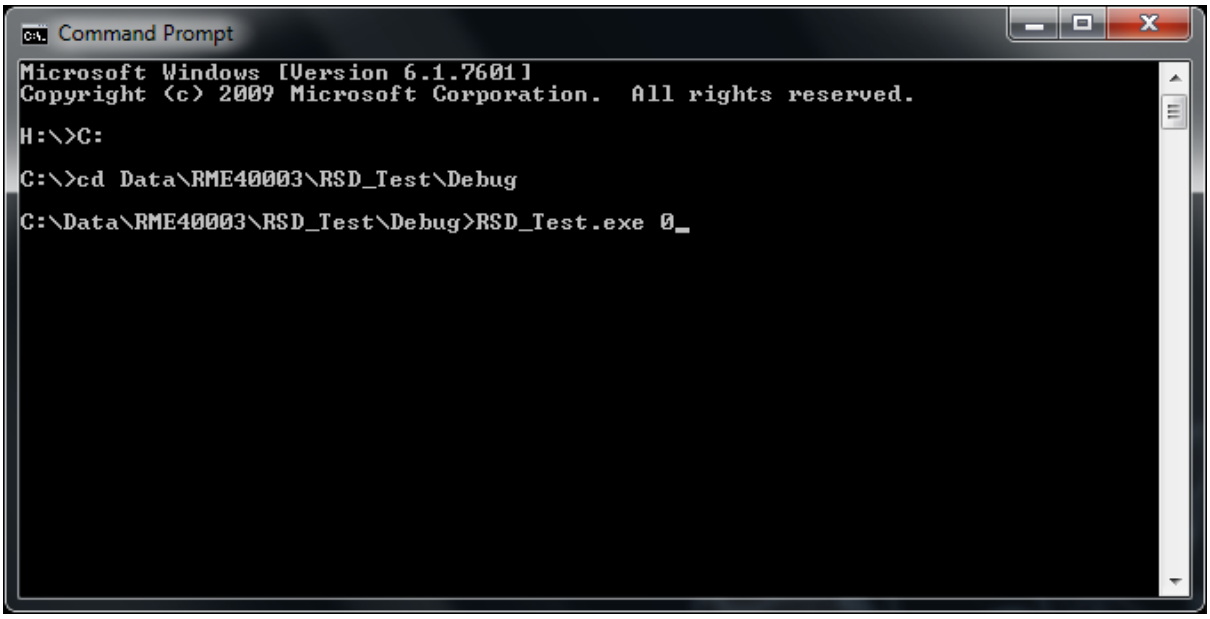

Figure 27 An example of the command to run the camera in the Command Prompt

20. A new window will open like that in Figure 28. The display shows the robot cell with the top half of the image has been modified to show bright colours. This is a result of the sample code at the entry point. This code demonstrates how to extract and modify pixel values from the display image.

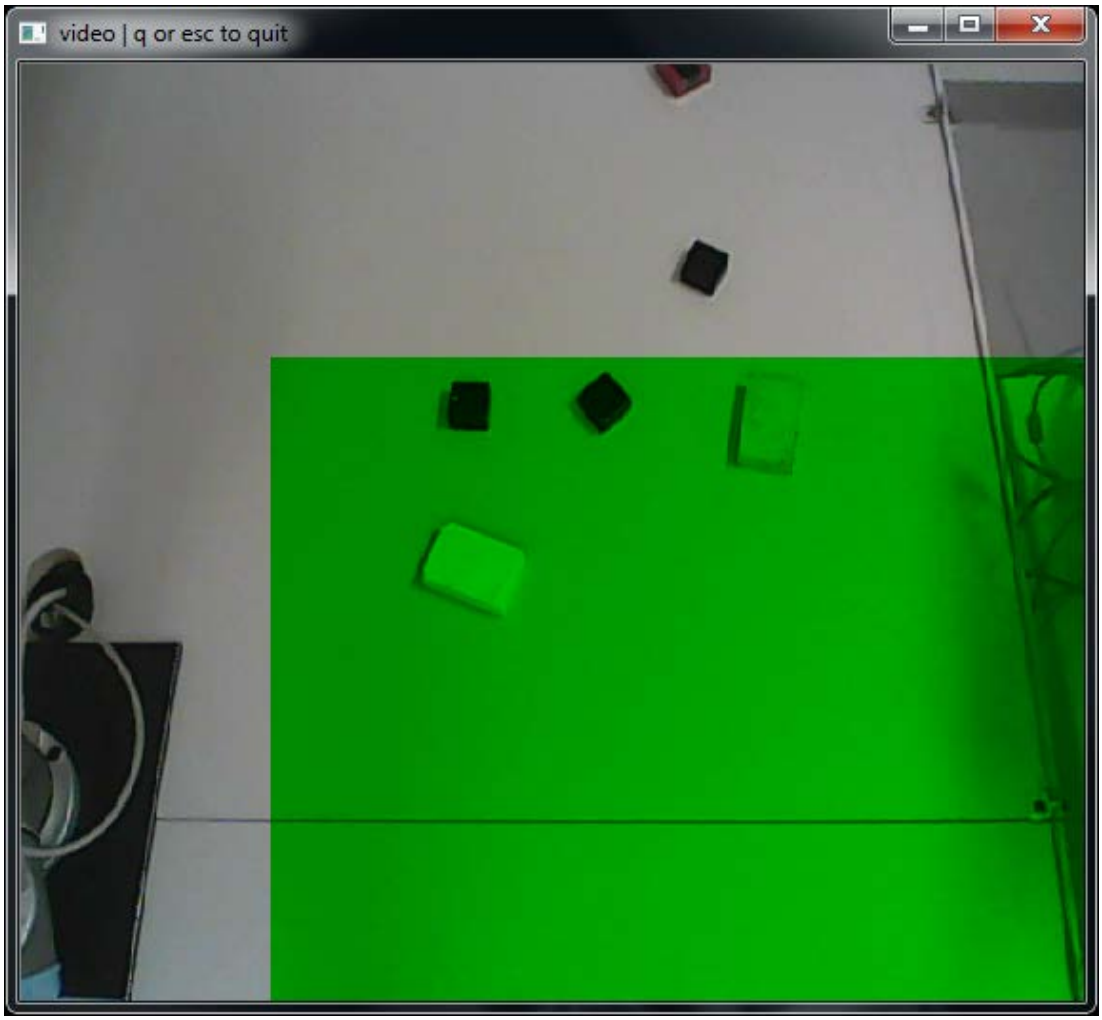

Figure 28 The output from the camera using the sample code provided

Shutting down

1. Close the Microsoft Visual Studio program on the computer that controls the camera and the parallel port.

2. Unplug the USB cable from the I/O Interface Box.

3. Shut down and turn off the computer that controls the camera and the parallel port.

4. Turn off the robot by pressing File in the top left hand corner of the pendant screen. From the drop down menu select “Exit”. In the welcome screen press the “SHUT DOWN Robot” button, and press “Yes” when asked to confirm.