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INTRODUCTION TO LEGO MARIO

Last week we learnt about human-robot interaction with our robot, Cruz. This week we delve into the fun world of LEGO® Super Mario™ and learn how these devices work!

What is LEGO® Super Mario™?

According to LEGO® (n.d.), they created the Super Mario themed product line to let fans experience the playful world of the game in an entirely new way. Players build the level to what they would like and then move the interactive figure (this is Mario, Luigi or Peach) through the level with the aim of collecting coins before the timer runs out (see figure 28).

Figure 28: Adventures with Mario Starter Course LEGO® Set
Retrieved from: https://www.lego.com/en-gb/product/adventures-with-mario-starter-course-71360

The Interactive Figurine

The LEGO® set comes alive when players use the interactive figure (let's refer to this as Lego Mario from now on) as it allows the players to interact with coins, power ups, enemies and different terrain types. Lego Mario will either react visually via the screens or audibly via the speaker (see figure 29).

Figure 29: Diagram of the Components on the Front, Under and Back Sides of the Figurines. Left to Right: Mario, Luigi (wearing Tanooki pants) and Peach (wearing Cat pants).

Microcontroller

The Microcontroller is the 'brain' of the figurine and is the component that controls everything; what to display on the screens, what audio to play through the speaker, Bluetooth connectivity, the camera, detecting what pants the figurine is wearing and processing the data from the camera and the accelerometer. Likely by this far into Bricks, Barks & Binary, you realise how important the microcontroller is, as without it, this technology wouldn't function.

Accelerometer

As the intention of the LEGO® series is for players to physically move Lego Mario through the levels, Lego Mario needs to know when they are moving – this is where the accelerometer comes into play. An accelerometer measures the change in velocity for given axes (plural of axis). Lego Mario has a 3-axis accelerometer which means it can measure the change in velocity in the x, y and z axes (see figure 30). This means when Lego Mario is lifted, tilted and rolled, the accelerometer detects this and informs the microcontroller, thus enabling the figurine to react to movement.

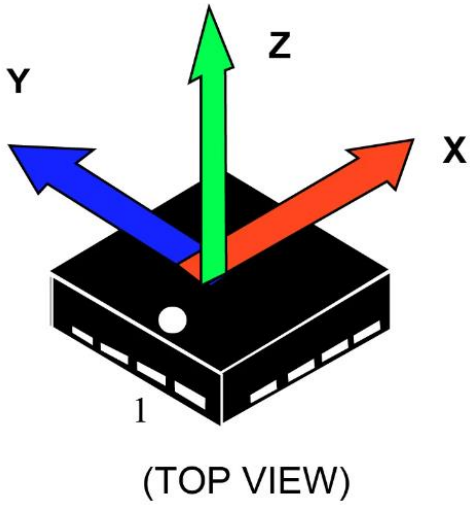

Figure 30: Axes Diagram for a 3-axis Accelerometer
Retrieved from: https://www.allaboutcircuits.com/news/high-stability-low-noise-3-axis-digital-accelerometer-STMicroelectronics/

To see how the accelerometer responds to movement, have a go at the exercises listed below.

Exercises:

1. Turn Lego Mario on (or Lego Peach/Luigi etc.).
2. Quickly lift Lego Mario upwards (i.e. make them jump), what happens? (Look at the screens and listen for audio).
3. Repeat step 2 but make Lego Mario do a backflip.
4. What happens if you shake Lego Mario?
5. Put Lego Mario on their back and leave them for approximately 20 seconds, what happens?

Hopefully you noticed that Lego Mario reacts to movement by playing various sounds (like a boing followed by a 'woohoo' when they jump) and updating the visuals (like when they get sleepy and their eyes shut).

Optical Sensor (Camera)

On the underside of Lego Mario is a camera with a white LED either side. This camera can detect what colour Lego Mario is currently on, as well as what tile. How this works is, the light is captured by the optical sensor and is then processed by the microcontroller which determines its hex colour code (i.e. a code with a format like 0x12) and tile code (an 8-10 digit integer). These 2 pieces of data enable Lego Mario to react to the surfaces they're on. To see how the camera works in practice, attempt the exercises below.

Exercises:

1. Turn Lego Mario on (or Lego Peach/Luigi etc.).
2. Hold (or place) Lego Mario over a green LEGO® brick. What happens? What can you see and hear?
3. Repeat step 2 with yellow and blue bricks.
4. What happens if you hold Lego Mario over a red object/surface that is not a LEGO® brick? Does Lego Mario still react?

It is probably no surprise to you that Lego Mario identified the colour and tile of a LEGO ® piece correctly, but did you expect step 4 to happen as it did? It still worked on a surface other than LEGO ® because colour determination is about light, its wavelength and how it reflects off the surface.

Bluetooth

The Bluetooth functionality allows the figurine to be connected to mobile devices using the LEGO® Super Mario™ App (available on Android and iOS, see figure 31). When connected, players can play through their level and once finished, the app displays the performance stats (such as time taken and points scored). There are also challenges on the app for players to try (current examples being 'Dodge Chain Chomp' and 'Beware of Boo' with more added regularly). The app is also used to update Lego Mario's software which is crucial if wanting to use the Bluetooth functionality for development purposes (which we do later in this series!) but don't worry, we've already done this for you.

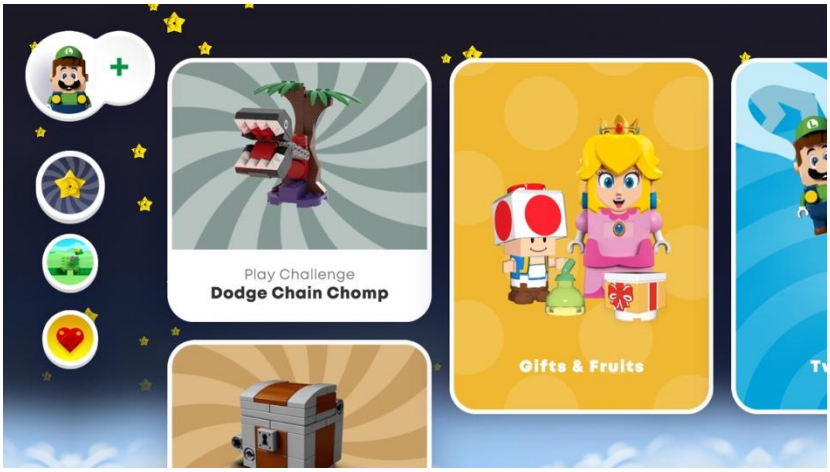

Figure 31: Screenshot of the LEGO® Super Mario™ *App Challenges Screen (Paired with Luigi)*

Pants

You may have noticed your figurine looks different than what their character would usually look like, this is because they have a power up suit on (see figure 32).

Figure 32: Regular Lego Mario and Builder Lego Mario

Typically, a suit includes new pants and headwear for the figurine, however some accessories like paw gloves or devices that resemble vacuum cleaners ('if there's something strange, in your neighbourhood, who you gonna call?') can be included as well. Each suit has unique characteristics such as the Frog suit which gives Lego Mario coins for walking on a water tile or the Poltergust ghost vacuum (i.e. the device 'that resembles vacuum cleaners', see figure 33) which allows Lego Mario to capture enemy ghosts for coins.

Figure 33: Lego Luigi with the Poltergust Pants
Images retrieved from: https://brickset.com/article/68408/review-71397-luigi-s-mansion-lab-and-poltergust

Watch this video if you want to know what each suit does: https://www.youtube.com/watch?app=desktop&v=gn41AWRFrc4

The pants have small rails which slot into the grooves located near the camera (see figure 34). These rails press down into the grooves which tell Lego Mario what suit they are currently wearing.

Figure 34: Showing the Location of the Metal Grooves and Plastic Rails on Lego Peach

Today's Exercise

Today we want you to use your imagination and build different levels with the provided LEGO® kit and then play through them with the Lego Mario character. **Please do not mix the LEGO® from your kit with LEGO® from the other kits as we want to keep the kits separate and with the correct pieces.** If you would like you can use the LEGO® Super Mario™ app as you play to keep track of your figurine's progress. We look forward to seeing creative level design!

Summary

In this session we introduced you to LEGO® Super Mario™ and how the interactive figurine works. We discussed the microcontroller being the 'brain' of the figurine, how the accelerometer detects movement and how the optical sensor (camera) analyses the surface beneath the figurine. We discussed how these components enable the figurine to react to the levels built around them.

Hopefully you enjoyed building the levels and playing through them with Lego Mario, Peach or Luigi. Next week we'll continue with LEGO® Super Mario™ but look at programming them with Python.

Useful Resources

- LEGO® Super Mario™ Website Page: https://www.lego.com/en-gb/themes/super-mario/about
- Accelerometer Basics: https://learn.sparkfun.com/tutorials/accelerometer-basics/all
- How Does a LEGO® Mario™ Work? IoT Hardware Teardown Series (if you want to see what's inside a figurine): https://youtu.be/haaaAJJ-ybU?si=gNUKhBmbt2qr10UV&t=136
- Using Code to Unleash Lego Mario (using Python to program Lego Mario, a sneak peek of what we're doing next week): https://www.youtube.com/watch?v=Zi-3scHOR1Q