Technical Guide for using EV3 Hardware

Trinity Term 2024

Basic Components

The robot primarily consists of LEGO EV3 brick, motors, gyro sensor and a touch sensor, see Figure 1. To turn the EV3 on, make sure the robot stays still on flat surface during the start-up process. Press the **Centre** button on the brick. To turn the EV3 off, press the **Back** button, refer to Figure 2 for button labels.

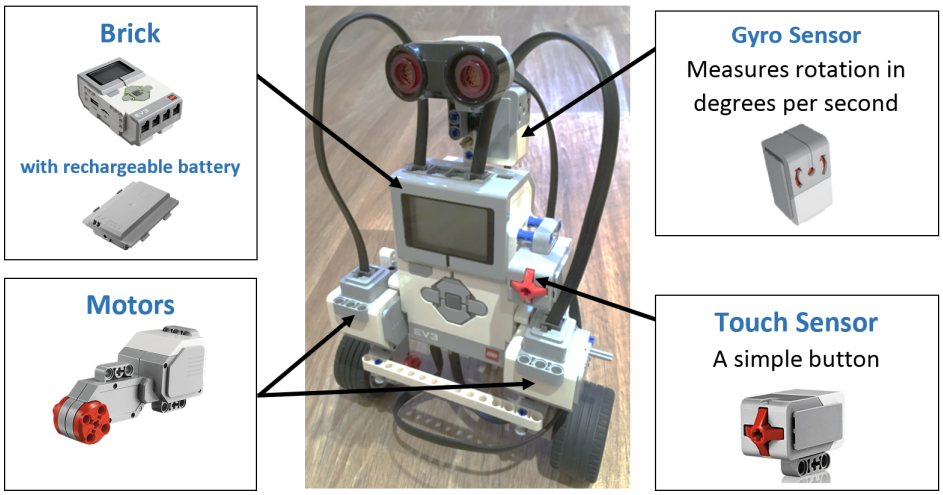
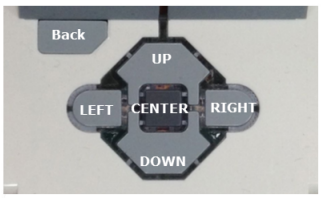


Figure 1: Basic components of robot

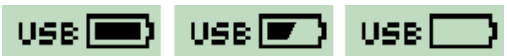
Figure 2: Button labels



About Battery

The EV3 is powered by a rechargeable battery pack, which gives a few hours use. However, it is recommended to charge the EV3 when you are not testing as when the battery depletes the EV3 may exhibit erratic behaviour. **Turn off the robot at lunch and at the end of the day**.

The EV3 display screen shows the battery status (solid battery is fully charged, outline is empty) as shown below:



When the battery pack is charging it has a green and red light. The red light will go off once the pack is fully charged.

V1.3: For comments and corrections, please email Junaid Memon- junaid.memon@eng.ox.ac.uk.

Running Simulink models on the LEGO EV3

The next three pages will show you how to run a Simulink model on the LEGO EV3. The first time you follow this process, do not skip any steps as all are necessary.

1. Connect your EV3 to the correct router. Turn on the EV3 by pressing down the Centre button, then:

   (a) Navigate to Settings (move right through the menus to spanner symbol). Navigate down to select WiFi.

   (b) Click to turn WiFi on

   (c) Navigate up to select Connections.

(a) (b) (c)

   (d) From the Connections menu, select your router with **no** encryption. The router you should connect to will be on a label on top of your computer.

   - EV3 number 1 and 2 connect to **router1**
   - EV3 number 3 and 4 connect to **router4**
   - EV3 number 5 and 6 connect to **router6**
   - EV3 number 7 and 8 connect to **router8**

   If you cannot see your router listed on the Connections list, scroll to the very bottom of the list and select ***Add Hidden****. You will need to type your router name exactly as above. No capital letters, no spaces.*

   (e) If it is successful, you will see two arrows next to the WiFi symbol:

   Press **Back** twice to close the WiFi menu on the EV3.
   If you cannot connect, tell a demonstrator and try the router with SSID **spare**.

   (f) Once connected to the router, the EV3 will be assigned an IP address in the formate of **192.168.1.10X** where X is the robot number on the front of the EV3. For example for robot3 IP address would be 192.168.1.103. You can view the **IP** and **ID** of the EV3 brick in the **Settings** menu (spanner symbol) by scrolling down to **Brick Info**. Leave the Brick Info open for now, or make a note of these values:

   - The **Device ID**, which begins 00165.
   - Scroll down to see the **IP address**. *If the IP address does not match, check you have connected to your specified router above and if you still have problems, tell a demonstrator.*

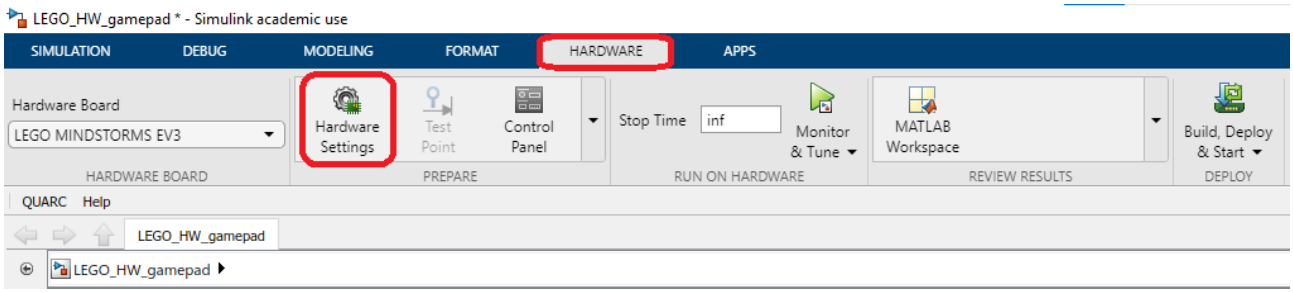
2. **In MATLAB 2023a**, run the script `run_LEGO_HW.m`
   This loads the correct control parameters into the MATLAB workspace.

3. Open the Simulink model `LEGO_HW.slx`. The Simulink model needs to know which EV3 to connect to:

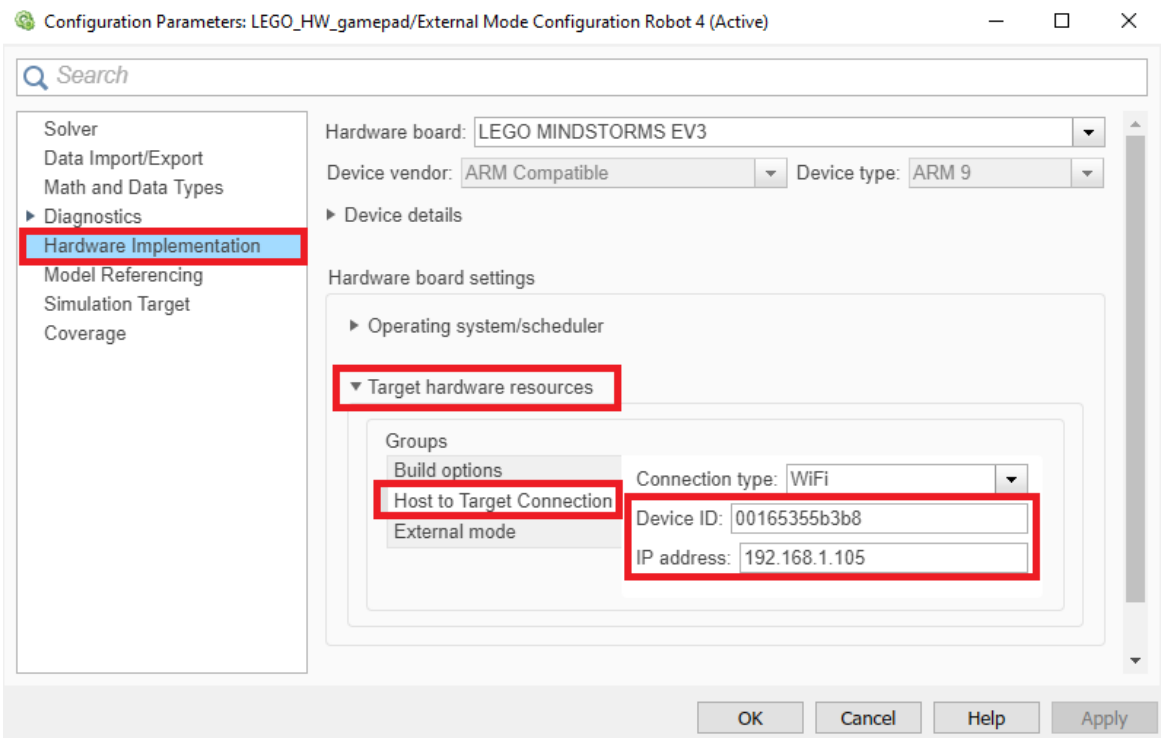
   (a) Navigate to **Hardware Tab**, and select **Hardware Settings**

   (b) Under the **Hardware Implementation** tab,
   set the **Hardware Board** to **LEGO MINDSTORMS EV3**.

   (c) Expand the tab under **Target hardware resources**.
   Under **Host to Target Connection** set: **Device ID** and **IP address** of the EV3.
   You should have a note of this from Step 3.(f) or still have the Brick Info menu open.
   Press **Apply** and then **OK**:



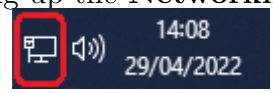
Step (a)



Step (b) and (c)

4. Check the computer is connected wirelessly to your designated router:

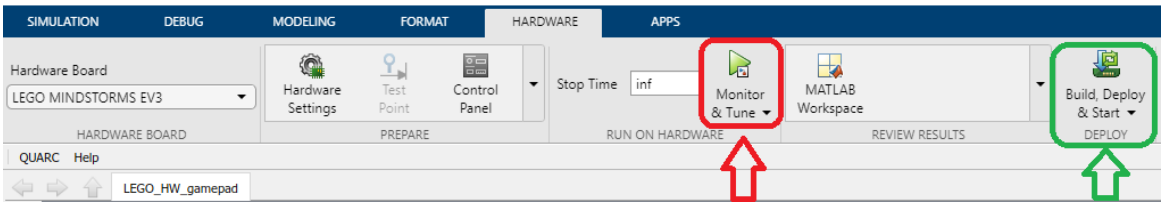
   (a) On the Windows Taskbar (lower right next to time/date), you will see a network icon (see below). Click it to bring up the **Networking Centre**.



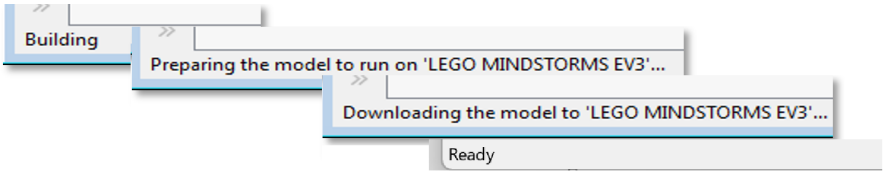
   (b) In the list of available connections, select your router.
   There is no password so it should connect automatically.

5. Ensure all menus are closed on the EV3 by pressing **Back** button.

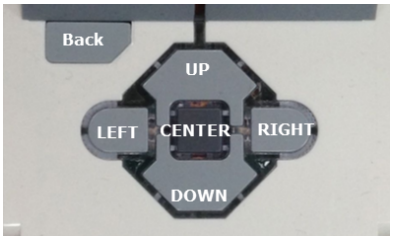
6. You can run the program in two modes. In the **Hardware Tab** of the Simulink model, locate **Monitor & Tune** and **Build, Deploy & Start** buttons, see figure below. The **Monitor & Tune** allows you to run the program, log data using scopes *and* update the program parameters simultaneously while **Build, Deploy & Start** only runs the program on the robot therefore you will not be able to see data on scopes. Real time performance of the robot while running on **Build, Deploy & Start** option is better since there is no communication lag. Therefore, press **Monitor & Tune** if it is first time you are running the program or if you want to tune the controller parameters and log data. Otherwise use **Build, Deploy & Start** button to run the program.



It will take around **90 seconds** to deploy the program. During this time, keep the robot still on horizontal surface to avoid program crashes and sensor miscalibration. In the lower left of the Simulink model it display messages like **Building**, **Connecting** etc. Once it says **Ready** hold the EV3 upright so it can self-balance and press the touch sensor once (see Figure 1 to identify touch sensor).

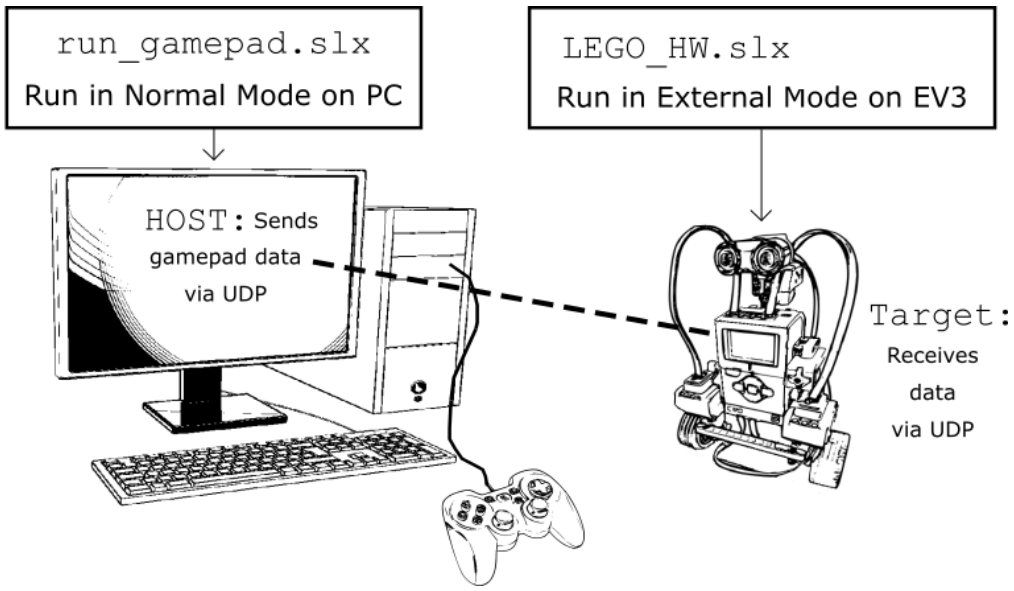


Once the model is running, the EV3 should follow the set reference values.
If the robot falls over, you can **Reset** the robot using **touch sensor**. Note that touch sensor acts as a latch i.e. press once to reset and it stays reset and press again to run and it keeps running.
To **Stop** the model running, either press the **Back** button on the EV3 or the **stop** button on the Simulink toolbar. Once stopped, you can re-run the program by pressing **Monitor & Tune** or **Build, Deploy & Start** button.

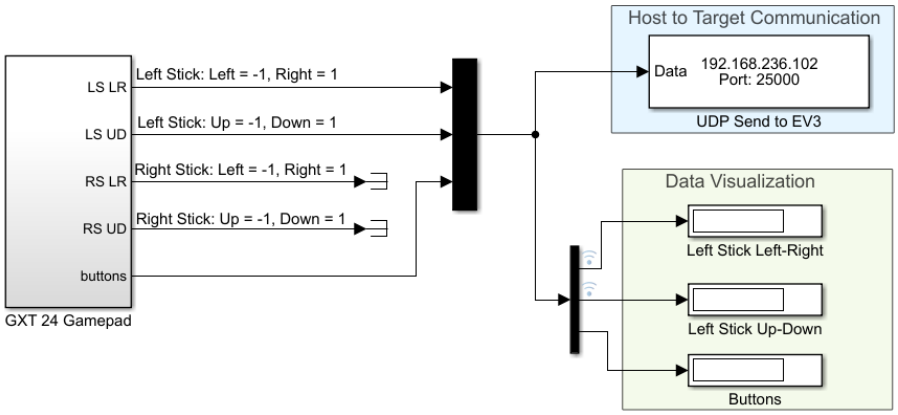


Using a gamepad with the EV3

The model `LEGO_HW.slx` also allows us to use a gampead with the EV3. It takes reference values `dot_phi_ref` and `dot_theta_ref`, however these are instead defined as signals from the gamepad. The model incorporates same reset functionality so that the EV3 can restart after falls without redownloading the model. The model `run_gamepad.slx` will run on your computer to read the signal from the gamepad and send it to the EV3, through WiFi in addition to running `LEGO_HW.slx` in external mode on EV3 as shown below.



1. On the left half of your screen, open `run_gamepad.slx` and ensure a USB gamepad is connected to the computer.



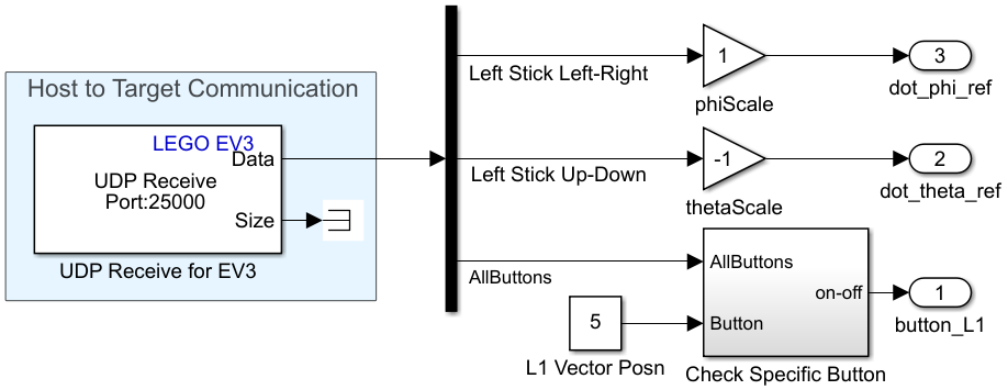
The subsystem 'GXT 24 Gamepad' reads the values from the gamepad and sends them to the EV3 via UDP. The first four channels output from the gamepad vary between -1 and 1 and correspond to where the analogue sticks are vertically and horizontally. Outputs from the right analogue stick are currently terminated. The **buttons** output is a single unsigned 32 bit integer, which signifies which buttons have been pressed based on the table below. For example, if buttons '3' and 'R2' were pressed then **buttons** = 4 + 128 = 132.

Button Pressed	1	2	3	4	L1	R1	L2	R2	9	10
uint32 Identifier	1	2	4	8	16	32	64	128	256	516

2. Ensure the IP address of the UDP Block in `run_gamepad.slx` is the same as the EV3 IP address. Double clicking UDP blocks will open Block Parameters, where the IP address can be changed. The IP address should be that of the EV3 (see page 2 for how to check the EV3 IP address).

3. Open `LEGO_HW.slx` on the right half of your screen.

   The **Gamepad** subsystem (see below) receives the signal via the 'UDP Receive' block. The signals from the left analogue stick are then scaled and become the reference signals for $\dot{\phi}$ and $\dot{\theta}$. Notice the gains `phiScale` and `thetaScale` in Reference Selector subsystem. These can be changed while the system is running.



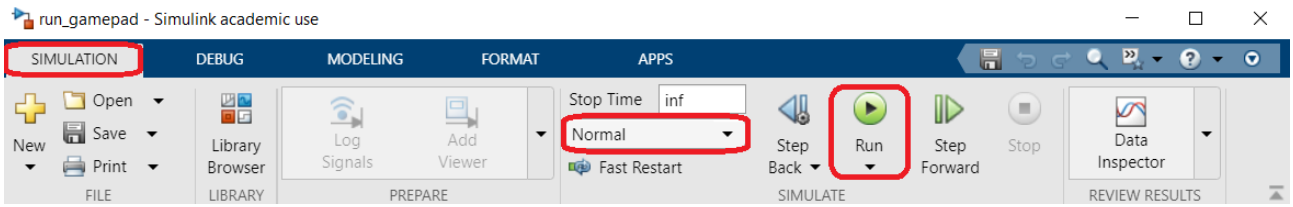
   Another subsystem checks if a specific button, here L1, has been pressed. This is used to stop the motors and reset the integrals if the EV3 falls.

4. Ensure the IP address for the `LEGO_HW.slx` model is the same as the EV3 IP address. See Step 3(c) on page 3 for a reminder on setting the IP.

5. Ensure the port numbers match for the UDP blocks in both models. (Any value between 1 to 65535).

6. Run script `run_LEGO_HW.m` to load control variables into the workspace.

7. Run model `run_gamepad.slx` in **Normal** mode.
   This means pressing the **Run** button while on the **Simulation Tab**.



   Test you can see signals displayed when you move the left analogue stick.
   The **centre triangle on the gamepad must be glowing red**, if not press it to activate the analogue sticks.

8. **Run** `LEGO_HW.slx` the model by pressing **Monitor & Tune** OR **Build, Deploy & Start** button on the **Hardware Tab** of model. Once downloaded, the model should run on the EV3.

*** Monitor & Tune vs Build, Deploy & Start ***

When the model is run by **Monitor & Tune**, you can change any of the values in the Simulink blocks **without** stopping the model. This means you can adjust the gains and instantly see the effect. Use this option when you are tunning your controller or need to log data (e.g. for presentation).

When the model is run by **Build, Deploy & Start**, there is no communication of parameters and data between robot and Simulink. This means your robot runs the control algorithm without any communication delays. Use this option, once you have tunned all parameters (e.g. when playing football or for trial runs).

*** Reset EV3 without re-downloading model ***

If the **EV3 falls over**, press and release the touch sensor (i.e. red button on the right of the EV3) or L1 on the gamepad, once to stop the motors. Hold the EV3 in an upright position, and press the button again, the robot will start balancing again.

To **stop the program on the EV3**, press the back button on the EV3. Sometimes the motors will keep spinning after this. In this case, you will need to manually power off the EV3 brick by removing the battery pack. Unfortunately, this means you will need to turn the EV3 brick on again and reconnect to the WiFi.

9. **Adjusting the response to the gamepad:** You can change the scaling on the $\dot{\phi}$ and $\dot{\theta}$ reference signals by changing `phiScale` and `thetaScale` in the Reference Selector subsystem in `LEGO_HW.slx`.

*** Battery Reminder ***

The EV3 is powered by a rechargeable battery pack which can drain quickly when used with the gamepad. As the battery depletes, the EV3 may exhibit erratic behaviour. Please monitor the battery levels (details on front page) and charge the EV3 when it is not in use. Each robot is provided with its own charger in lab.