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Professional Workshop (2) on Intelligent Soccer Robotics: Build, Train, Win!"

Presented by Dr. Khaled Eskaf

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- Ph.D in Computer Science from Salford University (UK), Professor in Intelligent System. Dean College of Informatics- Midocean University. More than 20 years in Teaching computer science courses.
- Training, Coaching Students in Robotics,
- Programming Languages (Java, python,Kotlin)
- Game Programming, Virtual Reality, Augmented Reality and Embedded System.
- Judging for many local and national Robotics competitions.

FIRST CANADA

makeblock education

makeblock MAKEX ROBOTICS COMPETITION

MATE ROV COMPETITION

IET STEM AMBASSADORS

Day 1

outline

Day 2

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Day 1: Introduction to Robotics and Basic Programming

Session 1: Welcome and Introduction
Session 2: Basic Components of Robots
Session 3: Motors and Actuators
Session 4: Sensor Integration

Session 5: Introduction to Webots

- Overview of Webots Simulation Environment
- Setting Up Your First Webots Project
- Creating and Running Simple Robot Controllers

Hands-on Examples:

1. Obstacle Detection and LED Flashing with e-puck Robot
2. Capturing and Analyzing Images with e-puck Robot's Camera
3. Red Obstacle Detection and Navigation with e-puck Robot
4. Color Score-Based Speed Control for e-puck Robot

Day 2: Advanced Applications and Machine Learning

Session 1: Recap and Q&A

⚽ **The First Virtual Robo Soccer Match**

Put your robot to the test in a real-time soccer match simulation

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Who is the Father of robotics ?

1- George Devol

2- Ismail al-Jazari

3- Isaac Newton

Day
01

Who is the Father of robotics ?

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1- George Devol

Devol's work in the 1950s and 1960s laid the groundwork for the robotics industry as we know it today

2- Ismail al-Jazari

"Father of Robotics." Al-Jazari was a 12th-century Islamic scholar and inventor who created numerous automatons and mechanical devices. His book, "The Book of Knowledge of Ingenious Mechanical Devices," described various innovative machines, including water clocks and automated musical instruments.

3- Isaac Newton

contributions to physics and mathematics, he is not typically associated with robotics.

Day

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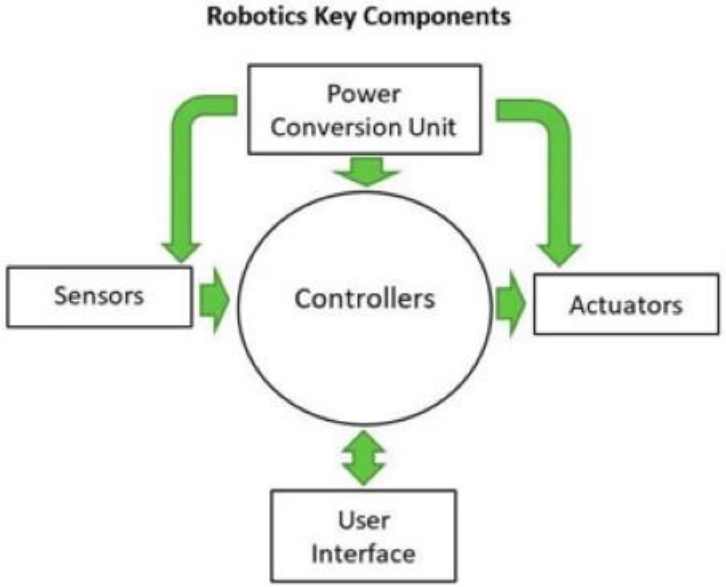
The Core of Robotics

Day 01

The Core Components of a Robot

An illustrative diagram showing the robot's core components: Computer Parts, Mechanical Components, Sensors, and Embedded Systems, leading to Human-Robot Interaction.



The Core of Robotics : Understanding Computer Parts

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Computer Parts in Robotics

Simplified explanations of CPUs, Memory, and Storage, using metaphors like the robot's "brain" and "memory bank."

Day
01

Actuators: The Muscles of Robots

1.What Are Actuators?

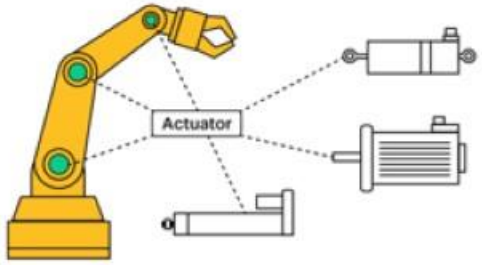
1. Brief Definition: Devices that **convert electrical energy** into **physical motion**.
2. Analogy: Just as muscles allow humans and animals to move, actuators enable robots to walk, grasp, lift, and perform other actions.

2.Types of Actuators

Electric Motors: The most common type, used in robotic arms, drones, and more. Illustrate with a snippet showing an electric motor in a robotic arm.

3. Why Actuators Are Important

Emphasize the role of actuators in expanding what robots can do, making them capable of interacting with the physical world in diverse and complex ways.



Day 01

Motors: Powering Robotic Movement

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1.Introduction to Motors in Robotics

1. Brief explanation of how motors are the driving force behind robotic movement, acting as the "muscle" that powers everything from robotic arms to autonomous vehicles.

2.Types of Motors

1. **Servo Motors**:
    1. Characterized by their ability to control angular position with precision. Commonly used in robotic arms, antennas, or any application where precise positioning is required.
2. **Stepper Motors**:
    1. Known for their accuracy in controlling steps, making them ideal for applications requiring exact movements, such as 3D printers and CNC machines.
3. **DC Motors**:
    1. Direct Current motors offer simple control and are used in a wide range of applications due to their speed variability and torque. Examples include hobby robots, drones, and electric vehicles.

Day

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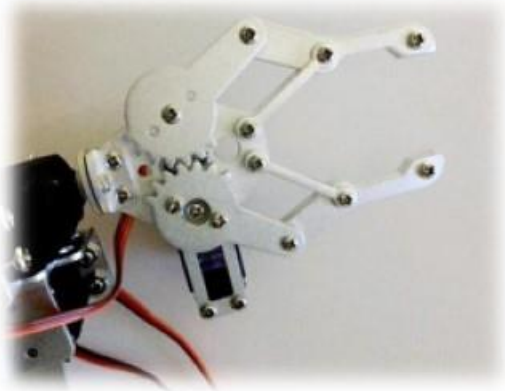
Servo Motor



Day

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Servo motor

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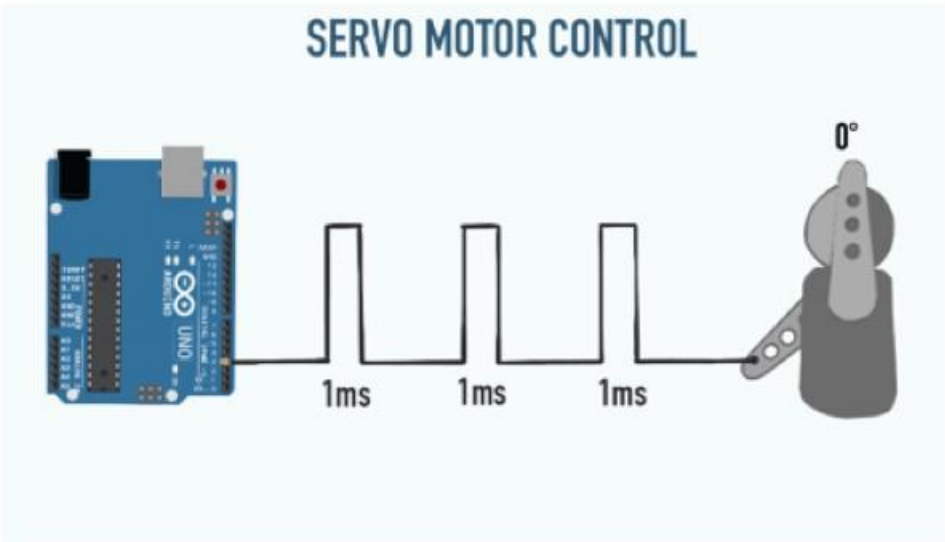
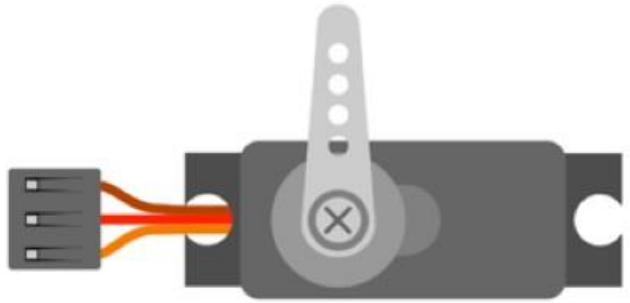
You can rotate the servo motor shaft from 0° to 180° by varying the PWM pulse width from 1 ms to 2 ms.

PWM (Pulse Width Modulation)





NAME	WIRE COLOR	DESCRIPTION
PWM	Yellow	Input control signal for the motor
V+	Red	Positive supply terminal
Ground	Brown	Ground terminal

Day

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Stepper Motor

Day
01

Stepper Motor

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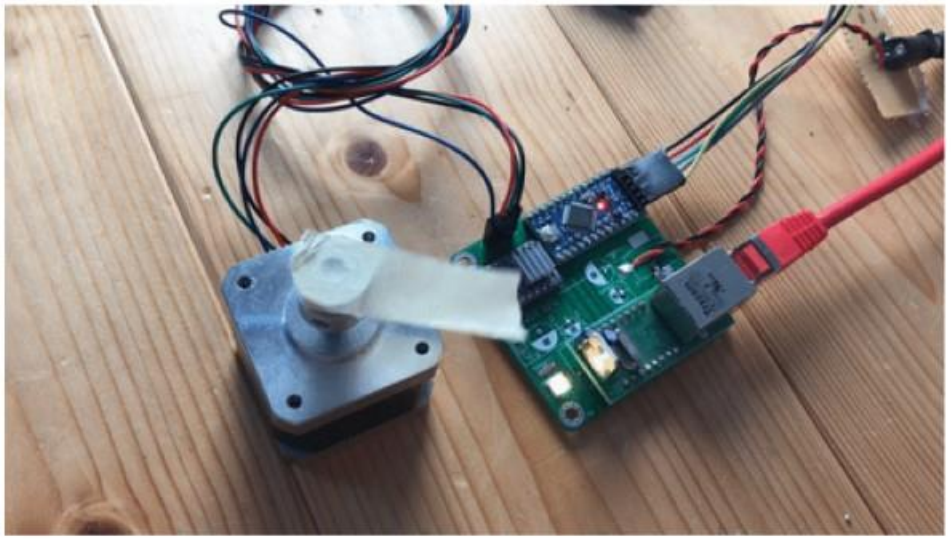

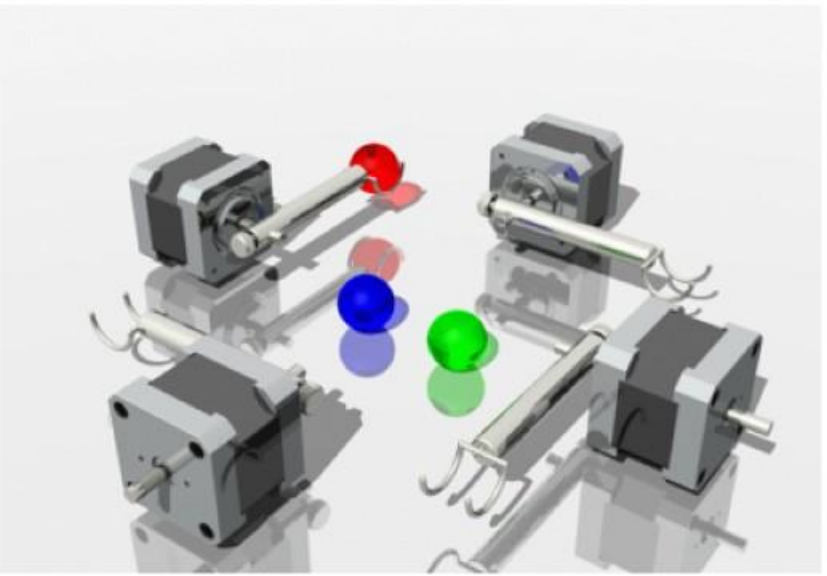

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Stepper Motor

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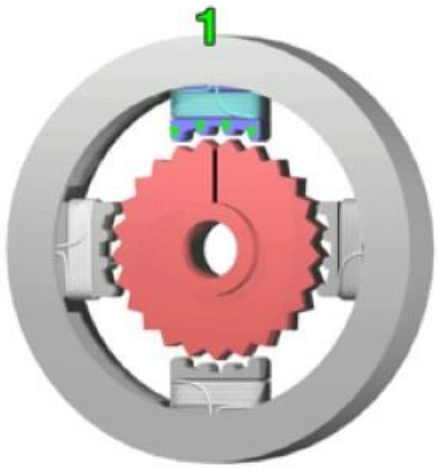

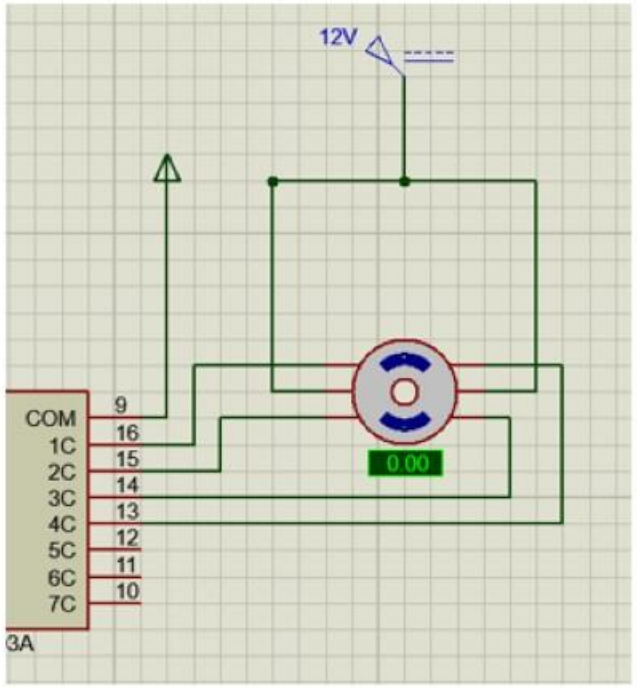

Day

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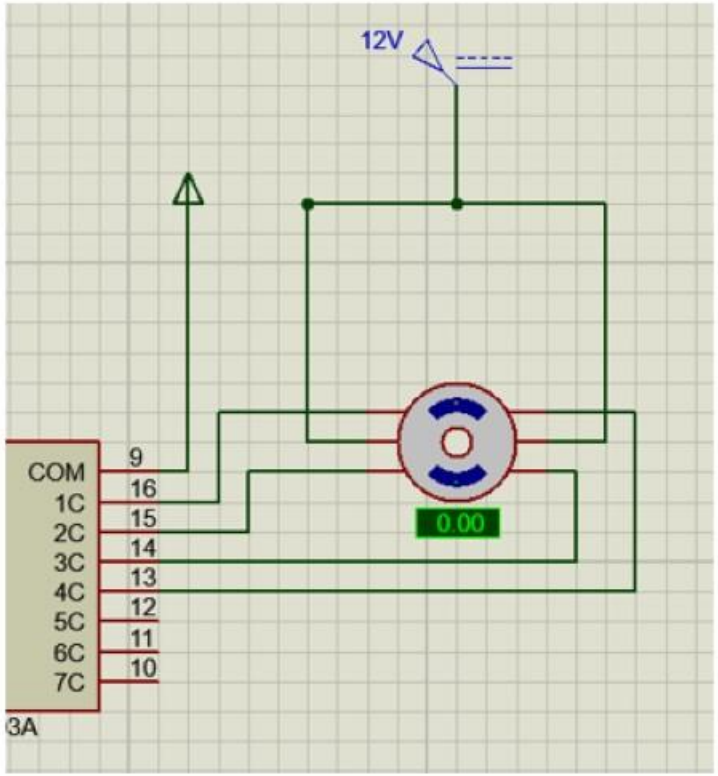
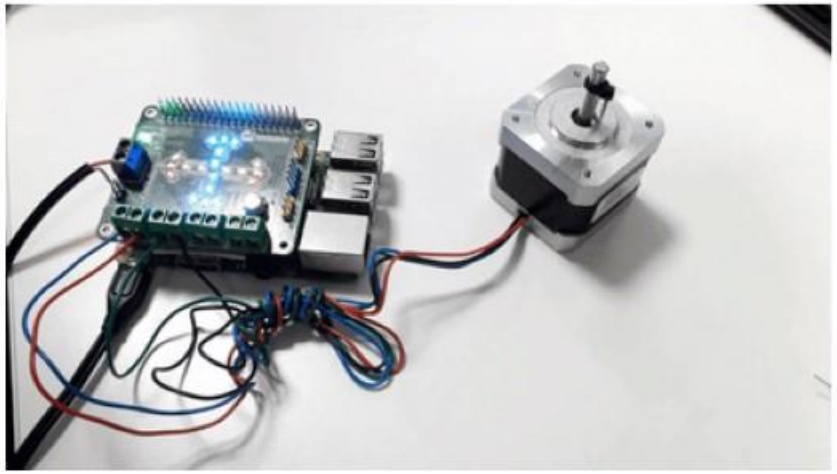
Stepper Motor



In the following table, A-B-C-D refers to the stator coils, that are to be energized sequentially in the manner and '1's and '0's refers to 'HIGH' and 'LOW' states.

Steps	A	B	C	D	HEX
1	1	0	0	0	0x08
2	0	1	0	0	0x04
3	0	0	1	0	0x02
4	0	0	0	1	0x01



Day

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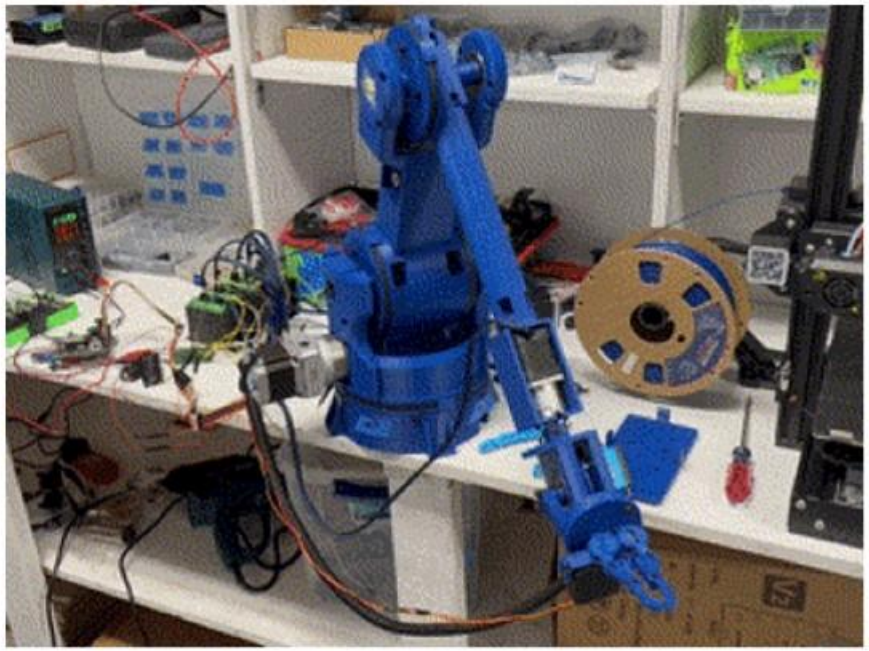
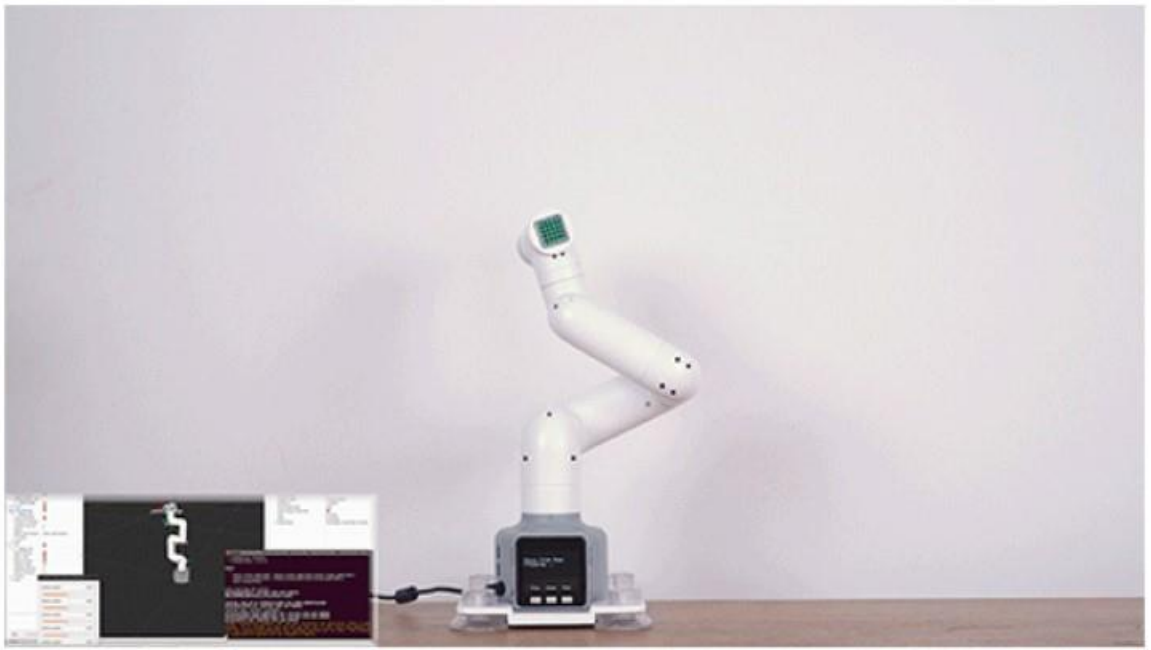
Stepper Motor





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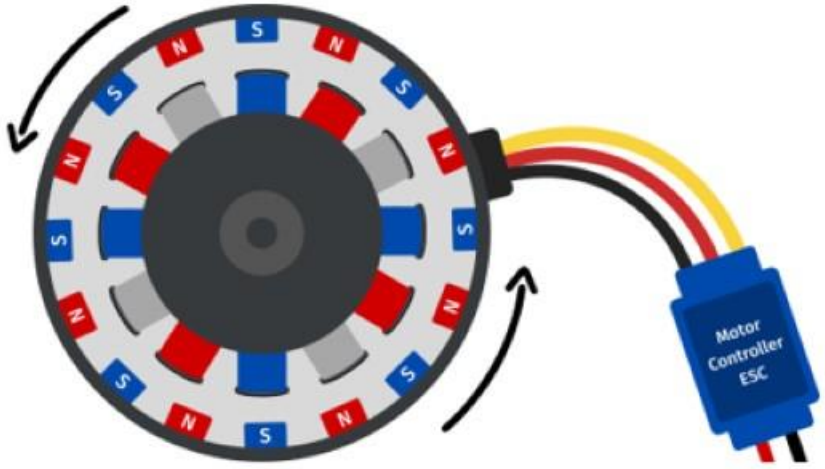
DC Motor



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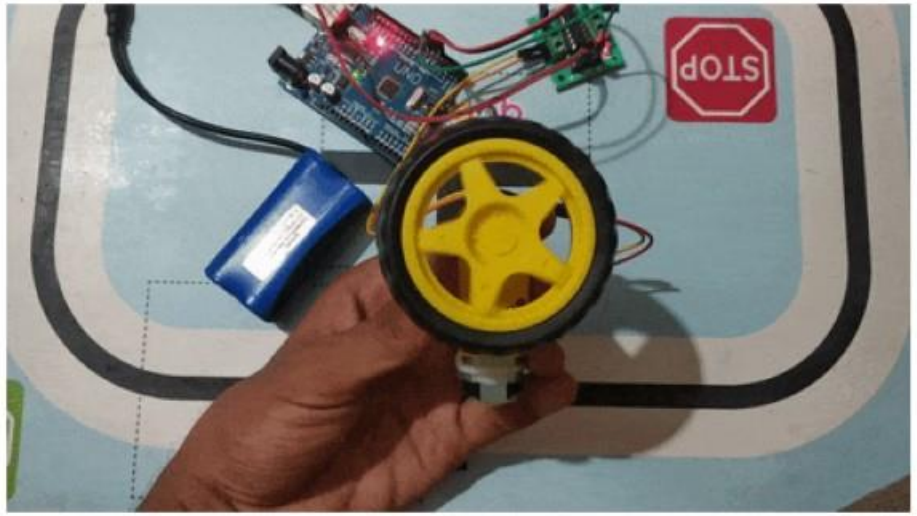
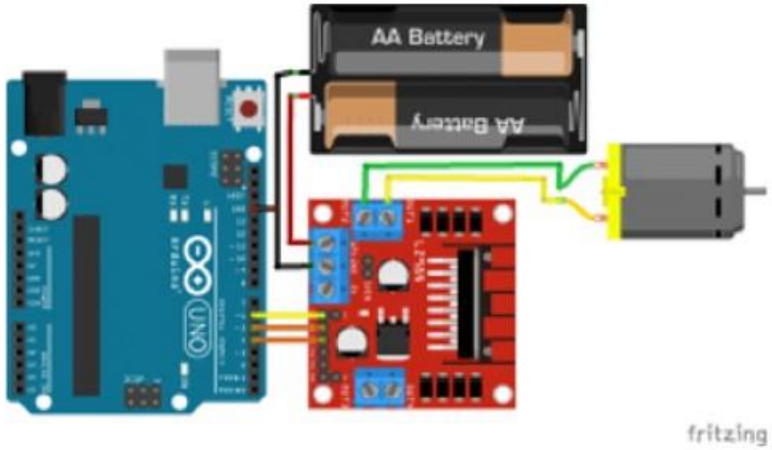
DC Motor





Arduino uno	Motor driver
D5	IN1
D4	IN2
GND	GND

Day
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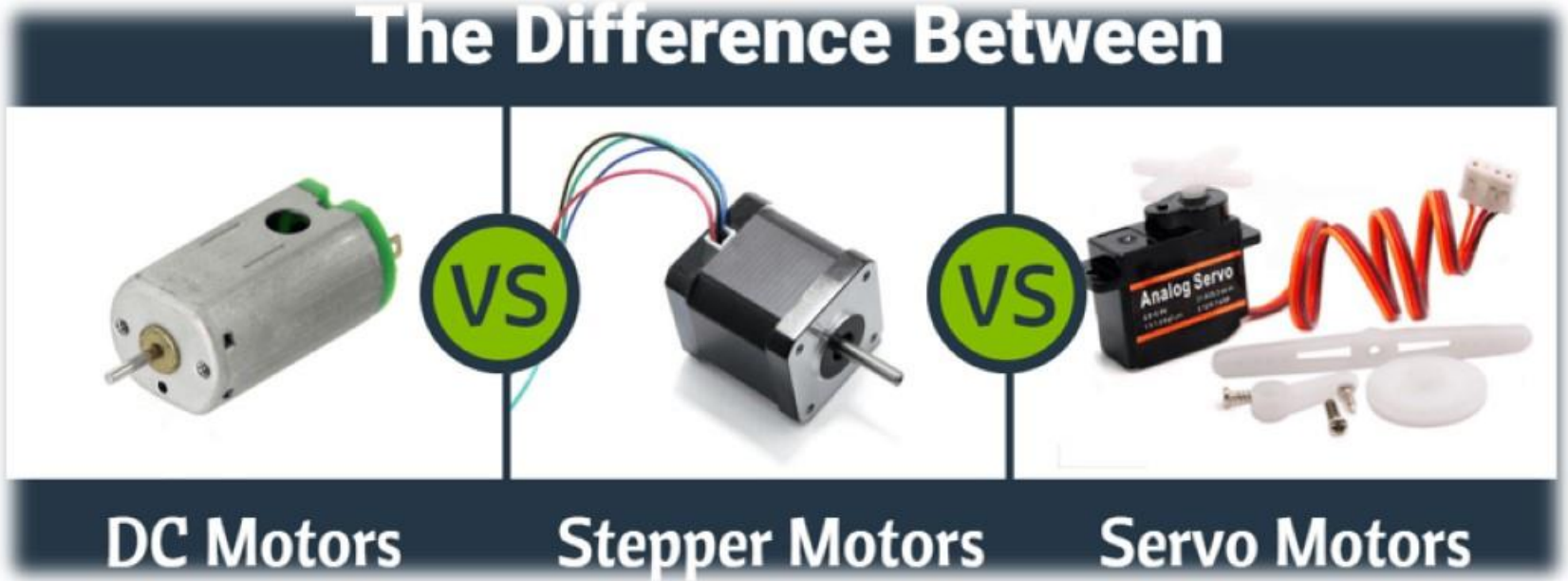
Motor Conclusion



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Fundamental differences between DC, Servo, and Stepper motors

Motor Type	Control	Precision	Speed	Torque	Primary Use in Robotics
DC Motor	Variable speed control	Low	High	Medium	Ideal for applications requiring variable speed and direction, such as robot wheels or drones.
Servo Motor	Positional control	High	Medium	High at low speeds	Best for precise control of movement, such as robotic arms or where specific positioning is crucial.
Stepper Motor	Step control	High	Low to Medium	High at low speeds	Suited for precise steps in motion, making them perfect for 3D printers, CNC machines, and robots requiring detailed positioning without feedback.

Day
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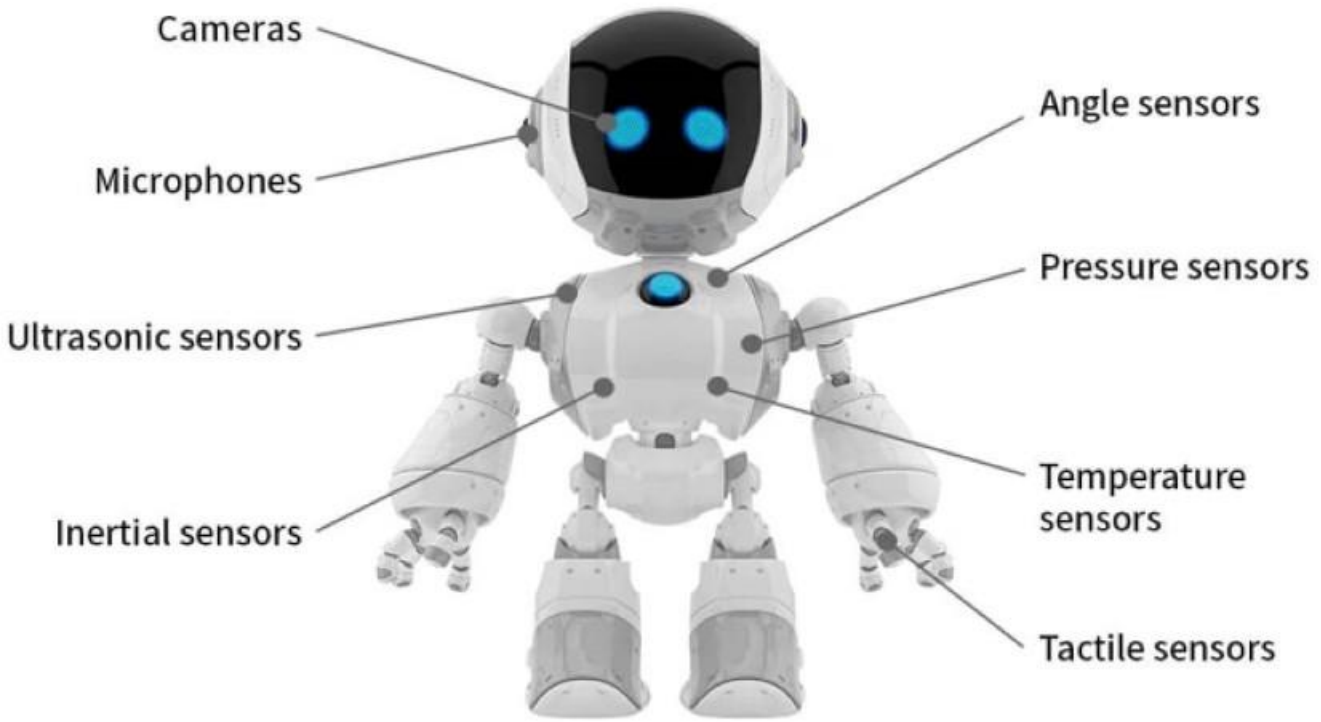
Sensors



Vision Sensors: The Eyes of Robots

- **Overview**: Introduction to how vision sensors allow robots to perceive their environment visually, simulate human sight.
- **Types**:
  - **Cameras (2D and 3D)**: Capture visual information. 2D cameras provide flat images, while 3D cameras add depth perception, crucial for tasks requiring spatial understanding.
  - **LIDAR (Light Detection and Ranging)**: Uses laser pulses to map out the robot's surroundings in high detail, essential for navigation and obstacle avoidance.
- **Applications**:
  - Object recognition, navigation, and environmental mapping.

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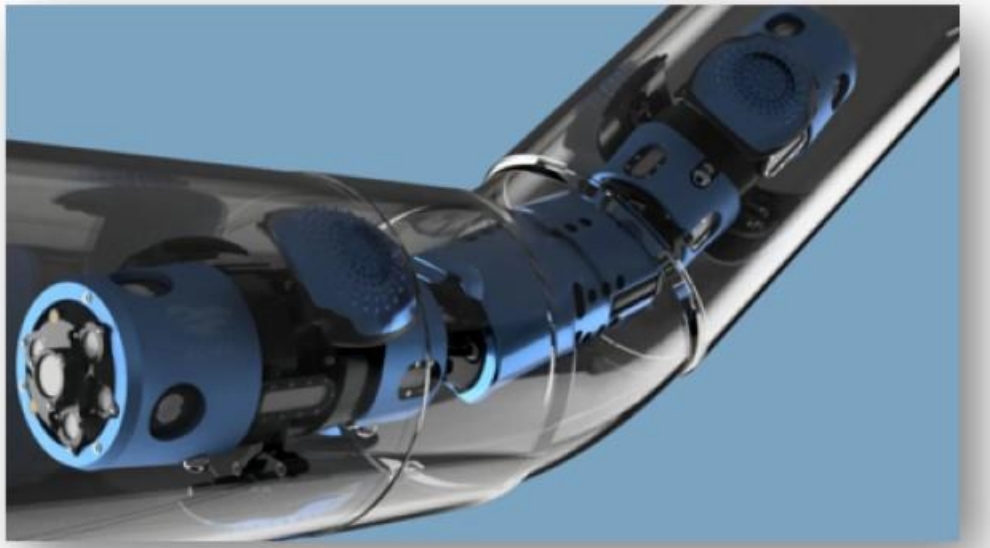
2D Camera Sensor



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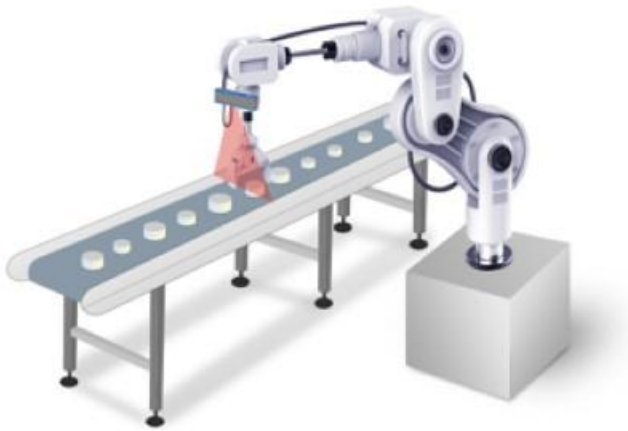
3D Camera Sensor



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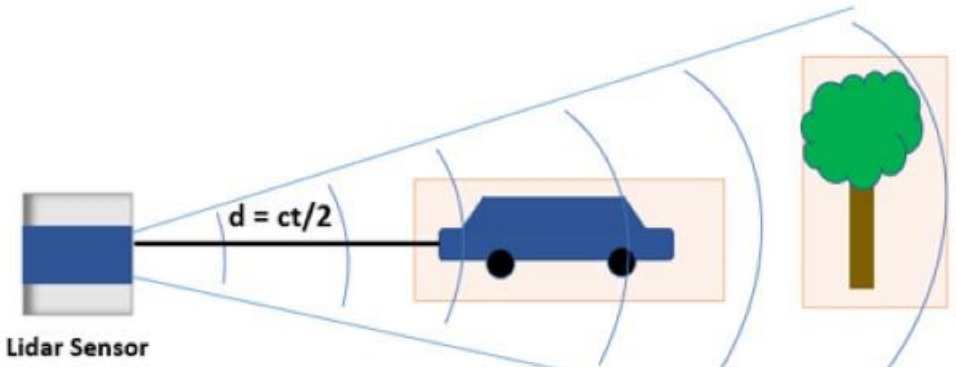
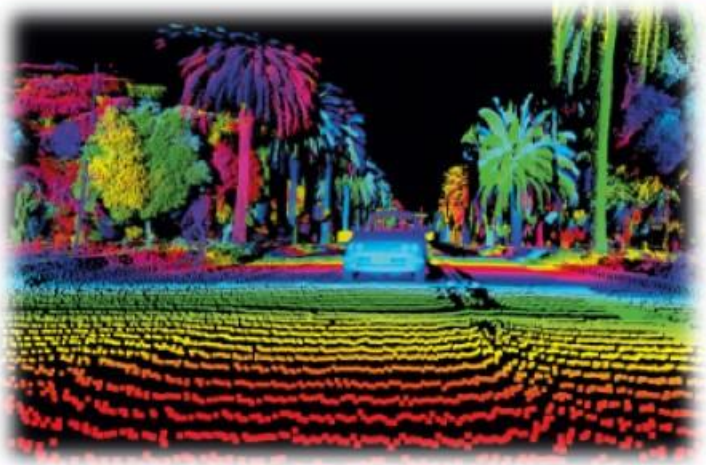
LIDAR (Light Detection and Ranging):



d = distance between point and the sensor
c = speed of light
t = time of flight



Proximity and Distance Sensors

Navigating Space: Proximity and Distance Sensors

- **Overview**: Explaining the role of proximity and distance sensors in detecting the presence of objects and measuring the distance to them.
- **Types**:
  - **Ultrasonic Sensors**: Emit ultrasonic waves and measure the reflection time to determine distance to objects. Widely used in robotic cars for obstacle detection.
  - **Infrared Sensors**: Use infrared light to detect objects and estimate distance, useful in line-following robots and simple navigation tasks.
- **Applications**:
  - Collision avoidance, area scanning, and precise movements in tight spaces.

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Ultra Sonic Sensor

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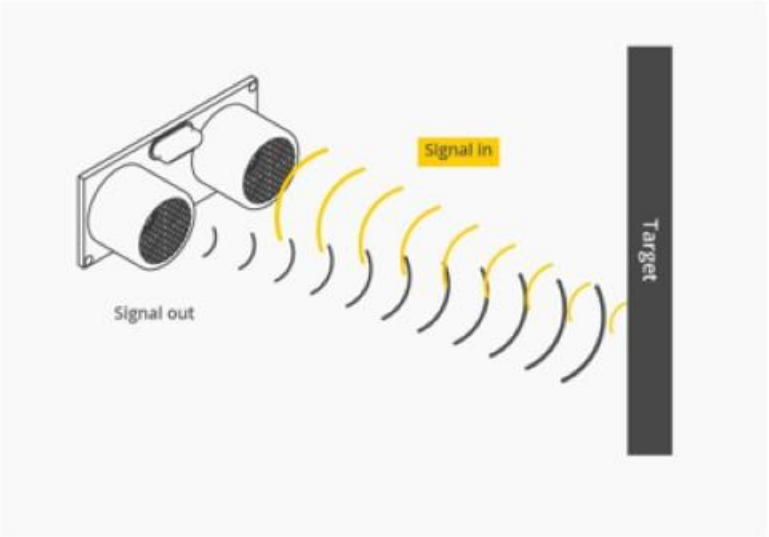

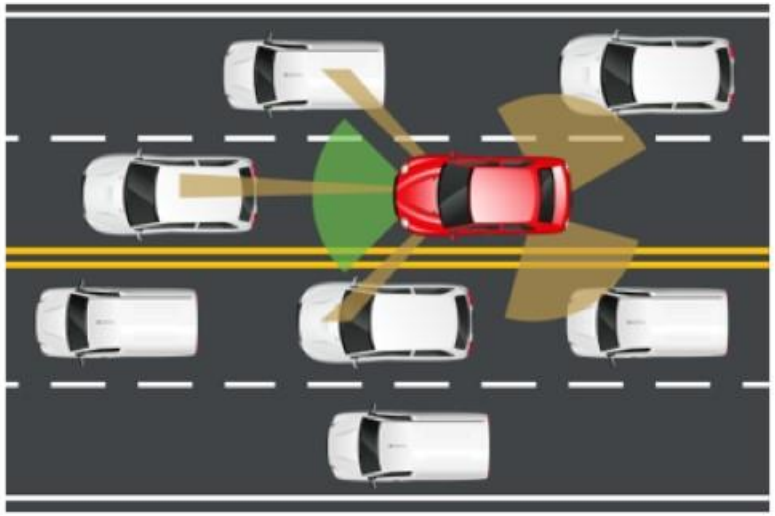

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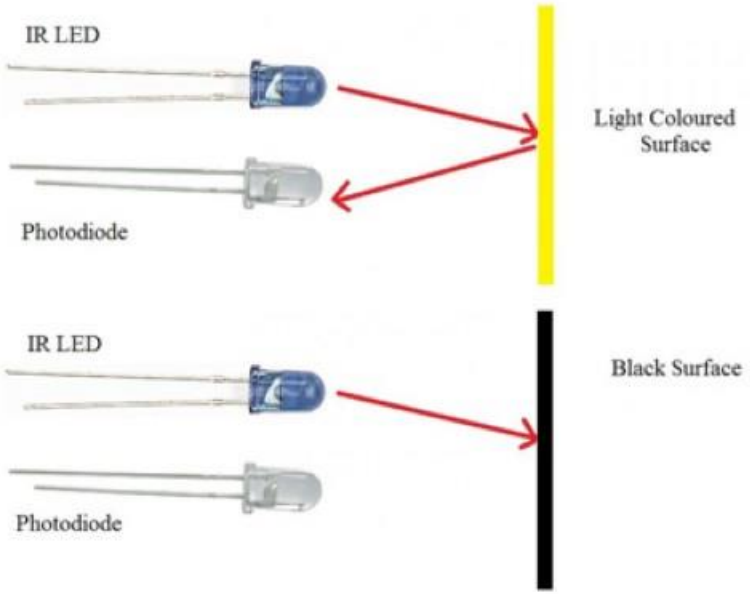
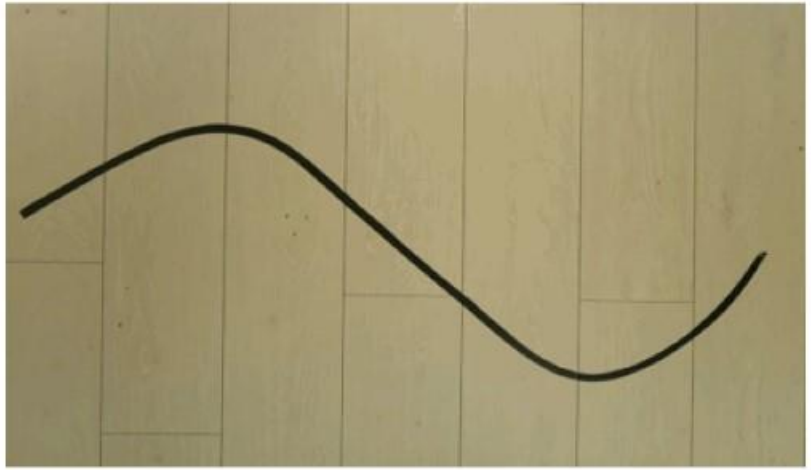
Infra red Sensor





Feeling and Interacting: Tactile and Environmental Sensors

- **Overview**: Highlighting sensors that allow robots to 'feel' their environment and respond to physical interactions or changes in their surroundings.
- **Types**:
  - **Tactile Sensors**: Enable robots to detect physical contact, pressure, and textures. Key in applications requiring delicate handling or manipulation, like robotic hands.
  - **Environmental Sensors**: Measure temperature, humidity, or gas concentrations, critical for robots operating in varying or extreme conditions, such as disaster response robots.
- **Applications**:
  - Hazard detection, material handling, and adapting to environmental conditions.

Day
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Tactile Sensors

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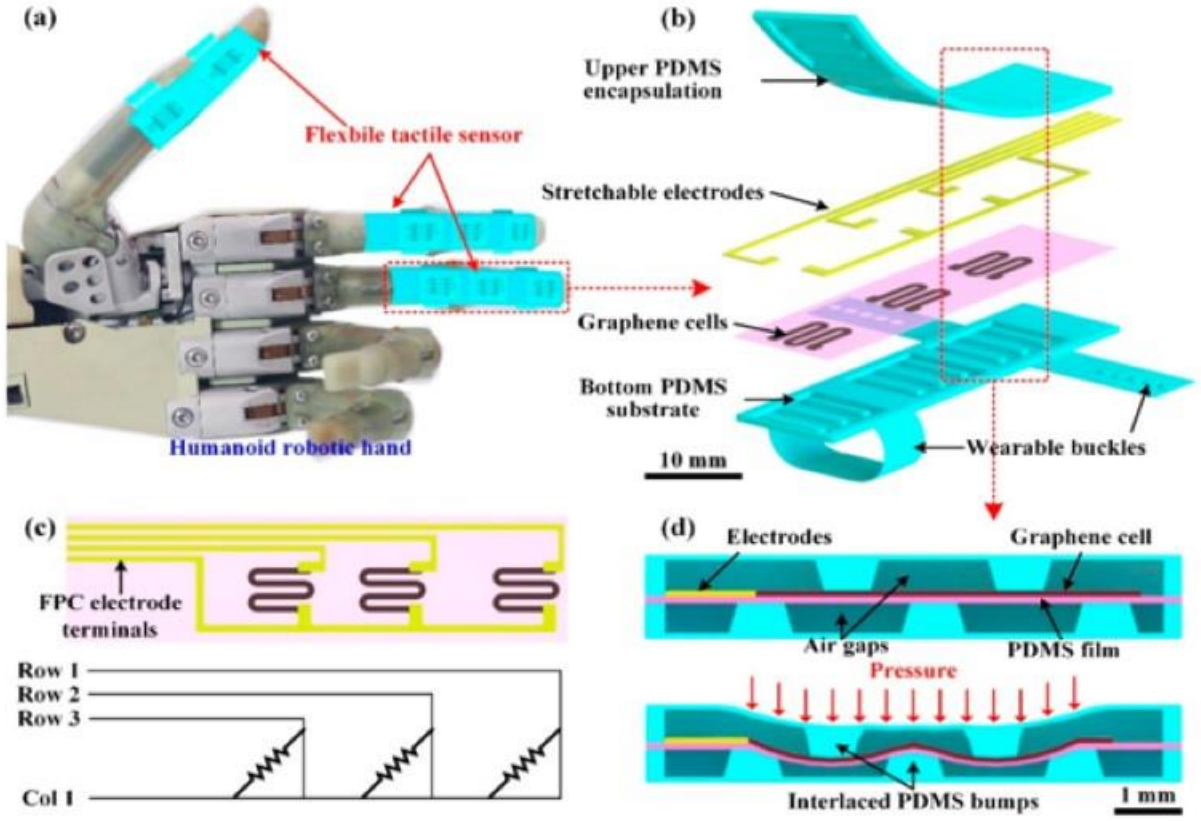

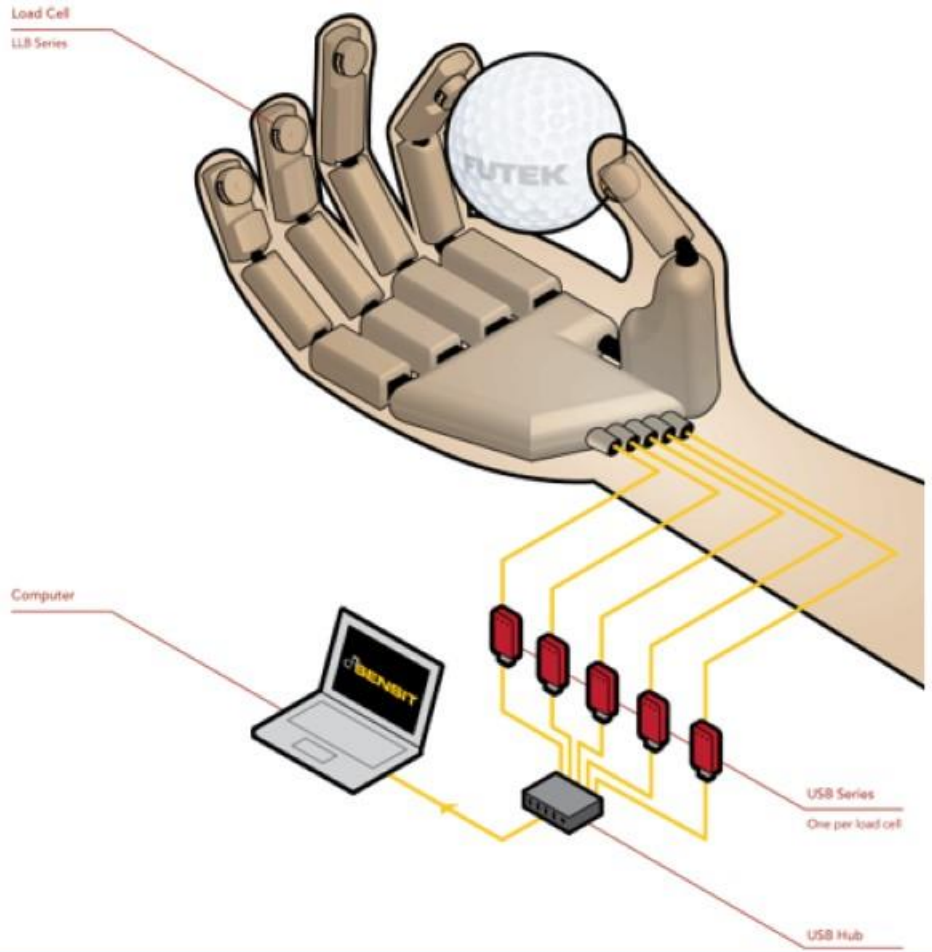

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Environmental Sensors

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Day
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Bringing It All Together

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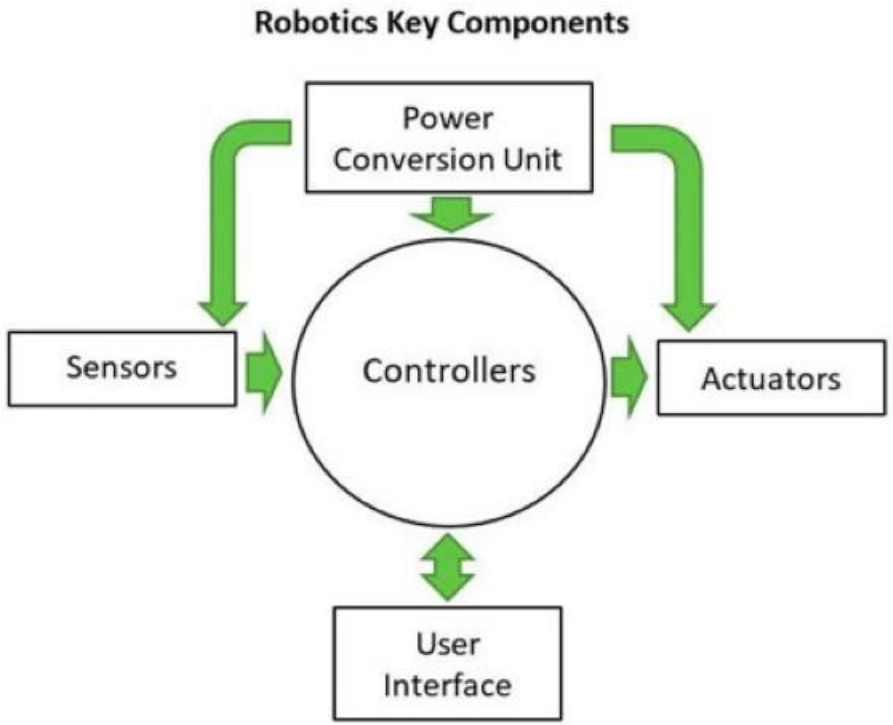

Day 01

Introduction to Webots

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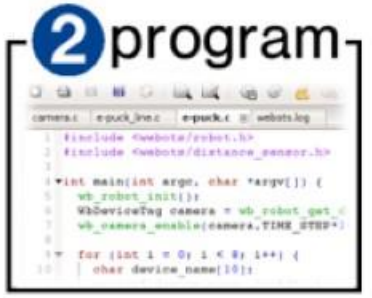
Webots

robot simulation

Webots is an open source and multi-platform desktop application used to **simulate** robots

https://cyberbotics.com/

Webots Open Source



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Introduction to Webots

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Introduction to Webots

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Introduction to Webots

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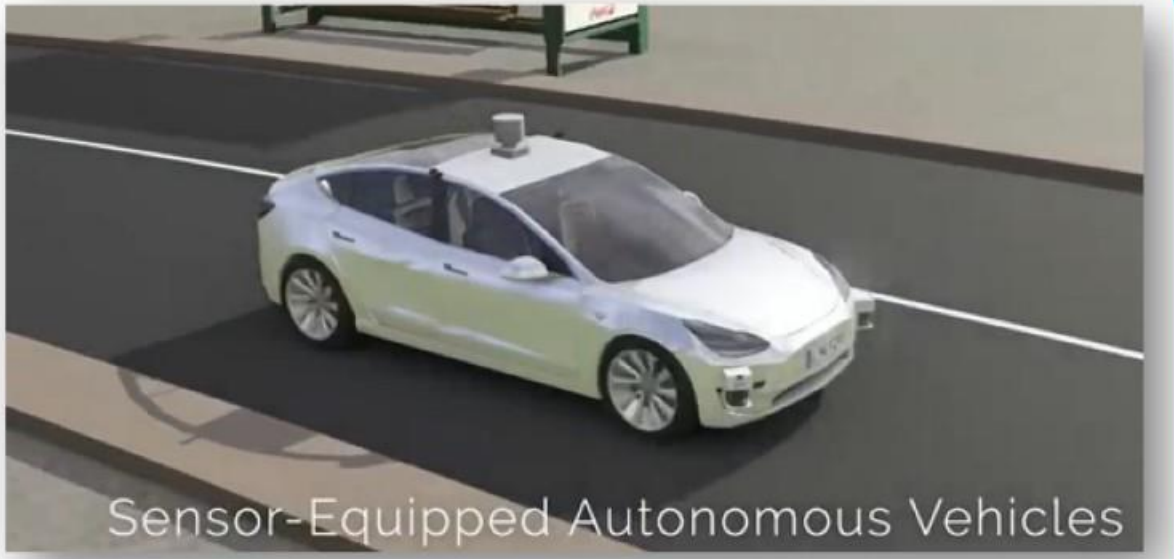

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Introduction to Webots

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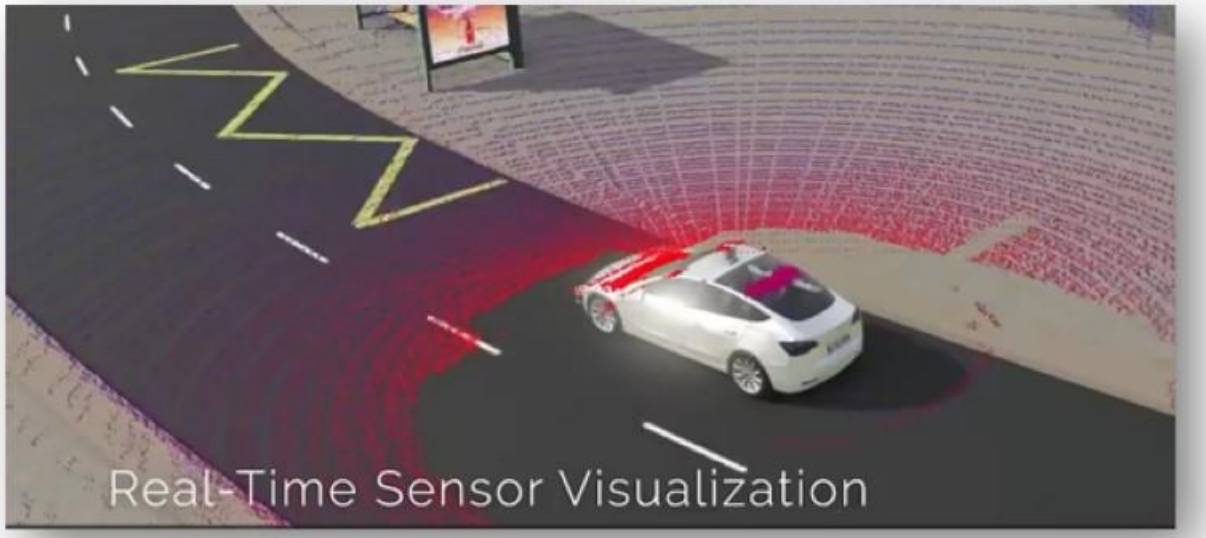

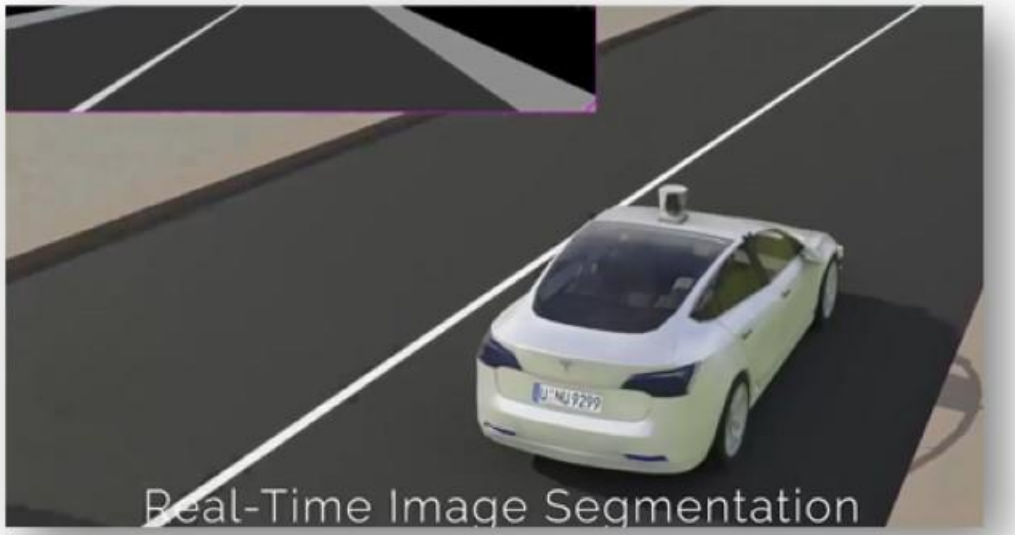

Day

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Webots is Amazing Because:

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- **Real Robots on Your Screen**: Your virtual robots in Webots move just like real ones. It's like having a robot pal in your computer!
- **Create Your Own Robot Places**: Make all sorts of places for your robots to explore, like cities, parks, or space stations!
- **Loads of Ready-Made Robots**: Choose from many robots that are already built in Webots. Start playing and learning right away.
- **Works on Any Computer**: You can use Webots on Windows, Mac, or Linux. It's super flexible!
- **Easy Robot Coding with Python**: Use Python, a simple programming language, to tell your robots what to do. Perfect for beginners and experts!
- **Teach Robots to Think**: Make your robots smart with Python. They can learn to solve problems by themselves, like real AI!
- **Robots with Cool Parts**: Add neat parts to your robots, like cameras, hands, or sensors, so they can see, touch, and feel.
- **All-in-One Robot Kit**: Webots has everything you need to create and control amazing robots.
- **For School, Research, and Business**: You can play with Webots alone, use it in school, or even in big research projects and businesses.
- **Used by Top Universities and Companies**: Many of the best universities and big companies in America use Webots. Places like MIT, Stanford, and tech giants in Silicon Valley trust Webots for their robot projects.

Day
01

WeBots

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Download & Install
User interface (UI)
Create your first project
Make your own object
Understand fundamentals
Run your first simulation
Add a robot & run simulation
Where is the code

Objective
User Interface (UI)
Create your first Project

Day 01

User Interface (UI)

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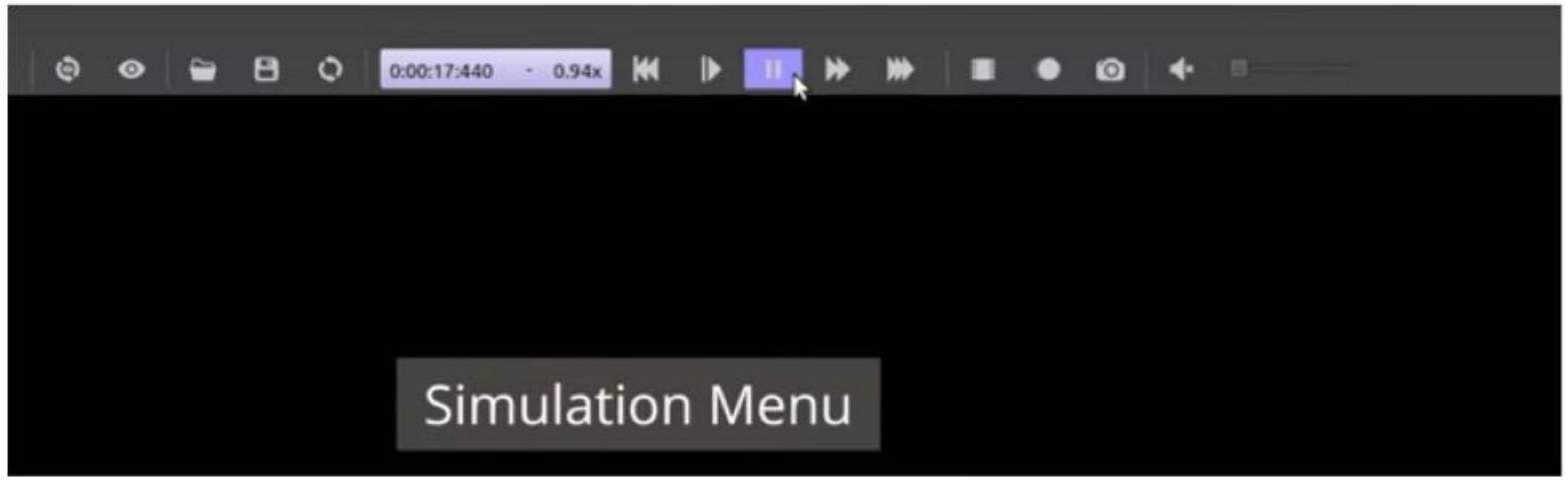

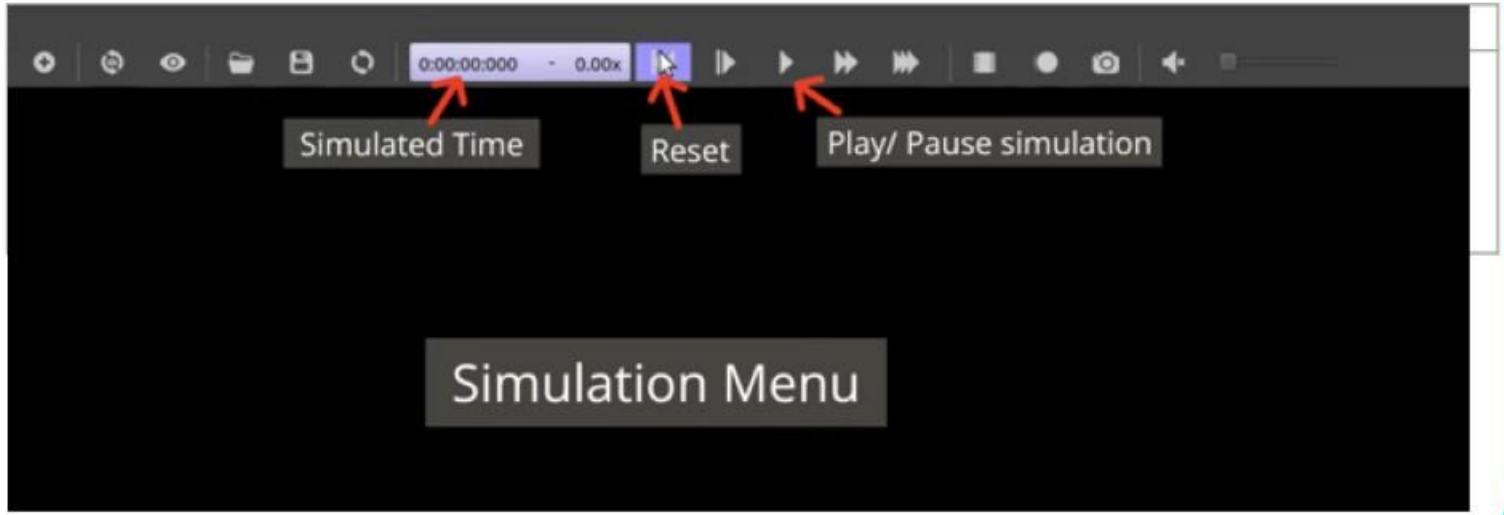

Day
01

Create new Project

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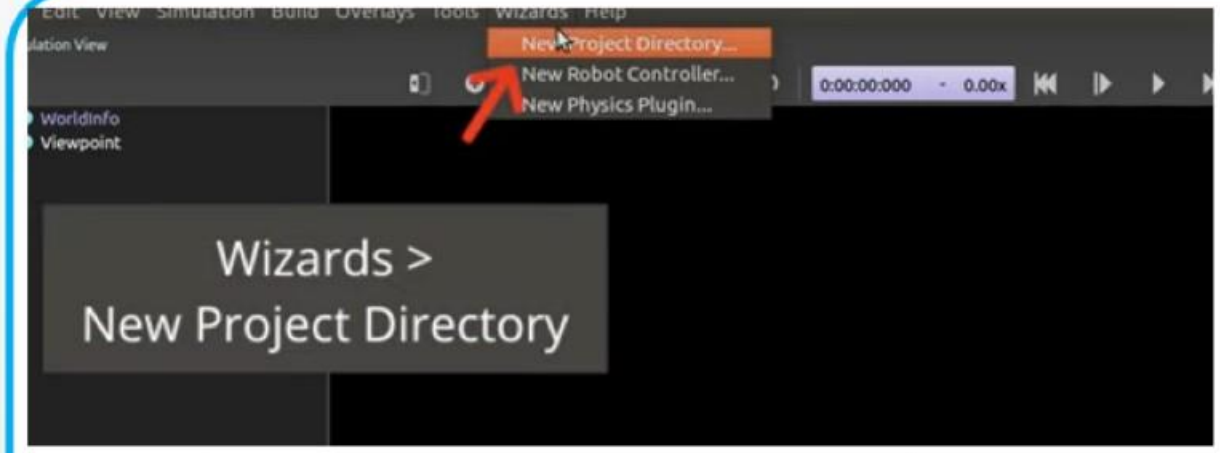

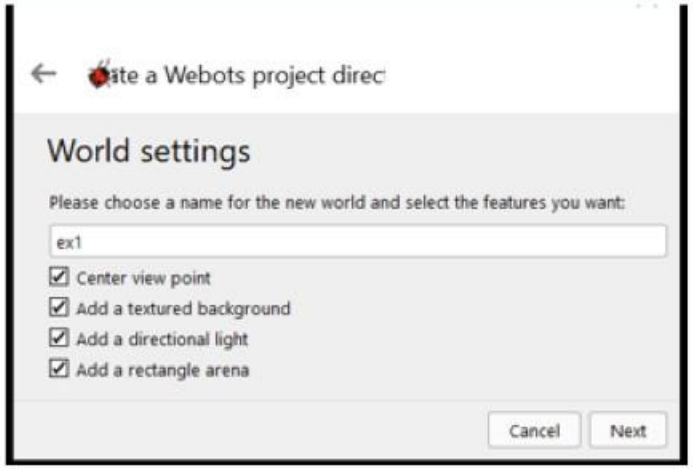

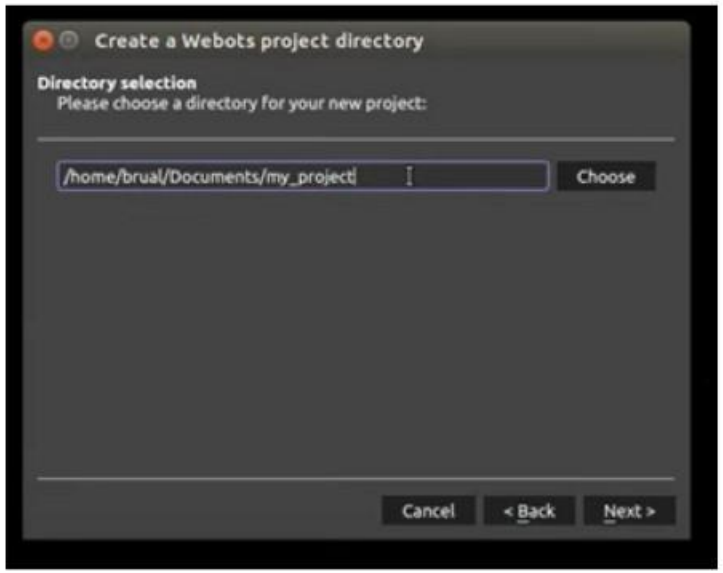

Day

01

Create new Project

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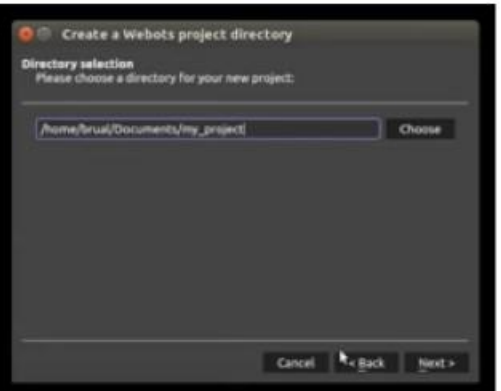
(1) Use "Choose" to choose where to save your project.

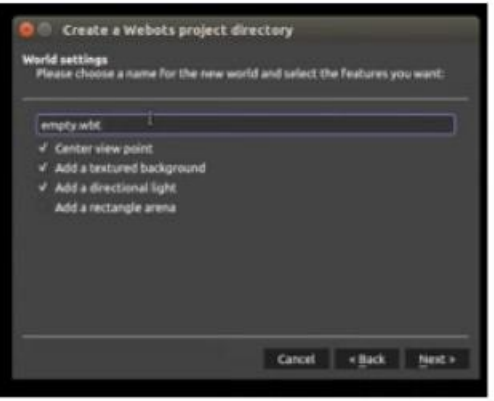
(2) Name your project. Eg: my_project

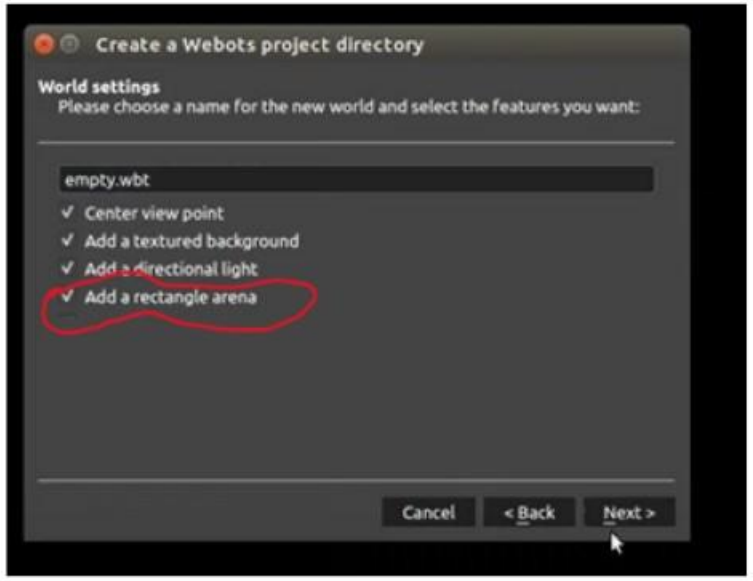


(3) Click Next

(4) Select "Add rectangle arena"

(5) Click Next & Finish





Day
01

Create new Project

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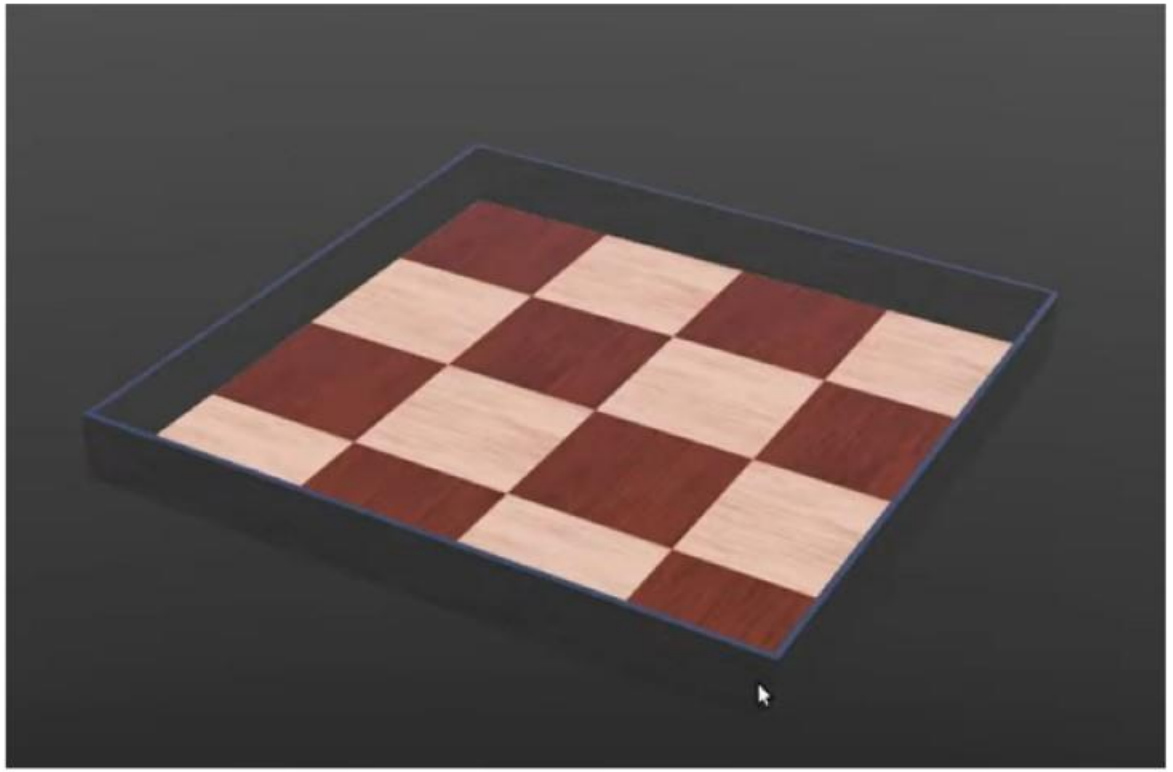

Loaded with a rectangular arena essentially a floor with four walls.

Day
01

Create new Project

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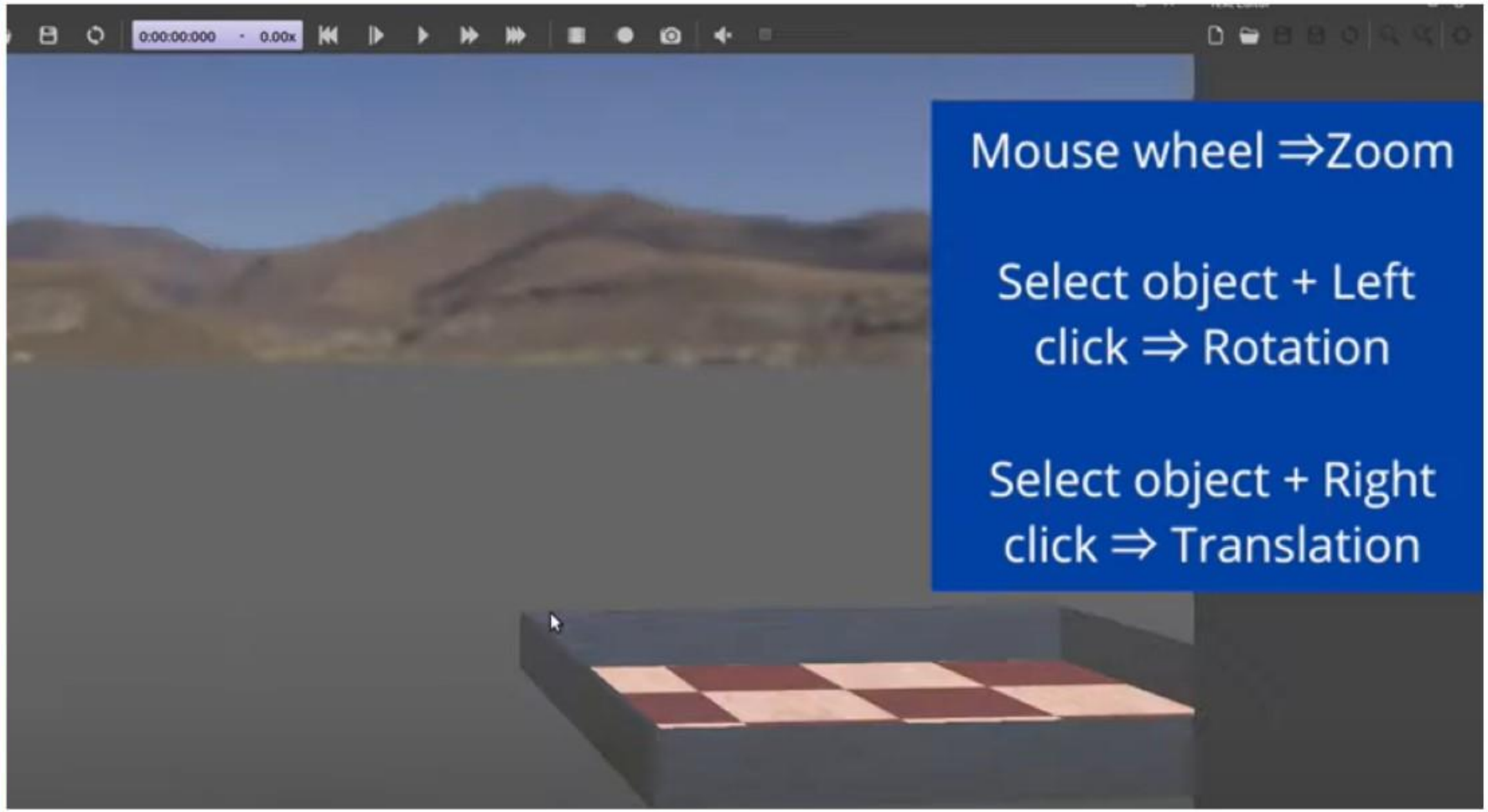

learn how to zoom in and zoom out this is simply done by scrolling in and out

Day
01

Create new Project

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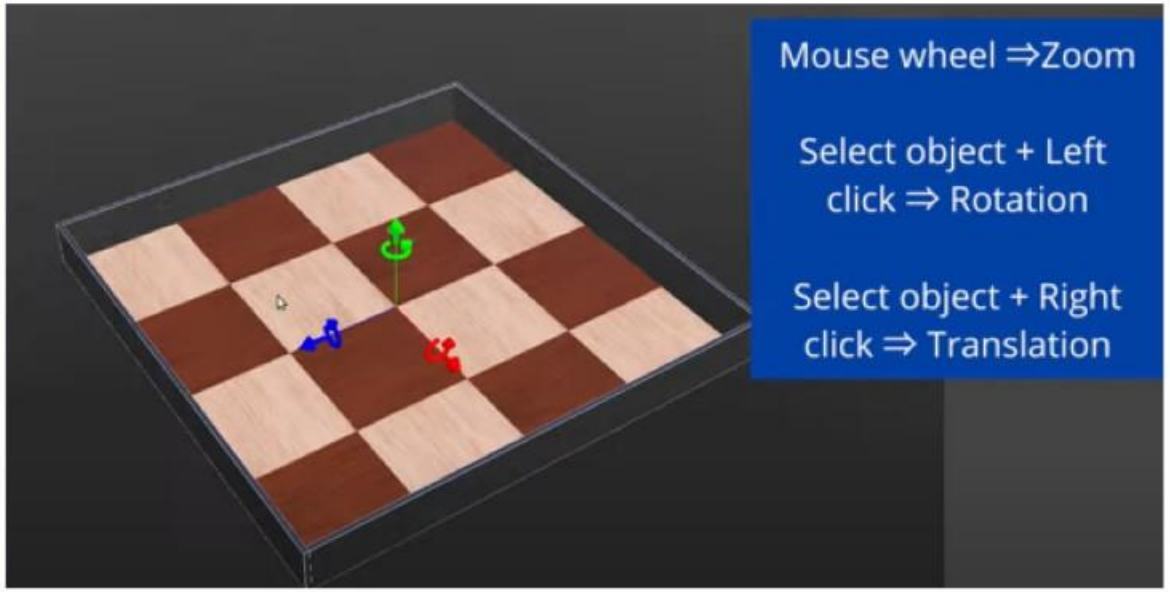

you can click on it and you can move it around to look at different views.

Day

01

Create new Project

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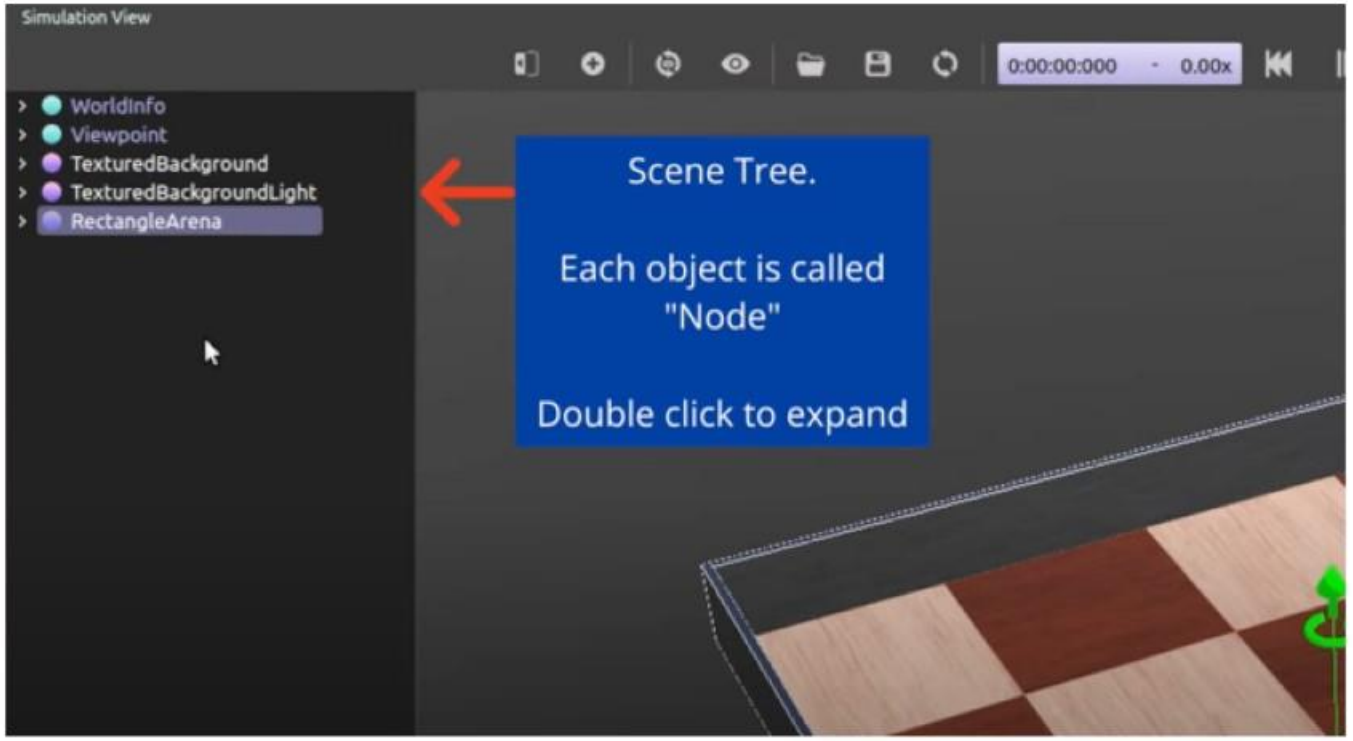

Day

01

Change the Floor Size

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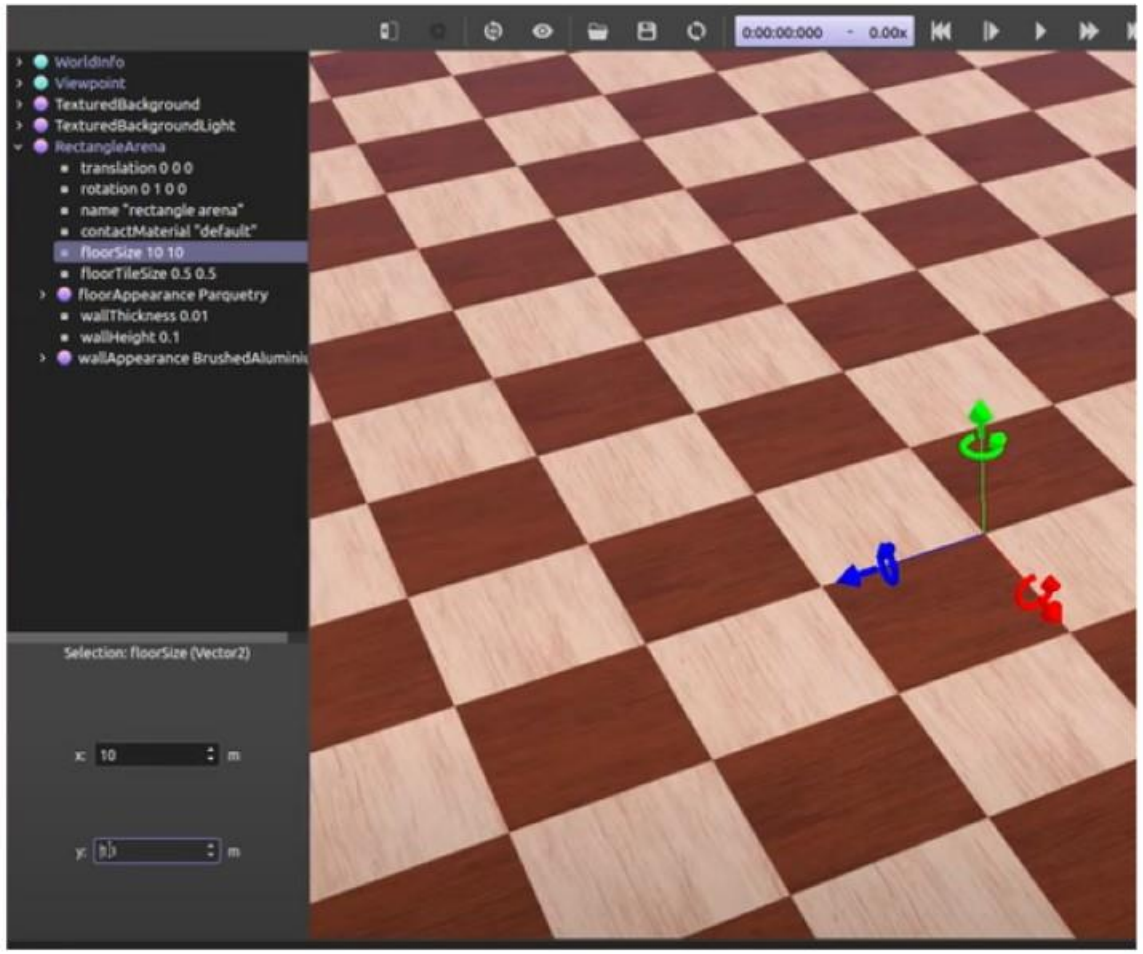

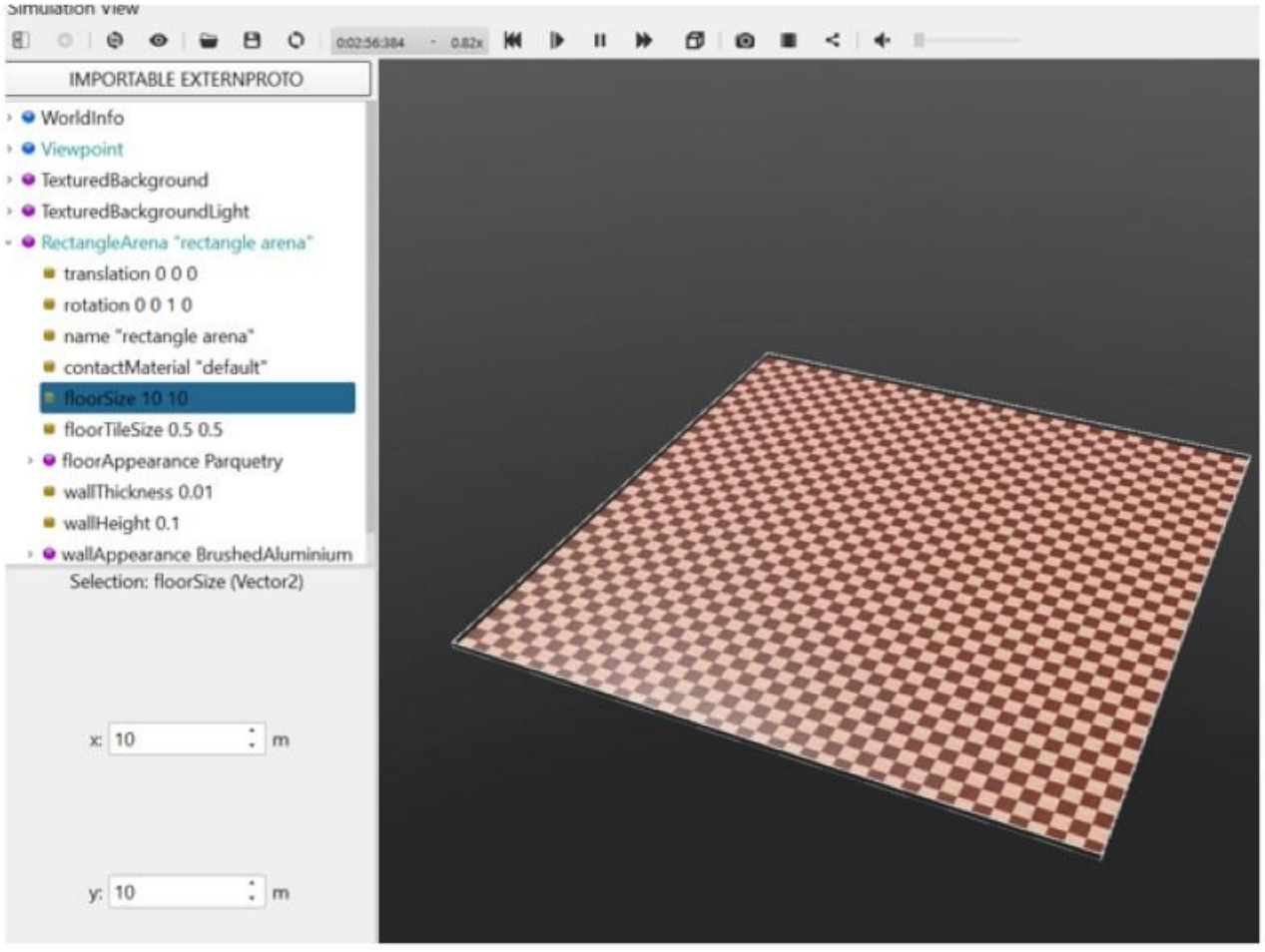

Day
01

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ADD Object

ADD NewObject.mp4

Day

01

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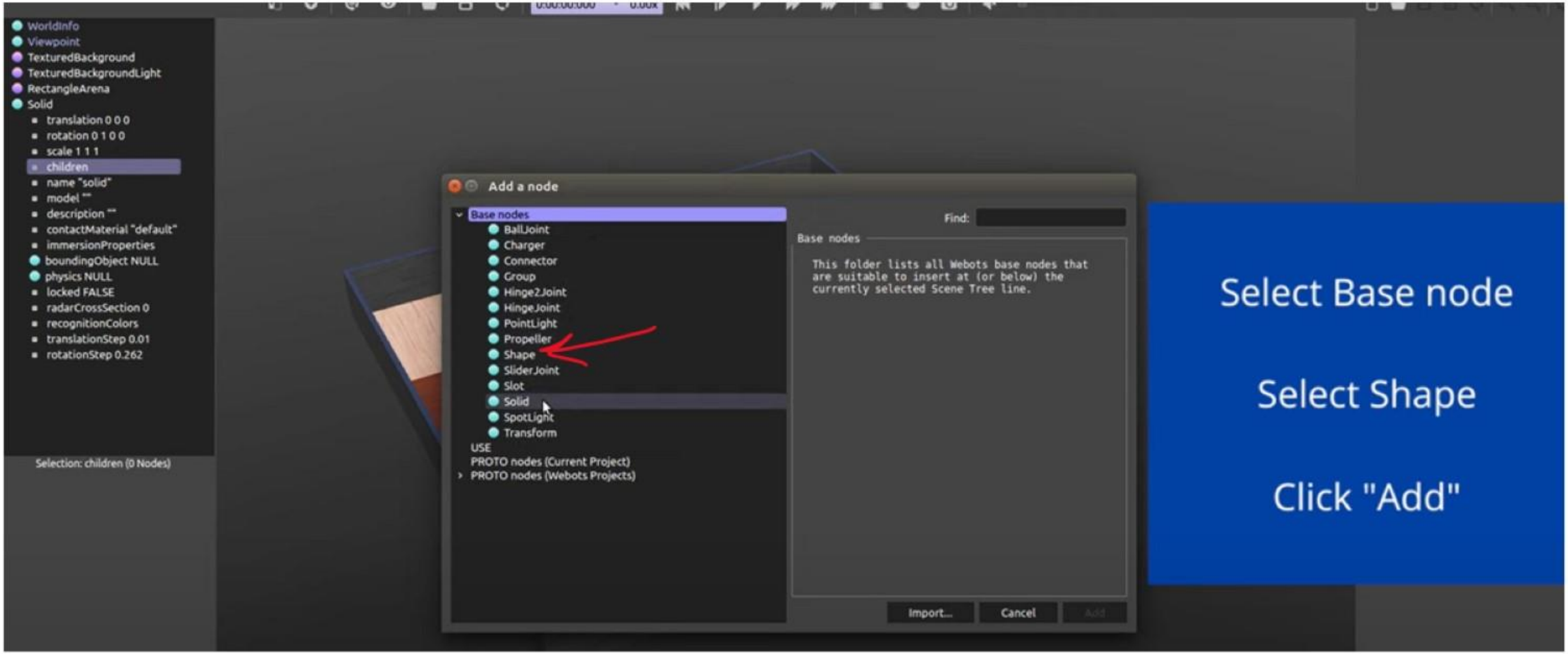

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Day

01

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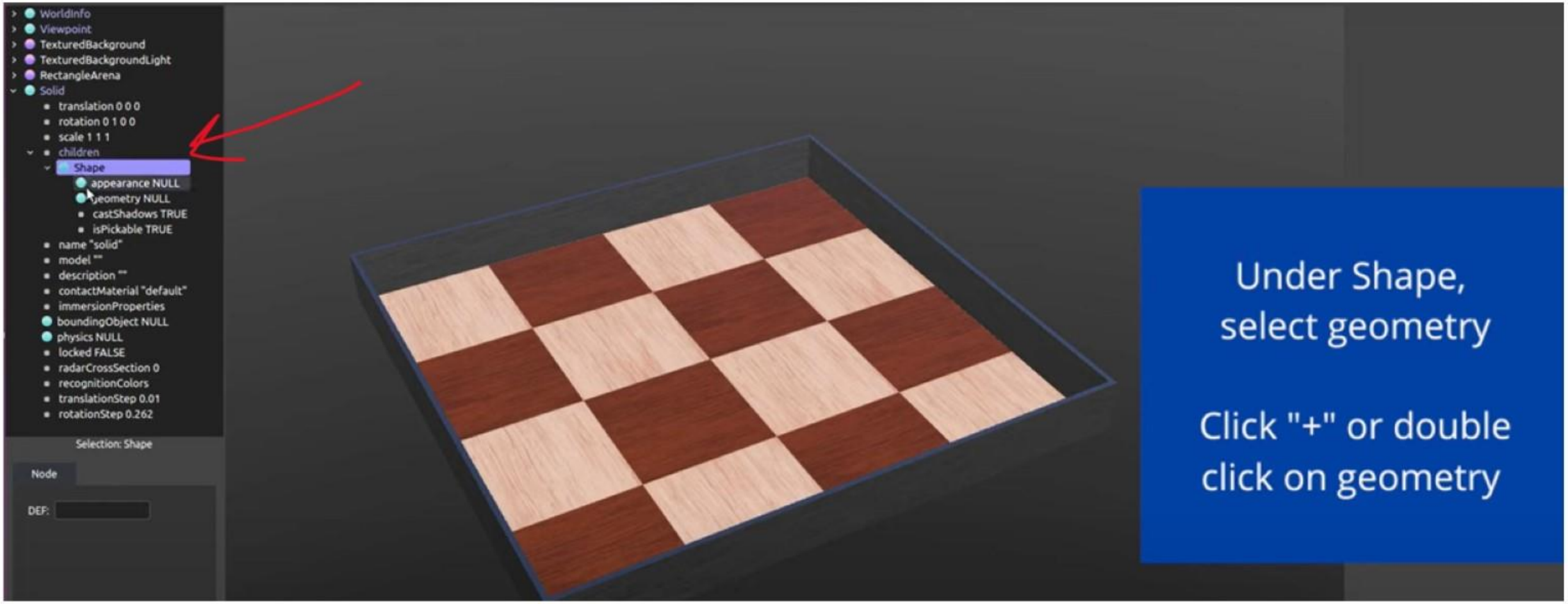

Day

01

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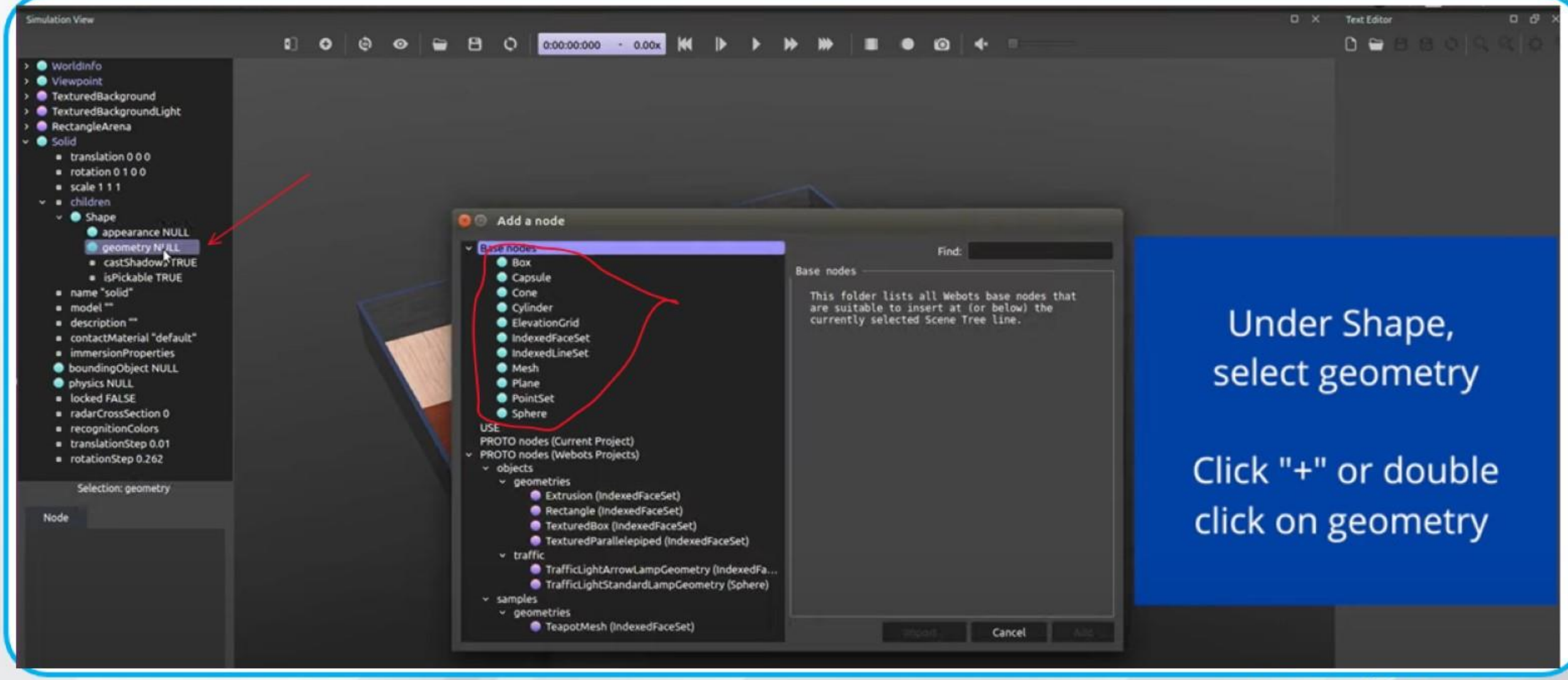

Day

01

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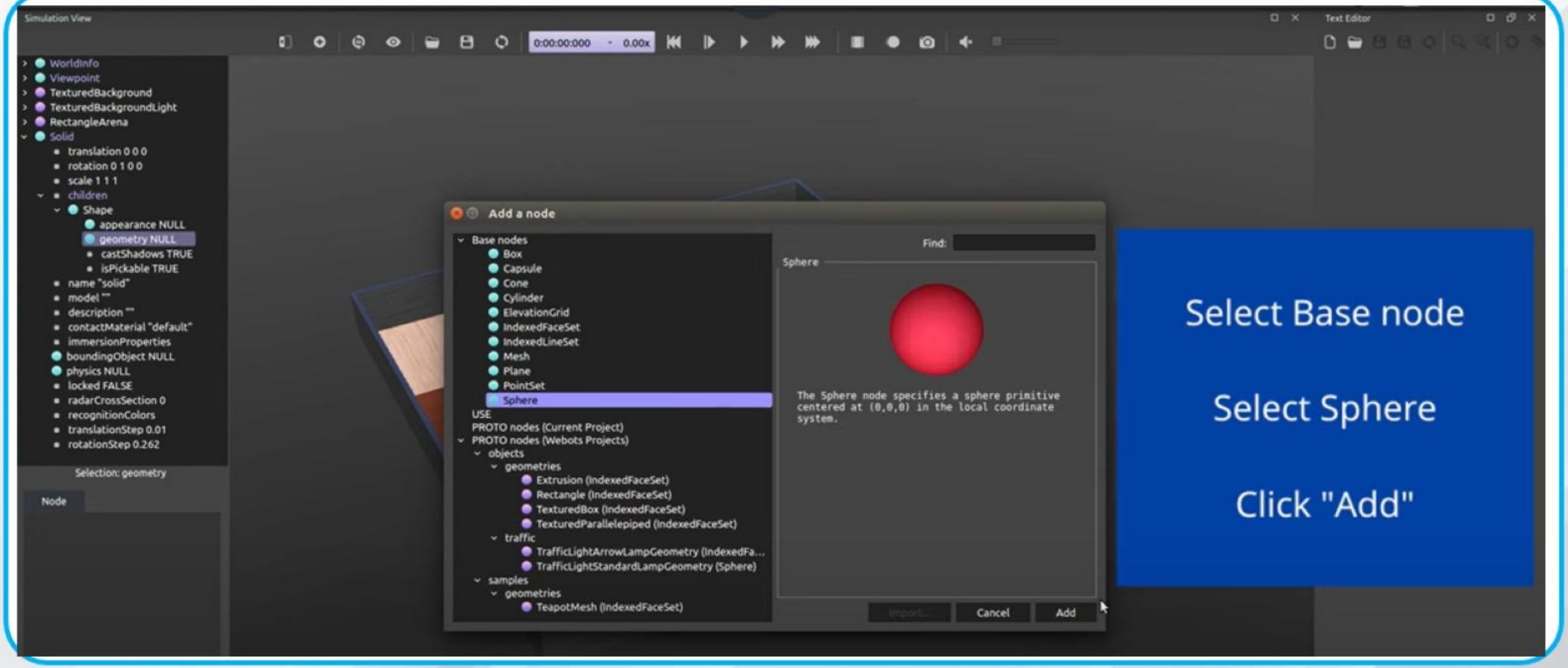

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Day

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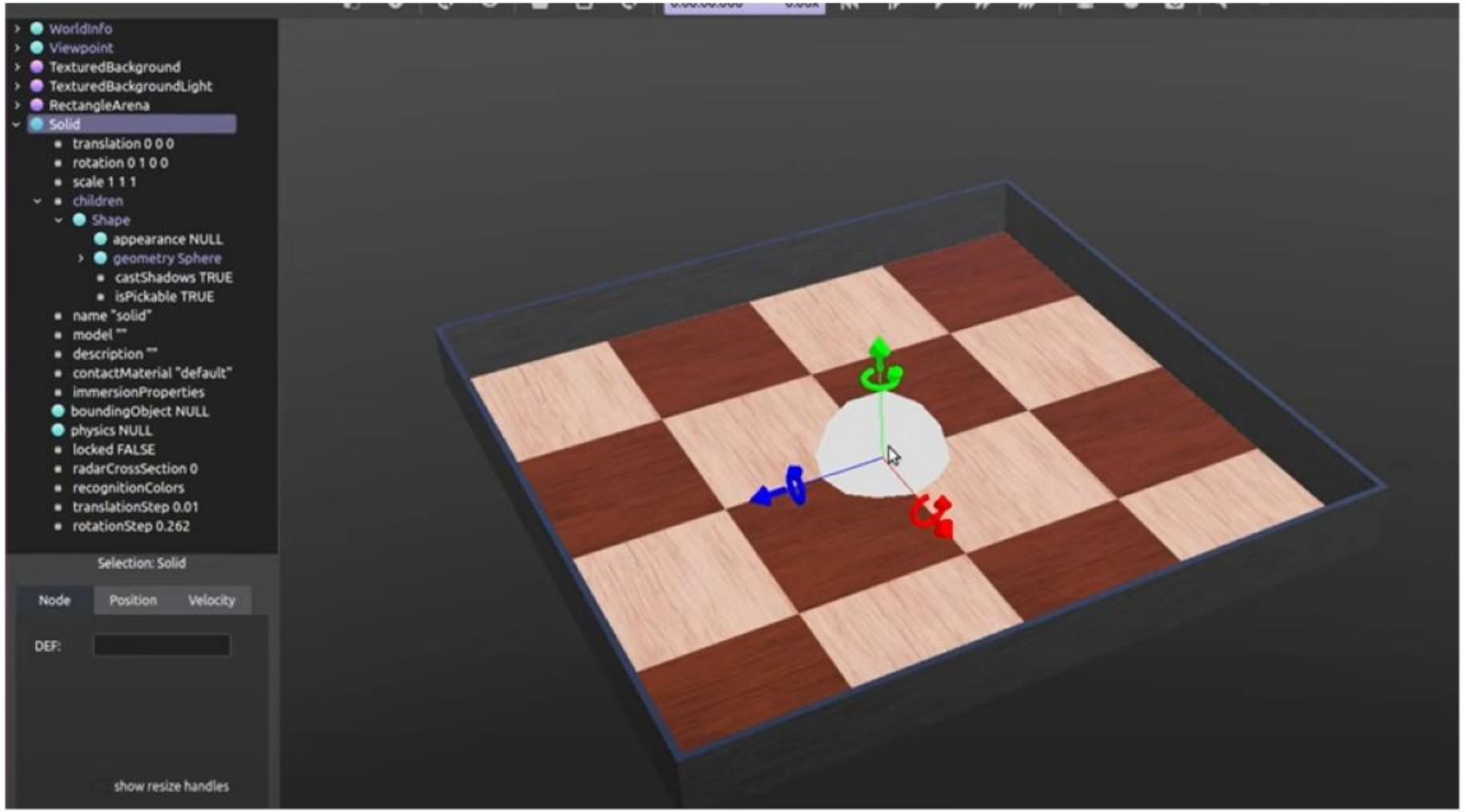

All objects added at (0,0,0).

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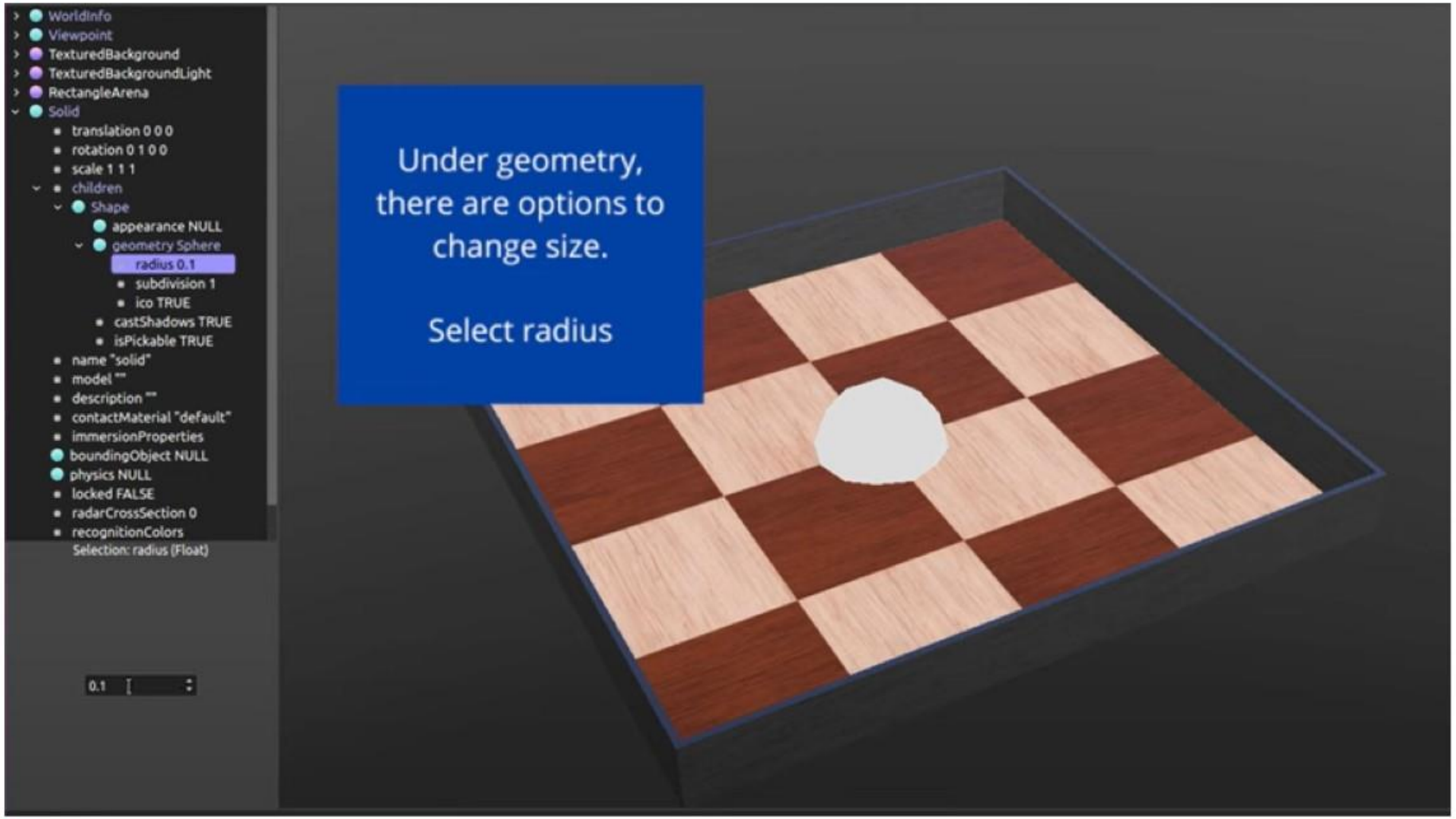

the dimensions so we could go from 0.1 to 0.05 and you can see the sphere has reduced

Day

01

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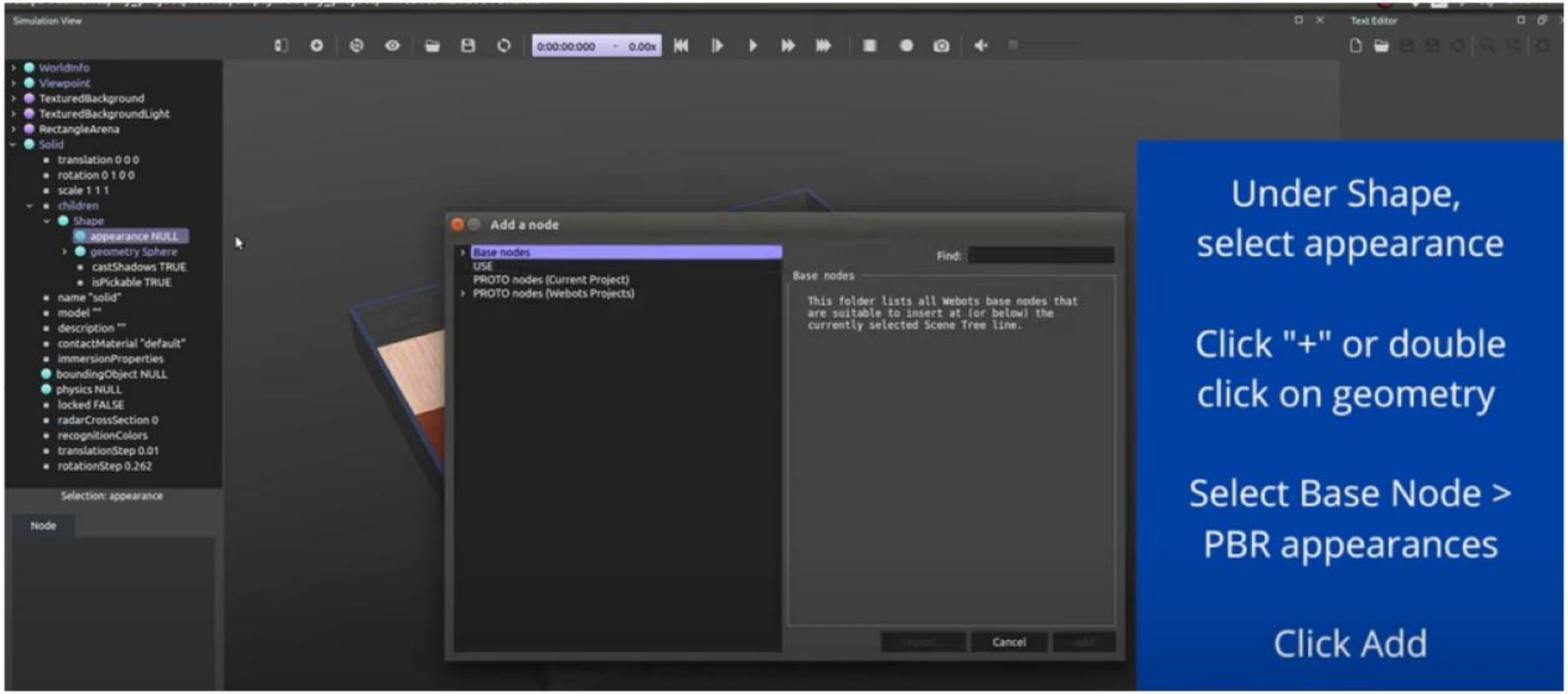

Day

01

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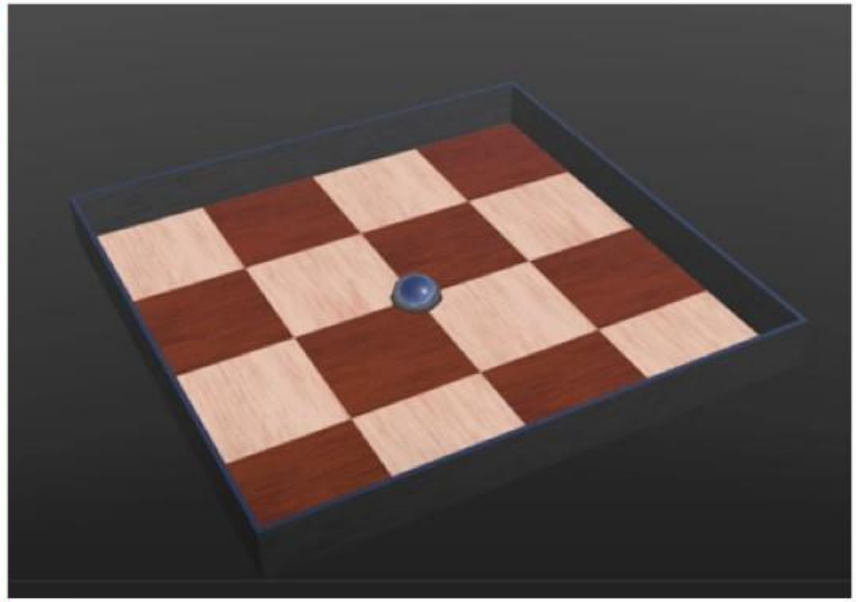
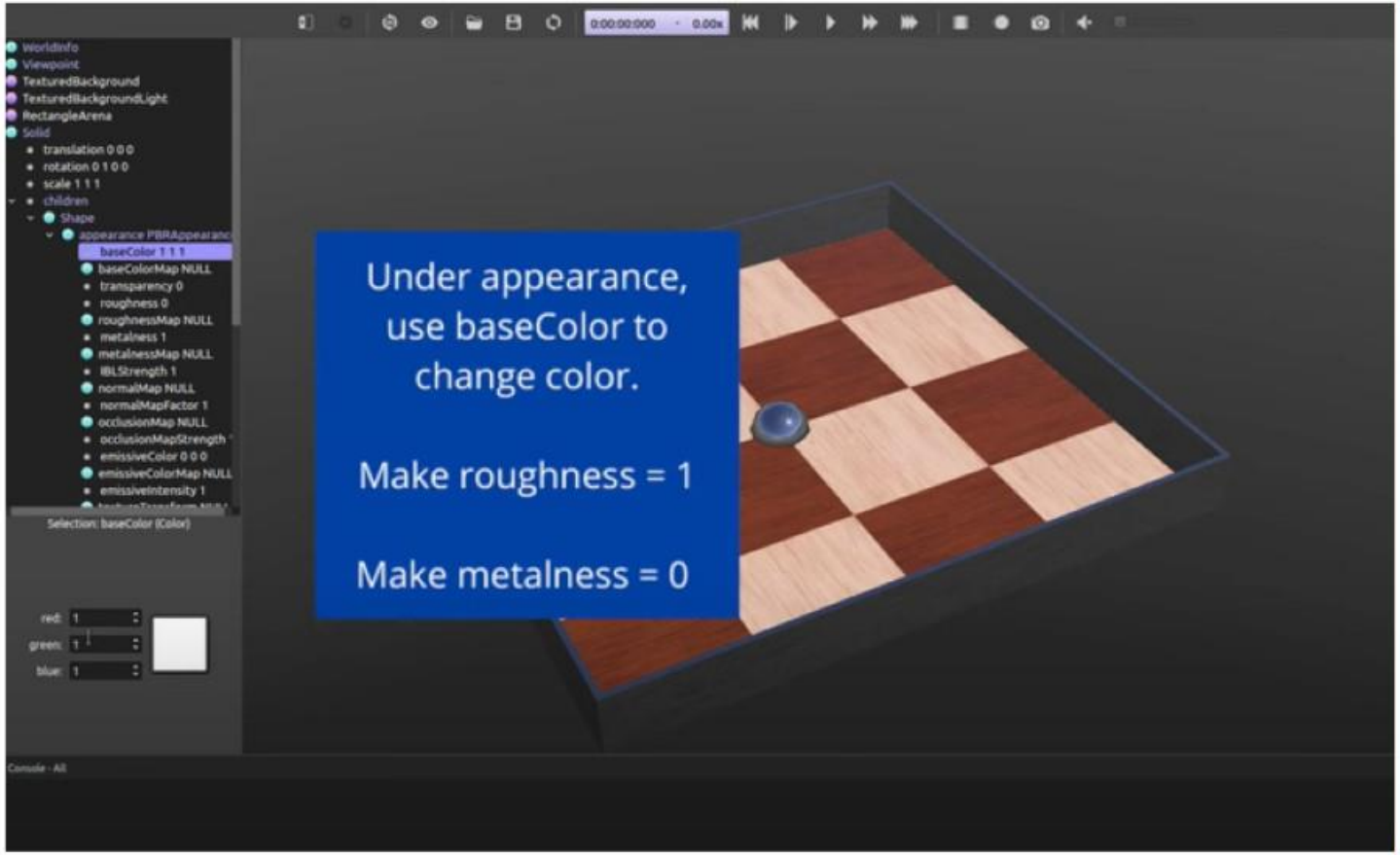


You have different options:



Day

01

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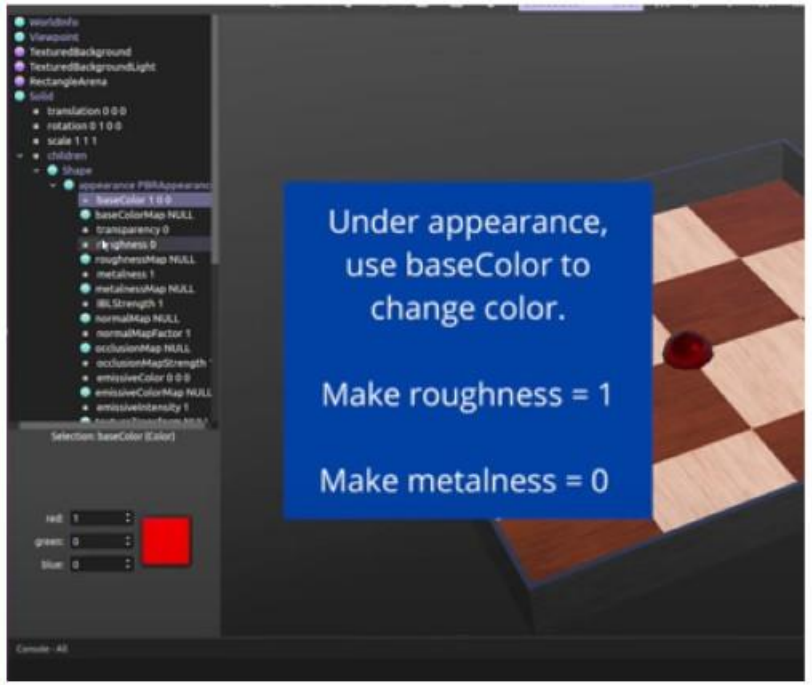

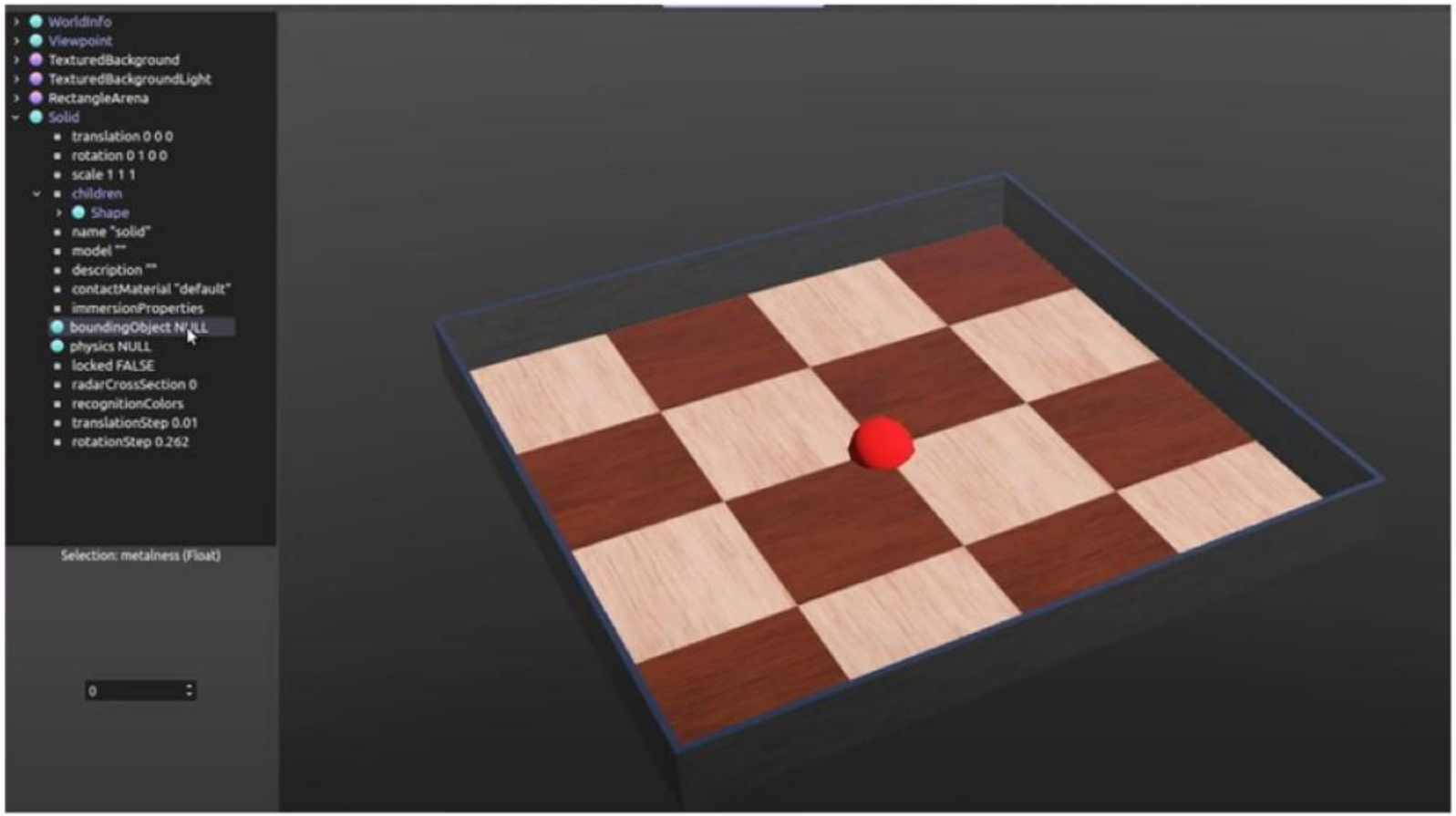

Day
01

NOW using Existing Objects and ROBOTS

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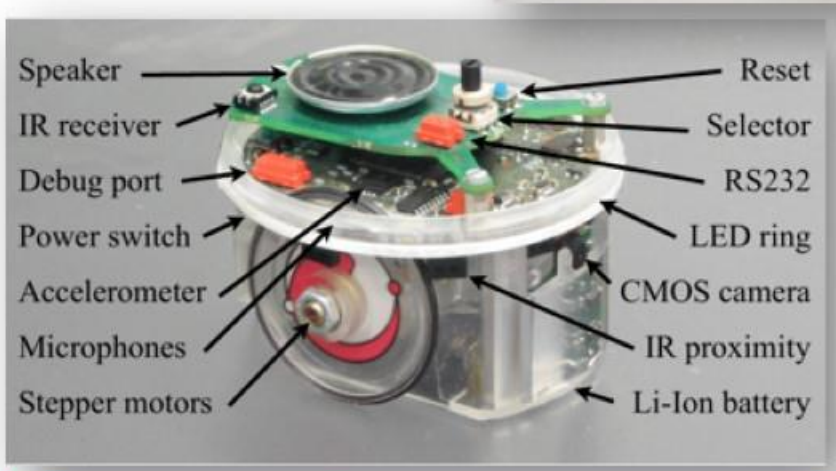
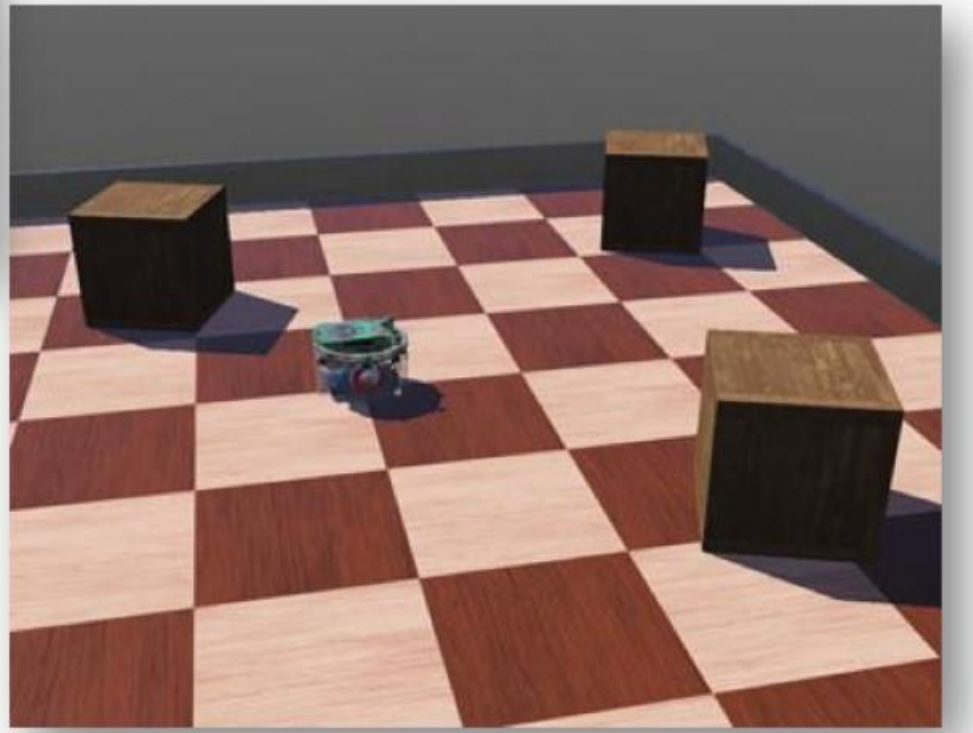
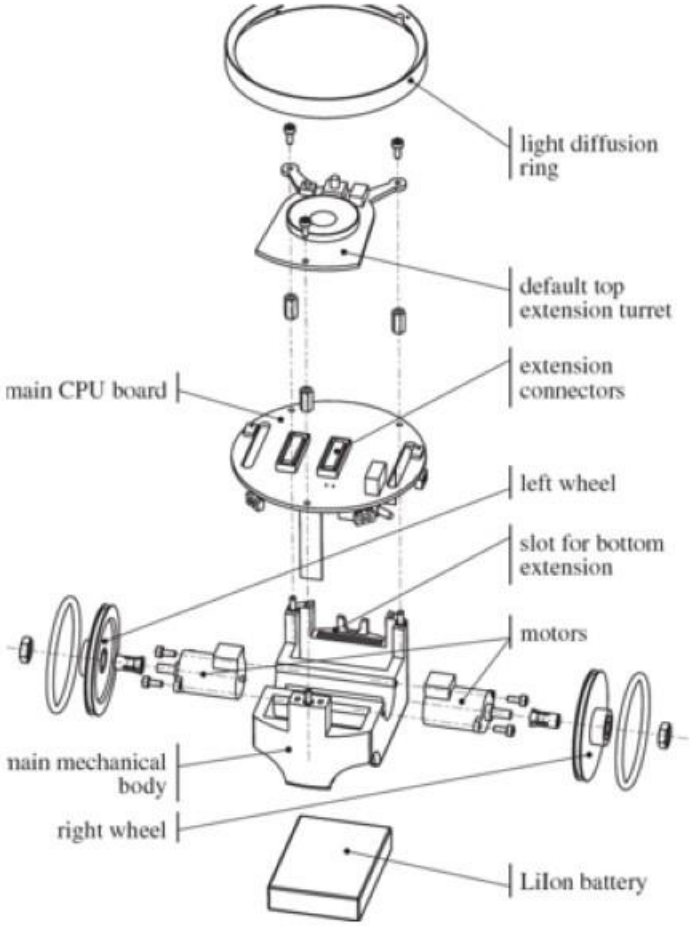
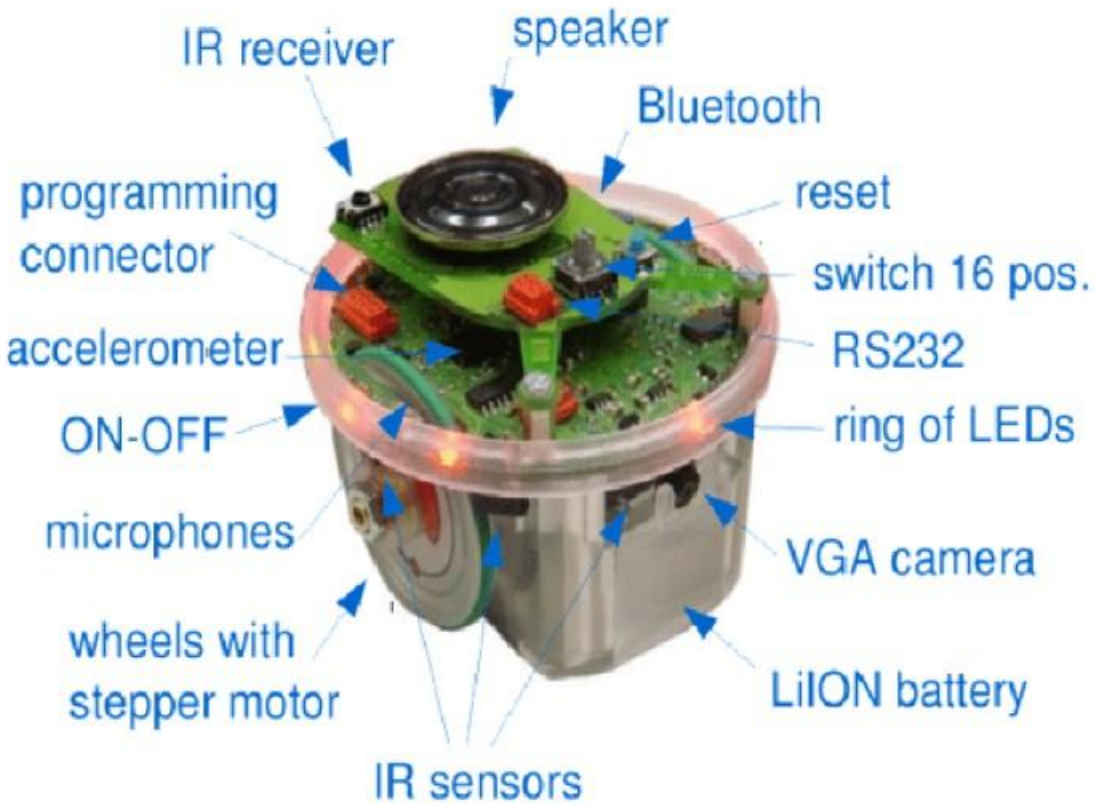


e-puck education robot



e-puck education robot





Day

01

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WATCH VIDEO

ADD ROBOT.mp4

Day

01

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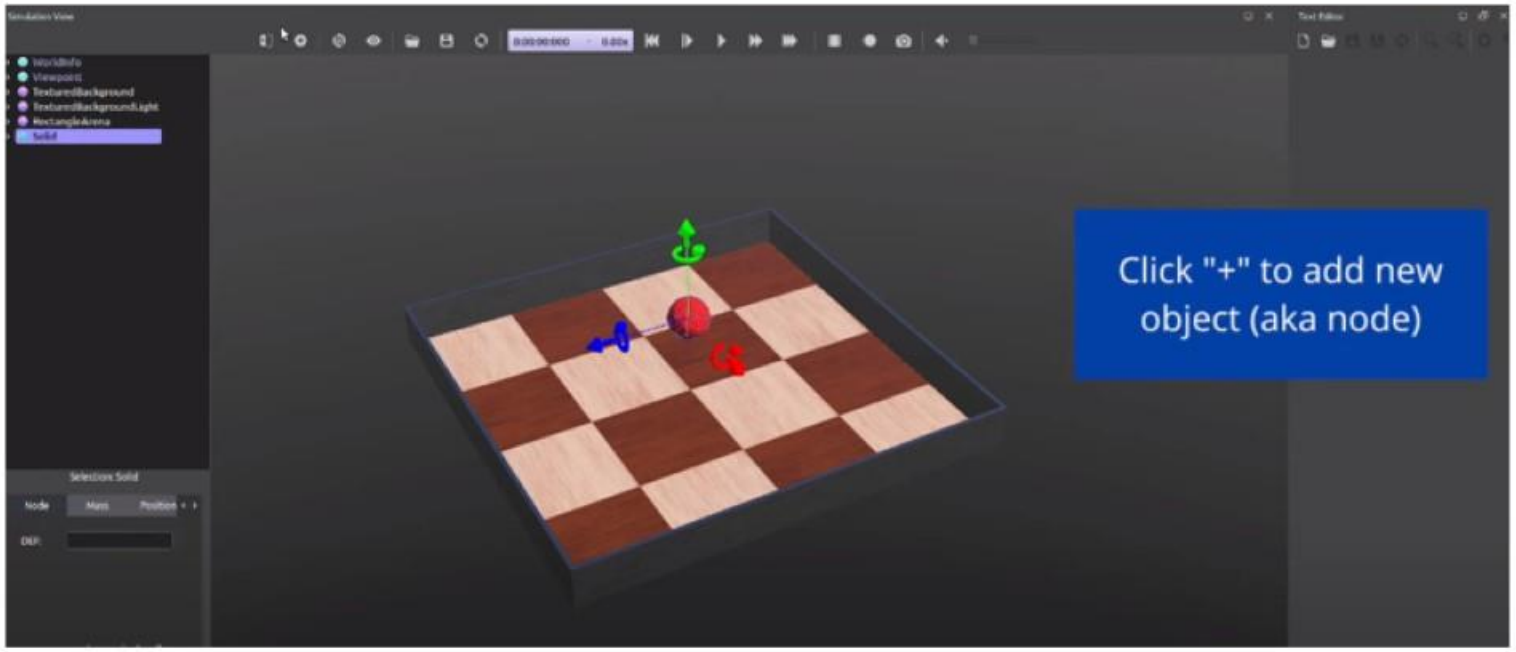

Click on the Add button at the top of the scene tree view. In the dialog box, choose PROTO nodes (Webots Projects) / robots / gctronic / e-puck / E-puck (Robot)

Day

01

Follow the following selection sequences:

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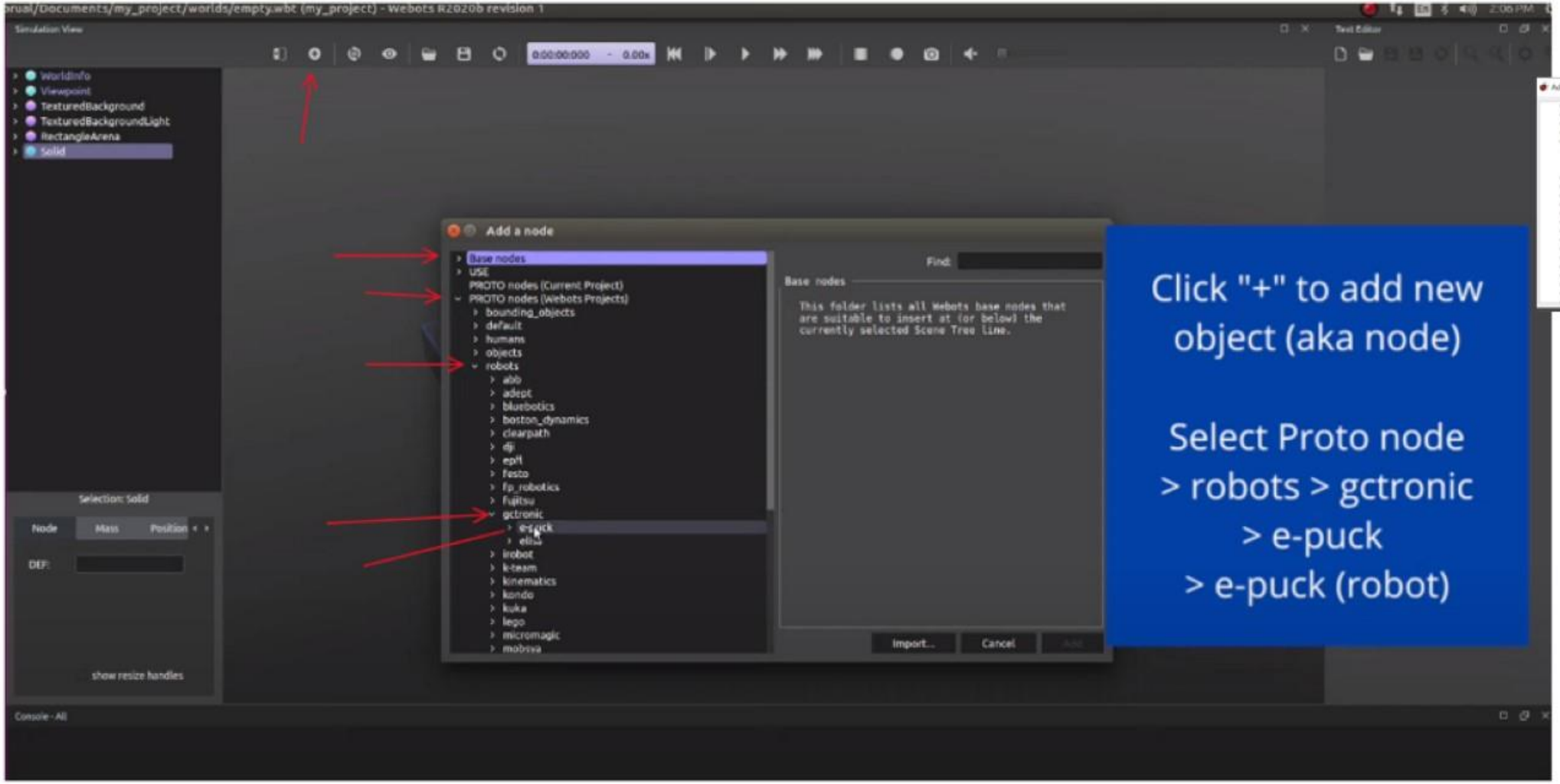

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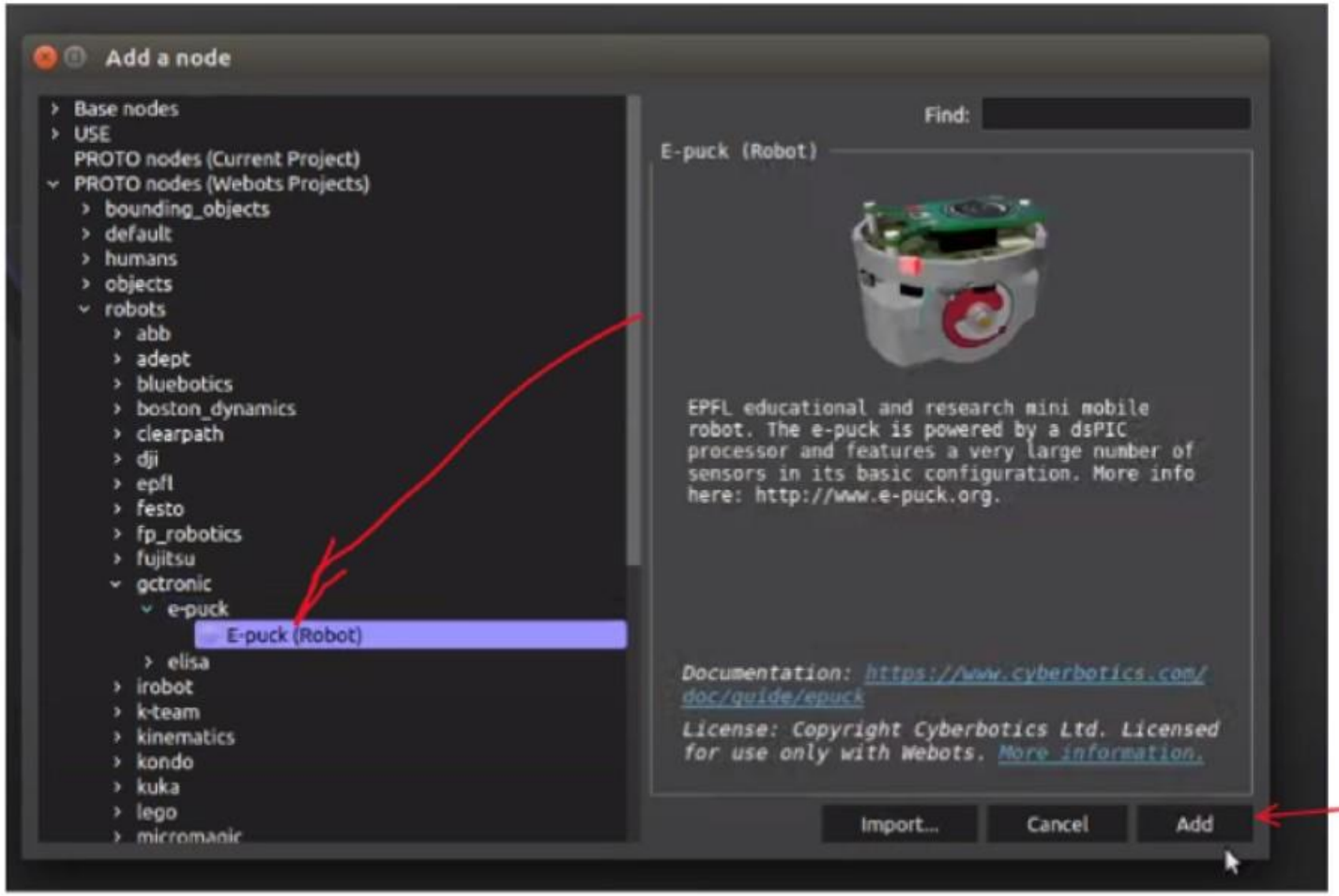

Day

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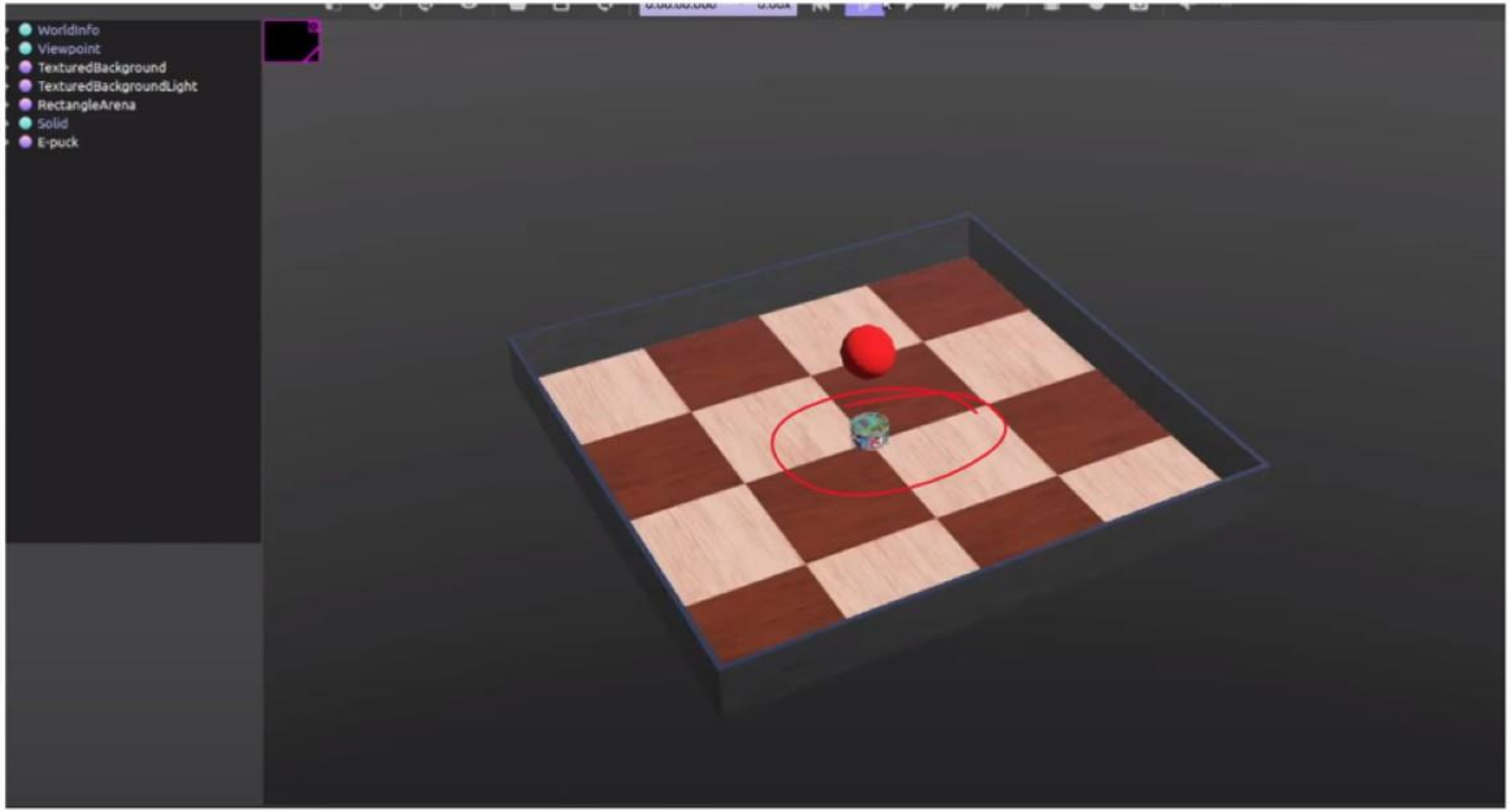

Day

01

When start the simulation (RUN) the Robot continue to drive.

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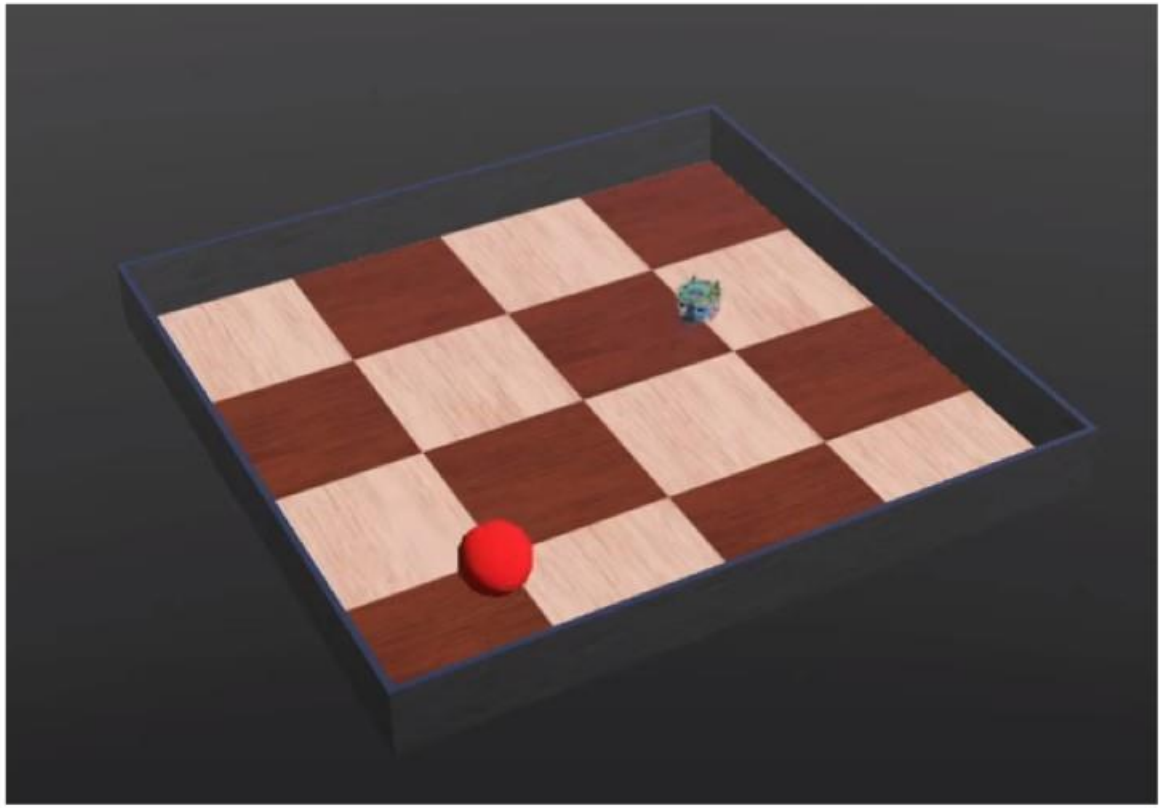

Day

01

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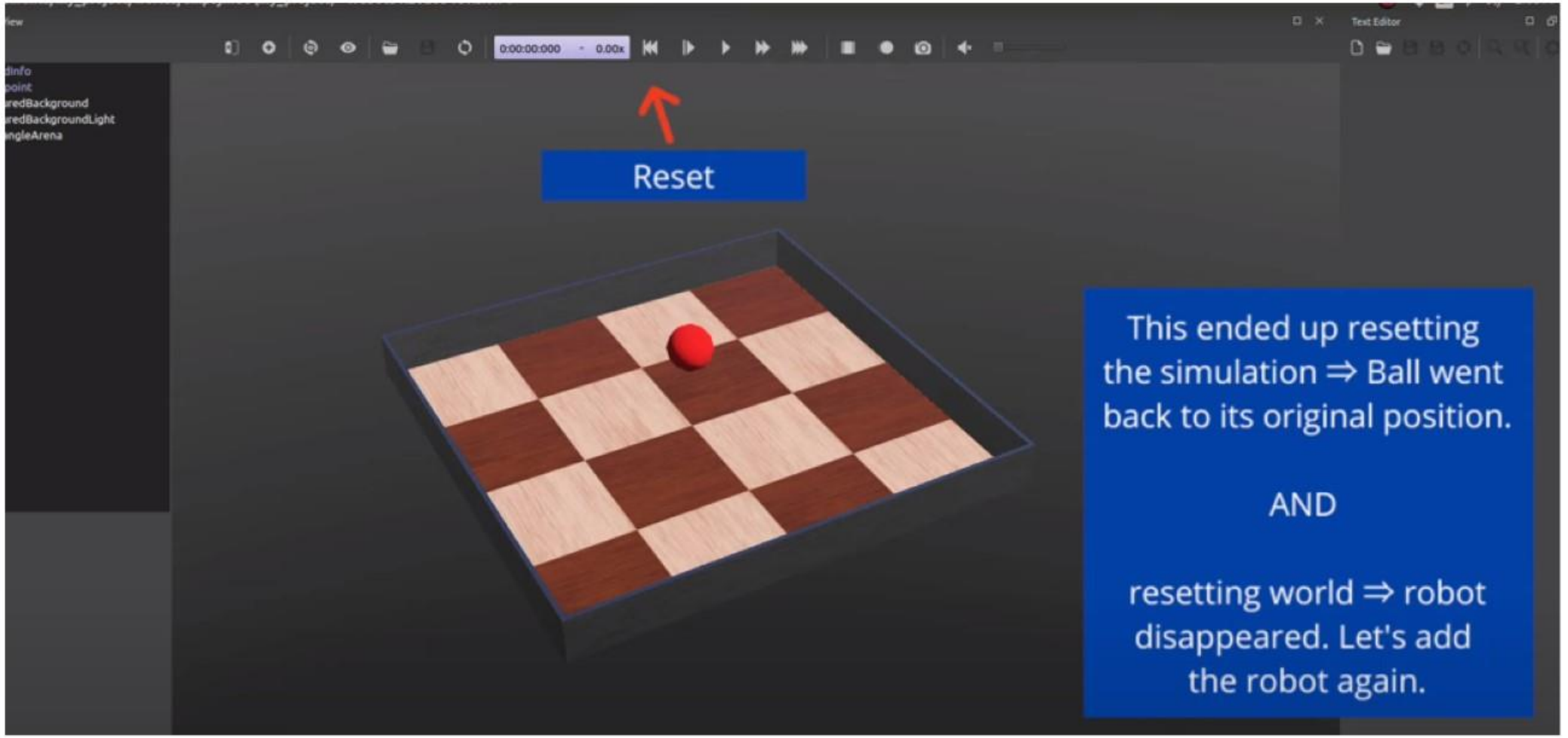

Day

01

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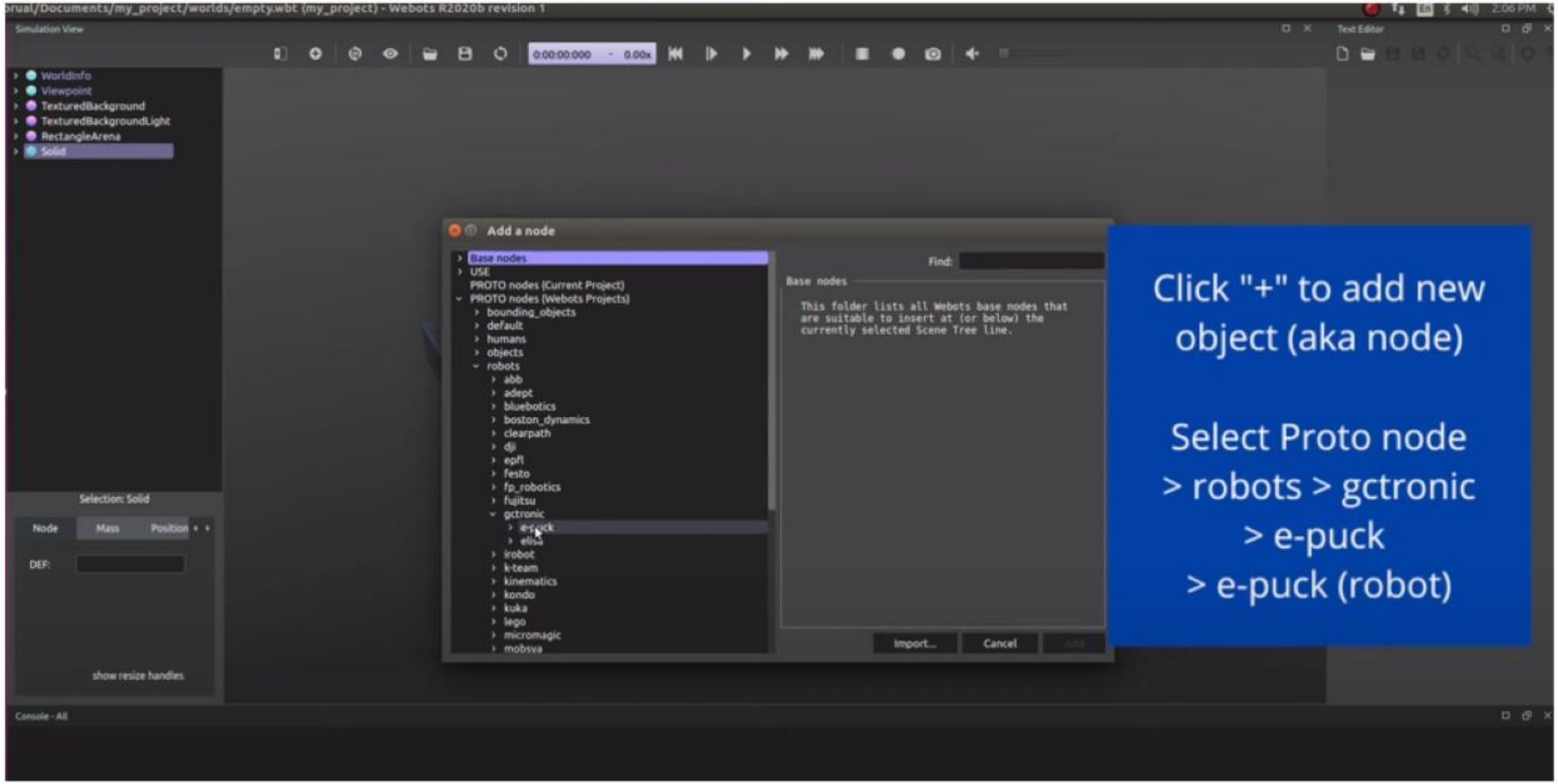

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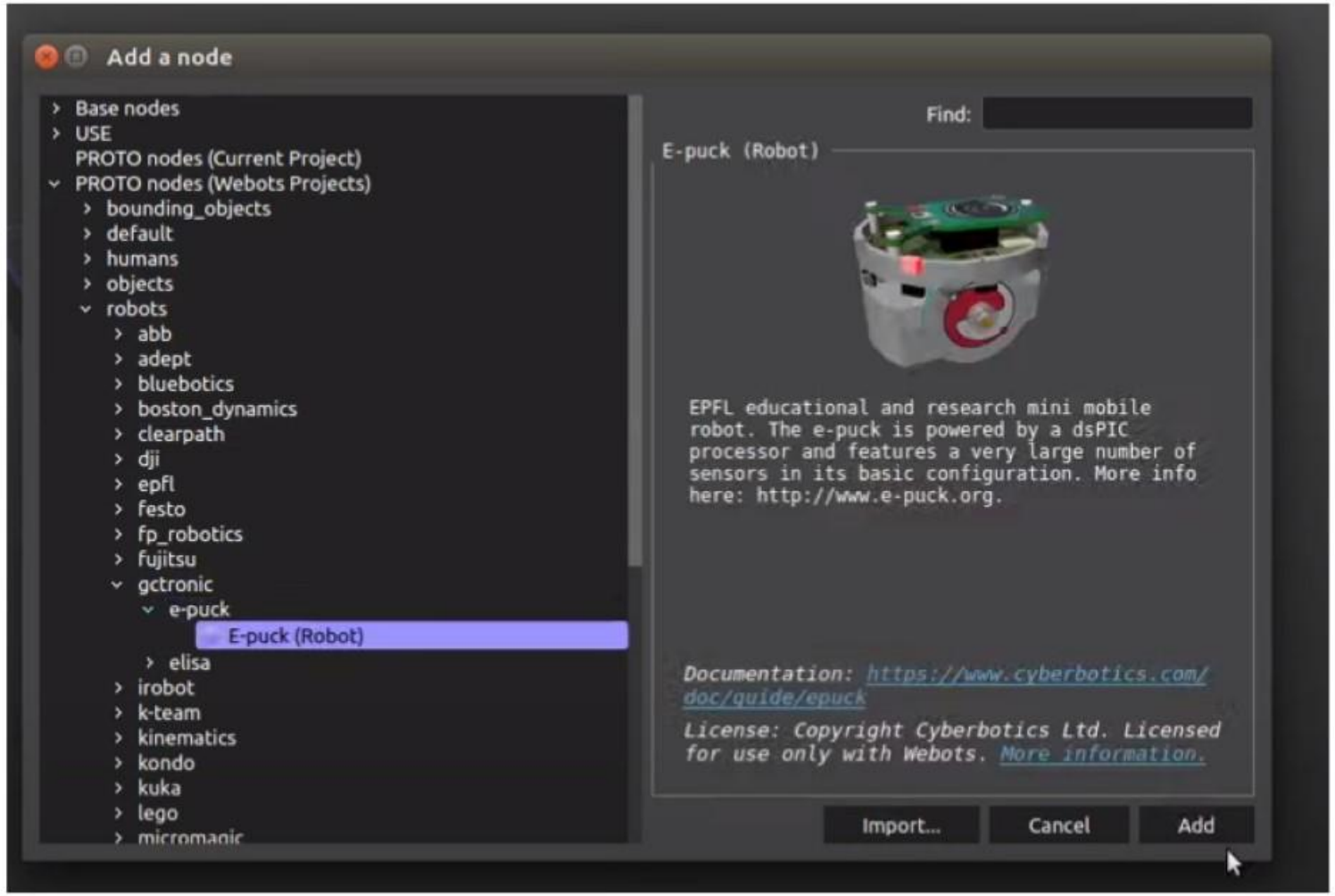

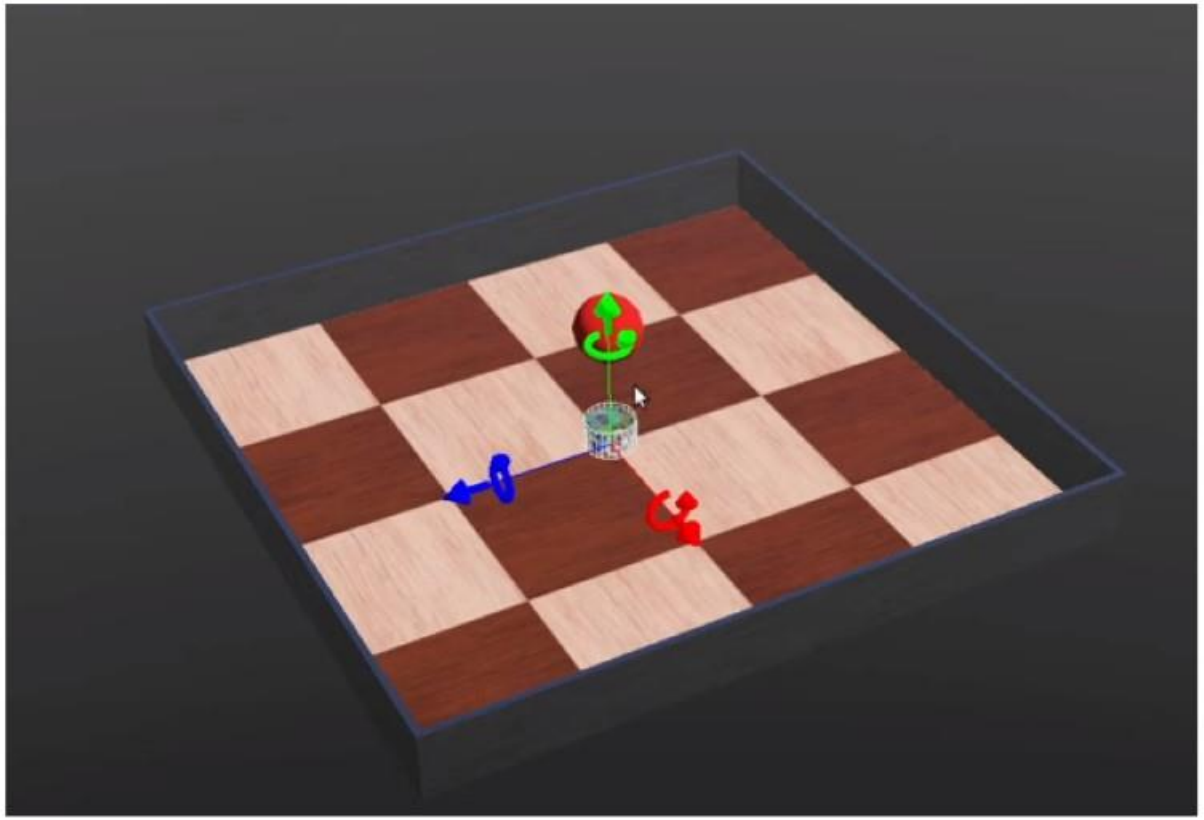

Day

01

Lets shift robot away from the original point (0,0,0):

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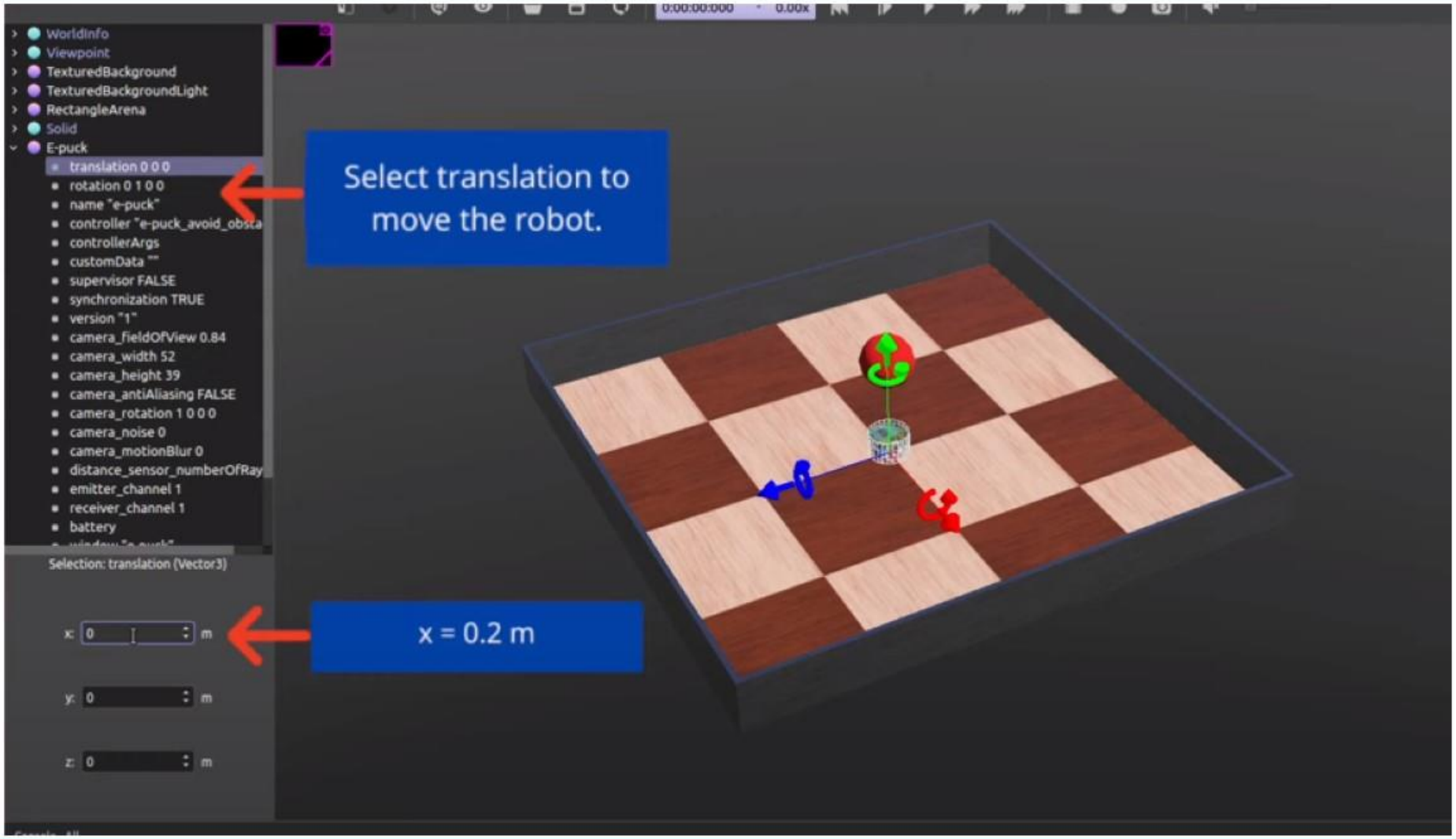

Day

01

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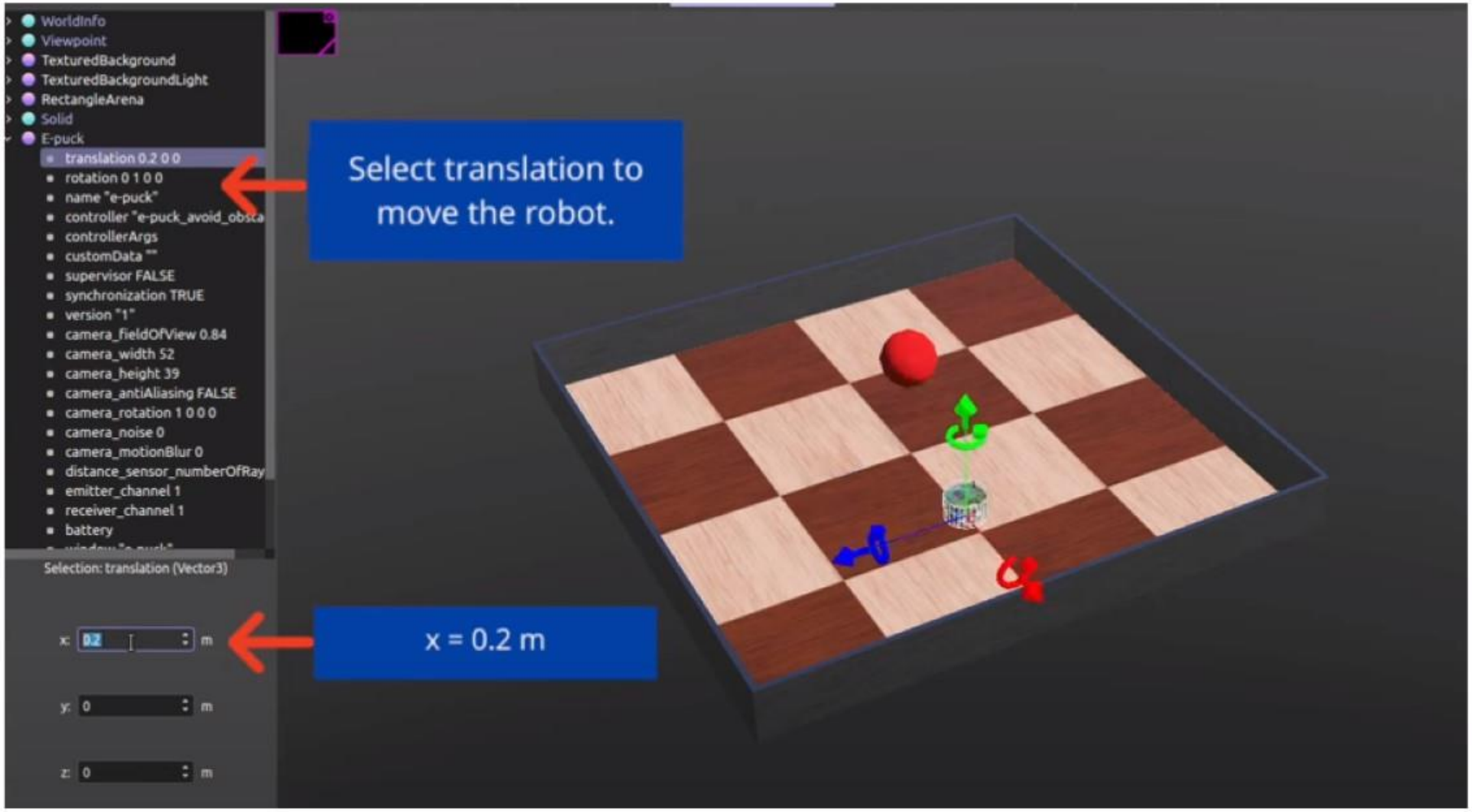

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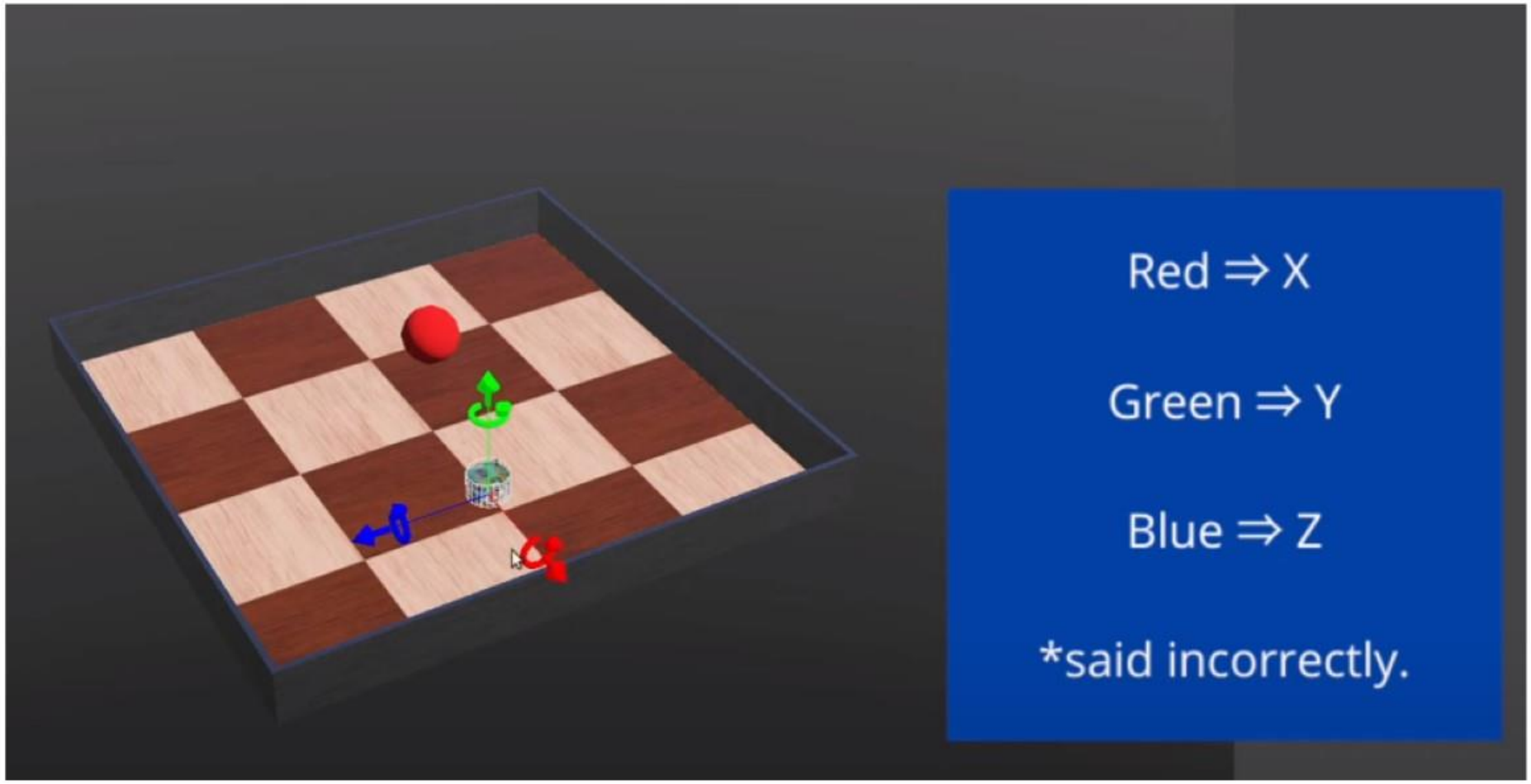

- The X-axis (Red Arrow) points forward from the robot.
- The Y-axis (Green Arrow) points to the left side of the robot.
- The Z-axis (Blue Arrow) points upwards from the robot.

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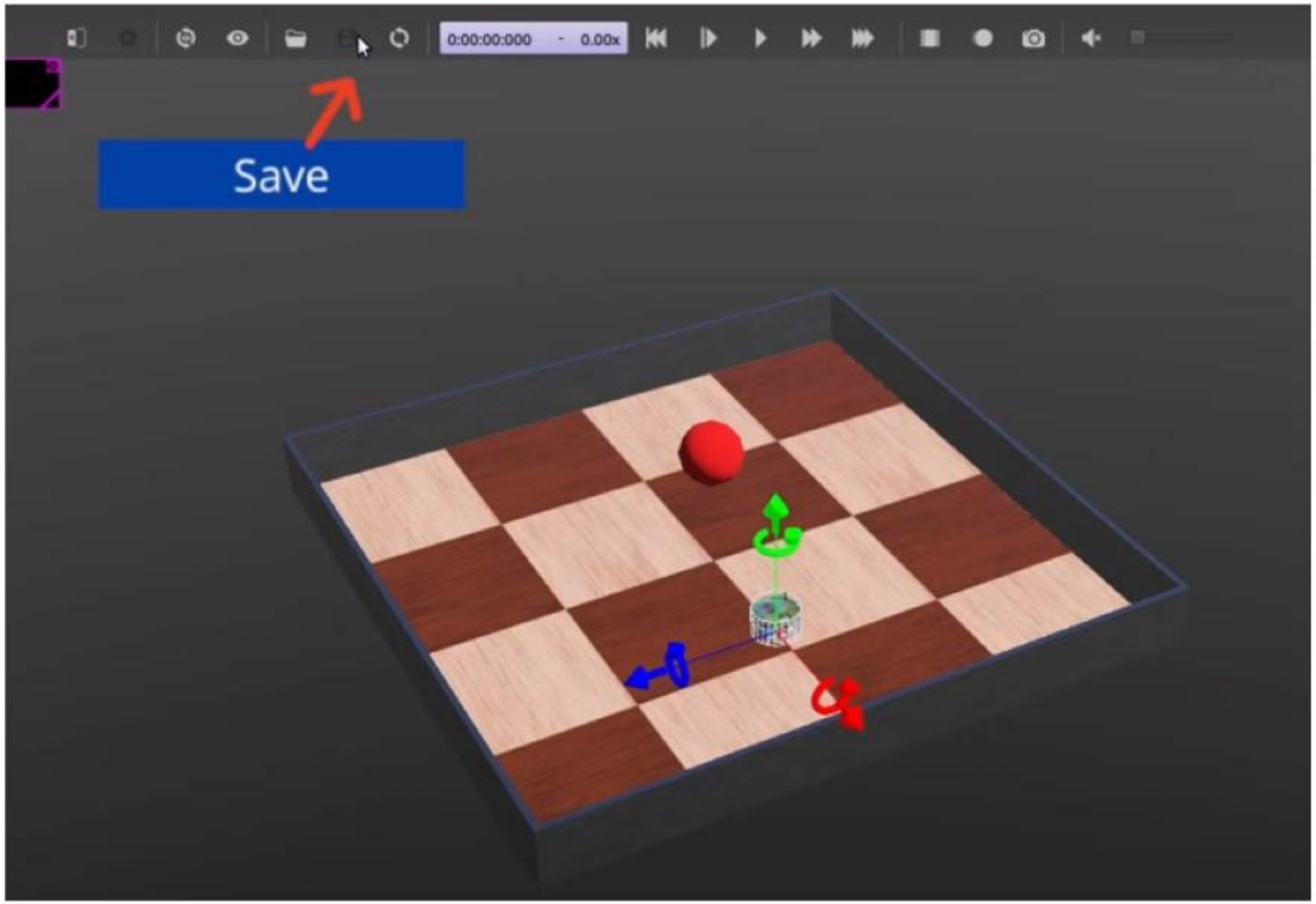
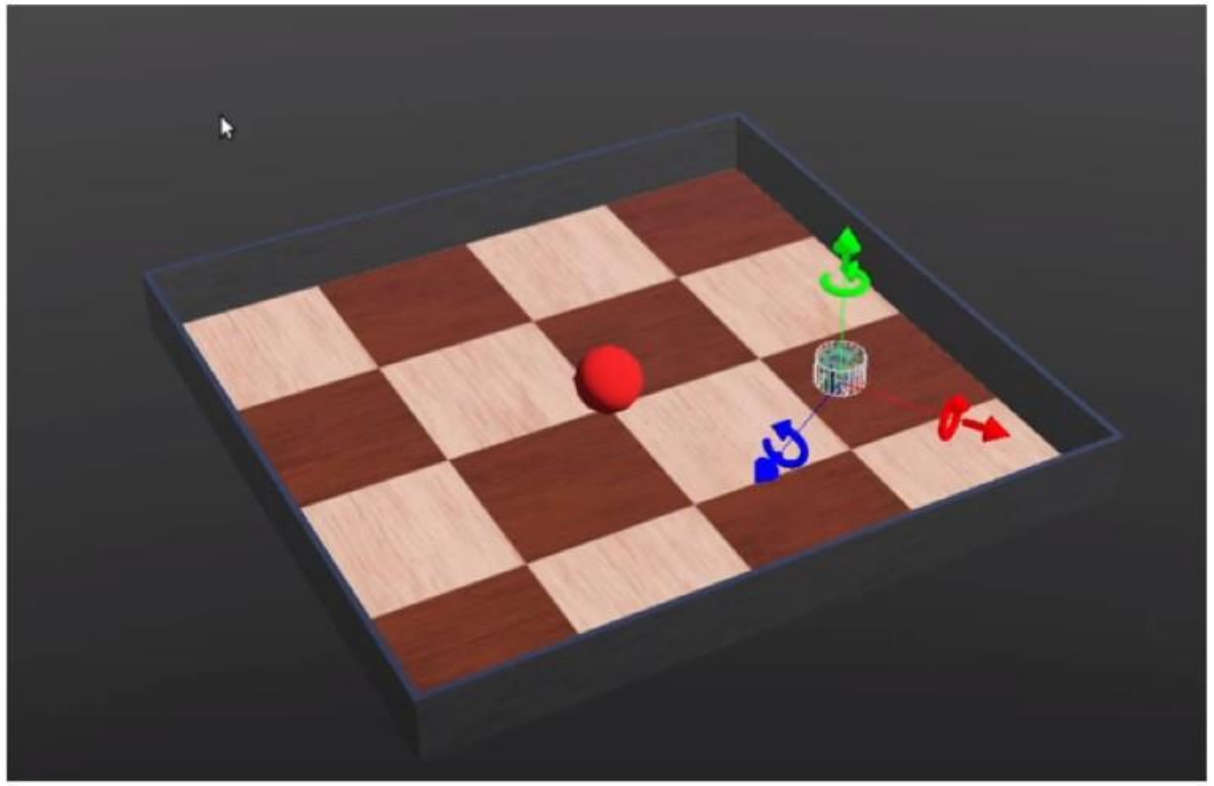


RUN the Simulation now: you will see the robot move ?

Why?

Because the robot comes with its controller.



Day

01

Lets check the robot Controller:

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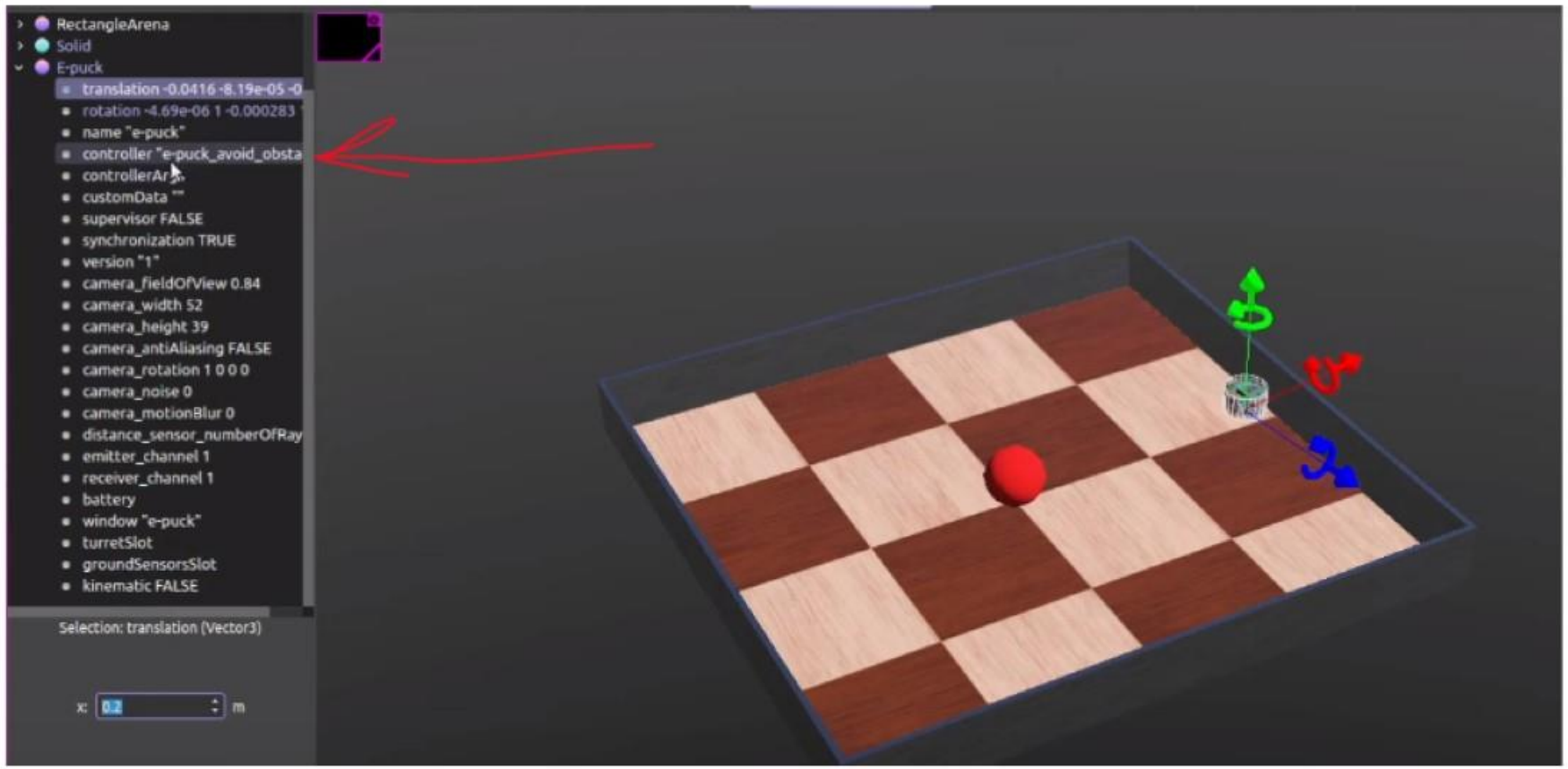
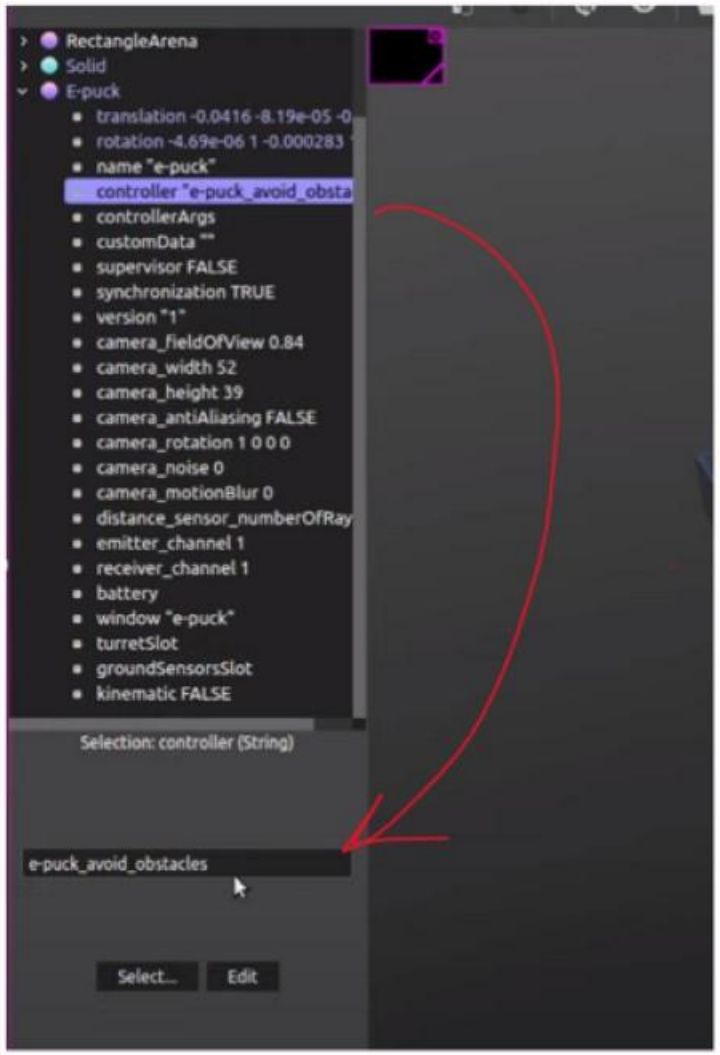


Day

01

Double click on the Controller:



Day

01

NOW you can add your own code , Click on the EDIT:

The code is written in C++ but you can write Python code.

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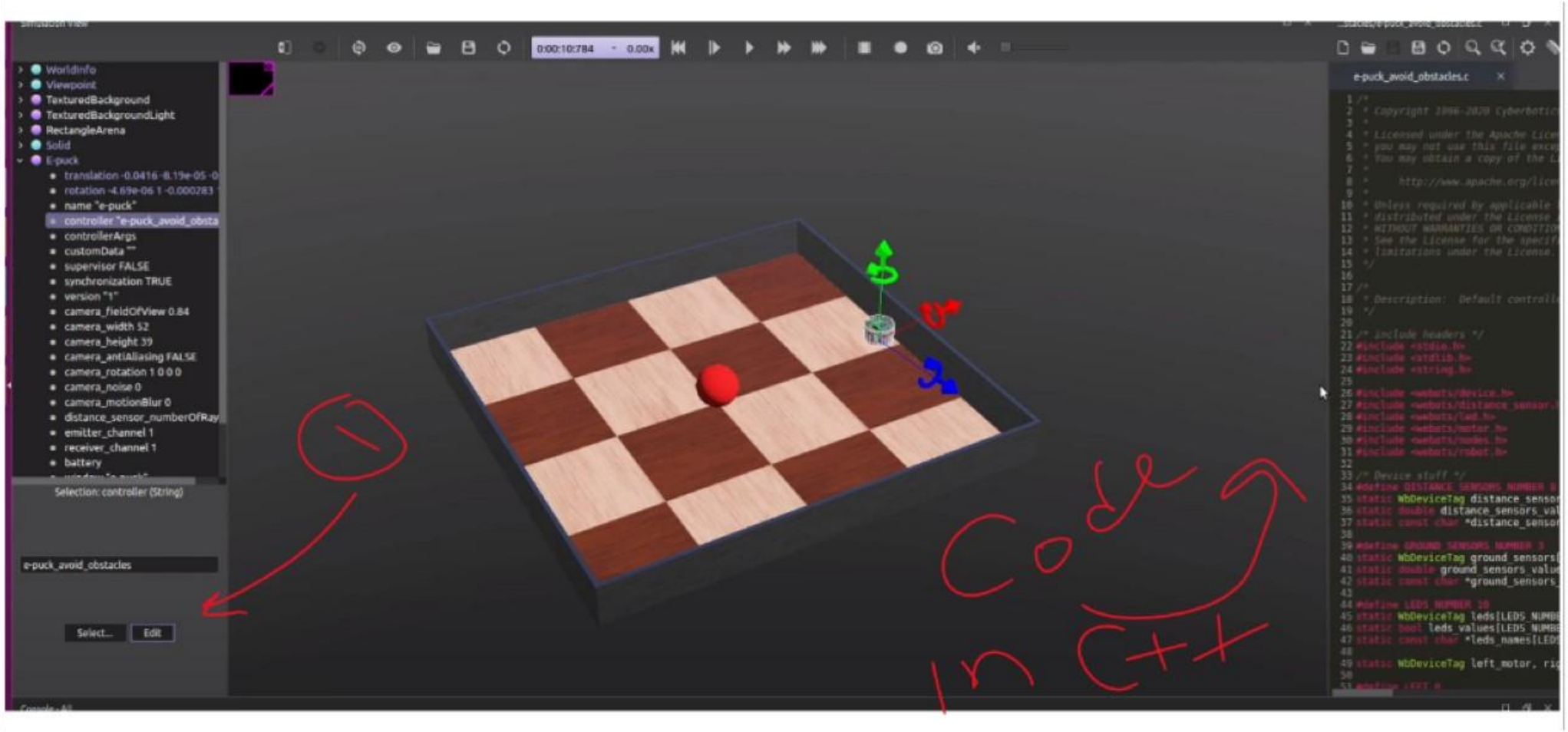

Day 01

https://github.com/keskaf-canada/MidOcean-University-Robo-Soccer-WORKSHOP2025/tree/main

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keskaf-canada / MidOcean-University-Robo-Soccer-WORKSHOP2025

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Example S2	Add files via upload	2 hours ago
Example S3	Add files via upload	2 hours ago
Example S4	Add files via upload	2 hours ago
ADV_ROBO_SOCCER_2025.jpeg	Add files via upload	2 hours ago
Competition Sample.mp4	Add files via upload	2 hours ago
Introduction	Create Introduction	2 hours ago

Create a New Controller

We will now program a simple controller that will just make the robot **move forwards**.
A **controller** is a program that defines the behavior of a robot.

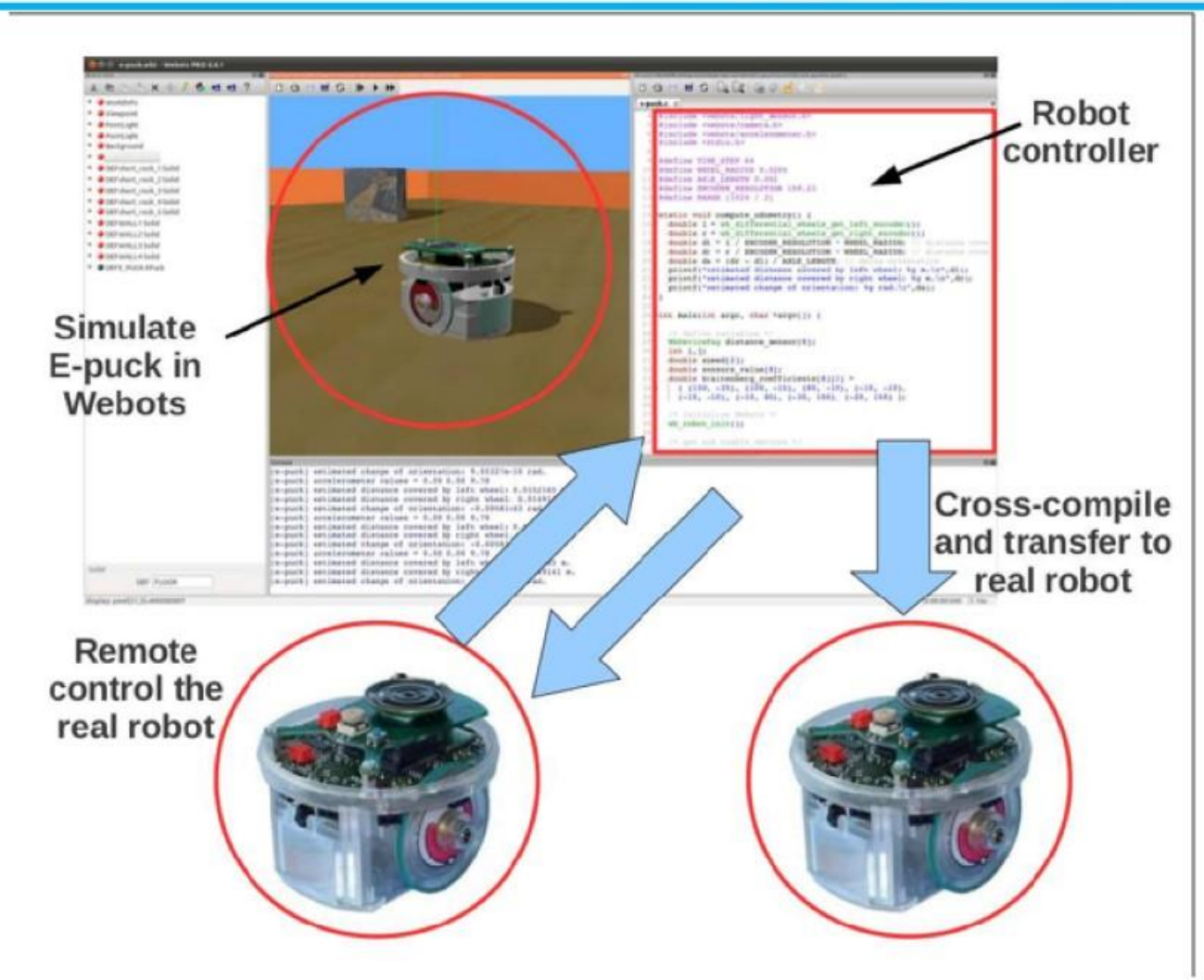
Webots controllers can be written in the following programming languages: C, C++, Java, Python, MATLAB, ROS, etc. C, C++ and Java controllers need to be compiled before they can be run as robot controllers.

Python and MATLAB controllers are interpreted languages so they will run without being compiled.

The controller field of a Robot node specifies which controller is currently associated to the robot. Note that the same controller can be used by several robots, but a robot can only use one controller at a time.

Each controller is executed in a separate child process usually spawned by Webots. Because they are independent processes, controllers don't share the same address space, and may run on different processor cores.

Create a New Controller



Hands-on #8: Create a new Python controller called epuck_go_forward using the **File / New / New Robot Controller...** menu item. This will create a new epuck_go_forward (or EPuckGoForward) directory in my_first_simulation/controllers. Select the option offering you to open the source file in the text editor.

Move forward

Day

01

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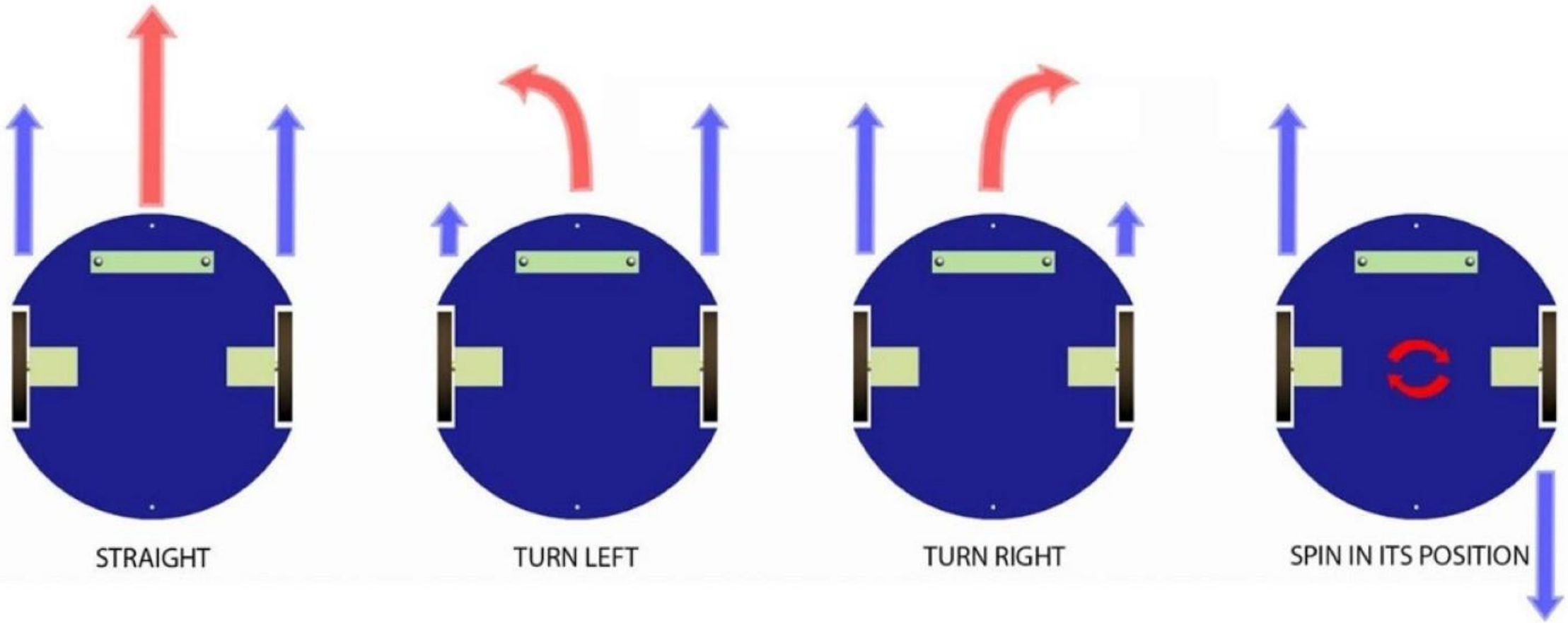

Day 01

Step-by-Step Guide

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Step 1: Set Up Your Webots Environment

1. **Open Webots:** Start Webots on your computer.
2. **Create a New Project:** If you don't already have a project, create a new one.
3. **Add the E-puck Robot:**
   - Go to the `Scene Tree` panel.
   - Right-click and select `Add...`
   - Navigate to `ROBOT` -> `E-puck` and add it to your scene.

Step 2: Associate a Controller with the Robot

1. **Select the E-puck Node:**
   - In the `Scene Tree` panel, find and click on the `E-puck` node.
2. **Assign a Controller:**
   - In the `Field` panel, find the `controller` field.
   - Click on the `Select...` button.
   - Choose `New File...`, name your controller file (e.g., `epuck_go_forward.py`), and confirm.

Step 3: Write the Controller Script

1. **Open the Controller Script:**
   - In your project directory, find and open the newly created Python controller script (e.g., `epuck_go_forward.py`).

Step-by-Step Guide

Step 1: Set Up Your Webots Environment

1. **Open Webots:** Start Webots on your computer.
   - **افتح Webots:** ابدأ Webots على جهاز الكمبيوتر الخاص بك.
2. **Create a New Project:** If you don't already have a project, create a new one.
   - **إنشاء مشروع جديد:** إذا لم يكن لديك مشروع بالفعل، قم بإنشاء مشروع جديد.
3. **Add the E-puck Robot:**
   - **إضافة الروبوت E-puck:**
   - Go to the `Scene Tree` panel.
     - انتقل إلى لوحة `Scene Tree`.
   - Right-click and select `Add...`
     - انقر بزر الماوس الأيمن واختر `Add...`
   - Navigate to `ROBOT` -> `E-puck` and add it to your scene.
     - انتقل إلى `ROBOT` -> `E-puck` وأضفه إلى المشهد الخاص بك.

Step 2: Associate a Controller with the Robot

1. **Select the E-puck Node:**
   - **حدد العقدة E-puck:**
   - In the `Scene Tree` panel, find and click on the `E-puck` node.
     - في لوحة `Scene Tree`، ابحث عن العقدة `E-puck` وانقر عليها.
2. **Assign a Controller:**
   - **تعيين وحدة تحكم:**
   - In the `Field` panel, find the `controller` field.
     - في لوحة `Field`، ابحث عن حقل `controller`.
   - Click on the `Select...` button.
     - انقر على الزر `Select...`.
   - Choose `New File...`, name your controller file (e.g., `epuck_go_forward.py`), and confirm.
     - اختر `New File...`، قم بتسمية ملف وحدة التحكم الخاص بك (مثلاً، `epuck_go_forward.py`) وقم بالتأكيد.

Step 3: Write the Controller Script

1. Open the Controller Script:

   - افتح برنامج وحدة التحكم:
   - In your project directory, find and open the newly created Python controller script (e.g., `epuck_go_forward.py`).
     - في دليل مشروعك، ابحث وافتح ملف وحدة التحكم Python الذي تم إنشاؤه حديثاً (مثلاً، `epuck_go_forward.py`).

2. Write the Script:

   - اكتب البرنامج:
   - Copy and paste the following simplified code into your controller script. Each step includes detailed comments to help you understand what each part does.
     - انسخ والصق الكود المبسط التالي في برنامج وحدة التحكم الخاص بك. يتضمن كل خطوة تعليقات مفصلة لمساعدتك على فهم كل جزء.

Day

01

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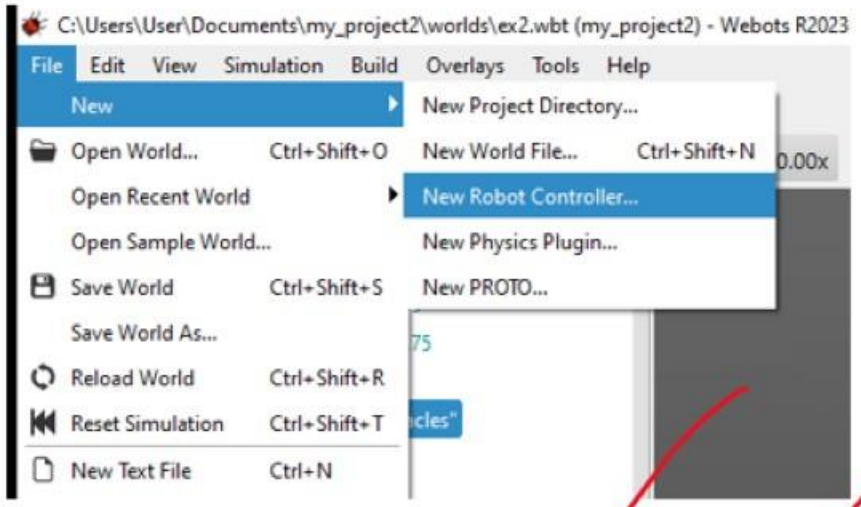
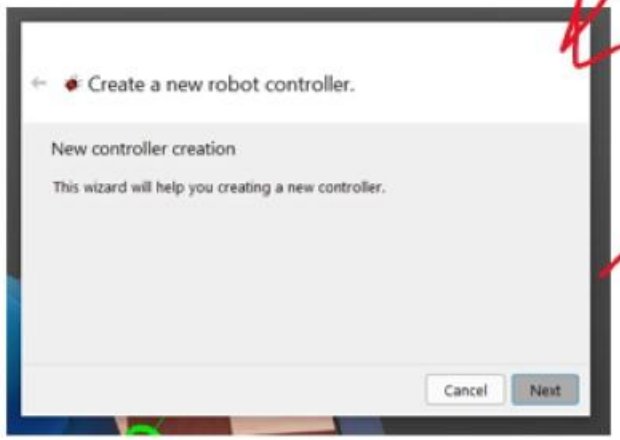
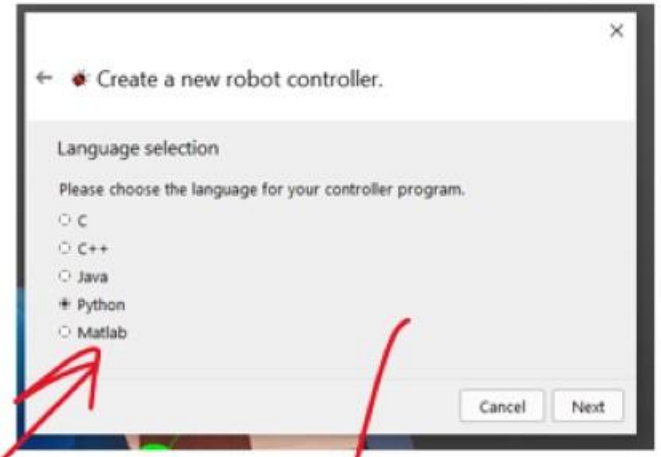
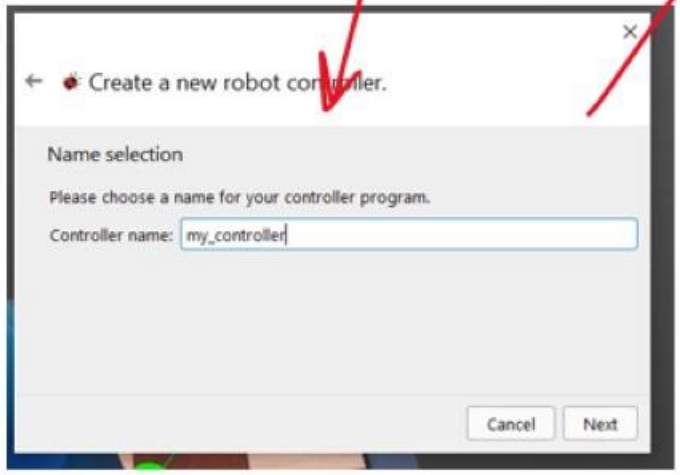
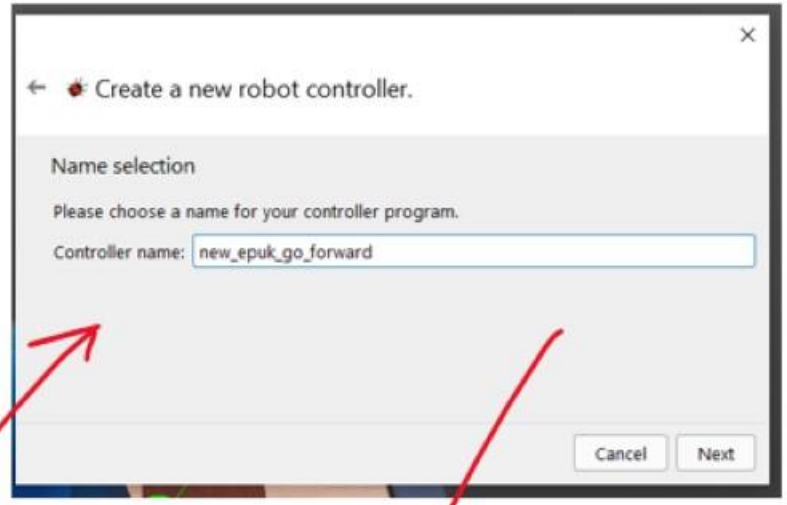
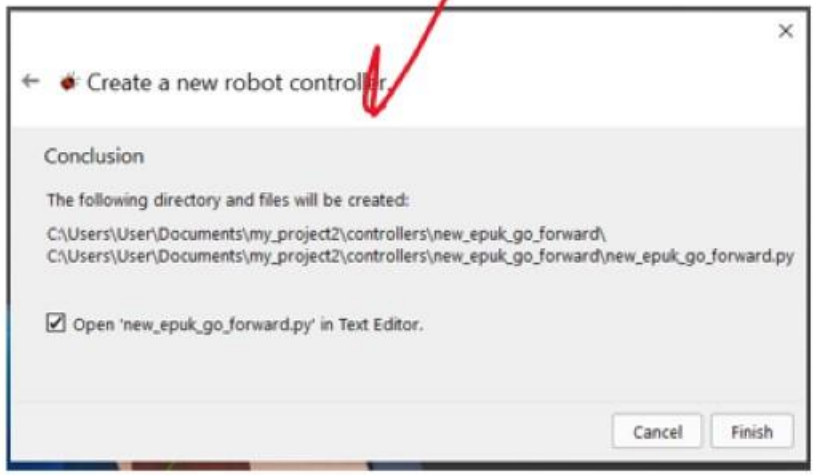






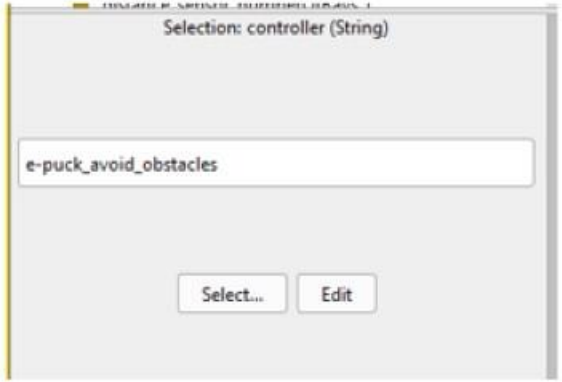


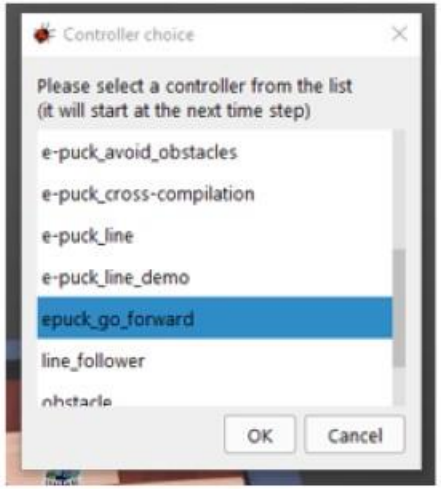




The new source file is displayed in Webots text editor window. We will now associate new epuck_go_forward controller to the E-puck node.

In the scene tree view, select the controller field of the E-puck node, then use the field editor at the bottom of the Scene Tree view: press the Select... button and then select epuck_go_forward in the list. Once the controller is associated with the robot, save the world. Modify the program by getting the motor devices (leftMotor = robot.getDevice('left wheel motor')), and by applying a motor command (leftMotor.setPosition(10.0)):





Day

01

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code

Day
01

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```
# Import the Robot and Motor classes from the Webots controller module
from controller import Robot, Motor
# استيراد الفئات Robot و Motor من وحدة التحكم Webots

# Define a time step for the simulation (this value should match Webots simulation time step)
TIME_STEP = 64
# تعريف خطوة زمنية للمحاكاة (يجب أن تطابق هذه القيمة خطوة الوقت في Webots)

# Define the maximum speed for the e-puck robot motors
MAX_SPEED = 6.28  # Note: e-puck's speed is often specified in radians per second
# تحديد السرعة القصوى لمحركات الروبوت e-puck
# ملاحظة: غالبًا ما يتم تحديد سرعة e-puck بالراديان في الثانية
```

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```
# Create an instance of the Robot class
robot = Robot()
# إنشاء مثيل لفئة Robot

# Get the left and right wheel motors of the e-puck robot
leftMotor = robot.getDevice('left wheel motor')
rightMotor = robot.getDevice('right wheel motor')
# الحصول على محركات العجلة اليسرى واليمنى للروبوت e-puck

# Set the target position of the motors to infinity (to control speed instead of position)
leftMotor.setPosition(float('inf'))
rightMotor.setPosition(float('inf'))
# ضبط الموضع المستهدف للمحركات إلى ما لا نهاية (للتحكم في السرعة بدلاً من الموضع)
```

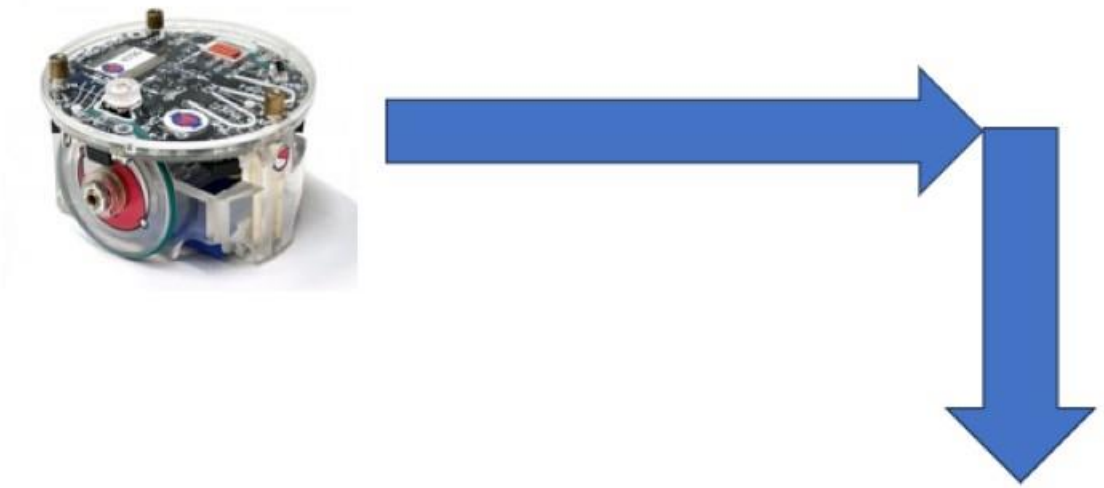
```
# Set the initial speed of the motors to 10% of the maximum speed
leftMotor.setVelocity(0.1 * MAX_SPEED)
rightMotor.setVelocity(0.1 * MAX_SPEED)
# ضبط السرعة الأولية للمحركات إلى 10% من السرعة القصوى


 #Main loop: run until the simulation is terminated
while robot.step(TIME_STEP) != -1:
    # In this loop, we don't need to do anything because the robot will keep moving forward
    pass
# الحلقة الرئيسية: تستمر حتى يتم إنهاء المحاكاة
# في هذه الحلقة، لا نحتاج إلى فعل أي شيء لأن الروبوت سيستمر في التحرك للأمام
```

EXAMPLES 2

Moving the e-puck robot **forward** for **10 steps** and then **turning right**

epuck_move_turn.py



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1. **Importing Classes:**

   - `` `from controller import Robot, Motor` ``: Imports the `` `Robot` `` and `` `Motor` `` classes from the Webots controller module.
   - `` `from controller import Robot, Motor` ``: يستورد الفئات `` `Robot` `` و `` `Motor` `` من وحدة التحكم Webots.

2. **Defining Constants:**

   - `` `TIME_STEP = 64` ``: Defines the time step for the simulation. This should match the time step set in Webots.
   - `` `TIME_STEP = 64` ``: يحدد خطوة الزمن للمحاكاة. يجب أن تطابق هذه القيمة خطوة الوقت في Webots.
   - `` `MAX_SPEED = 6.28` ``: Defines the maximum speed for the e-puck robot's motors.
   - `` `MAX_SPEED = 6.28` ``: يحدد السرعة القصوى لمحركات الروبوت e-puck.

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3. Creating the Robot Instance:

- `robot = Robot()`: Creates an instance of the `Robot` class, allowing you to control the e-puck robot.
- `robot = Robot()`: ينشئ مثيلًا لفئة `Robot`، مما يتيح لك التحكم في الروبوت e-puck.

4. Getting the Motors:

- `leftMotor = robot.getDevice('left wheel motor')`: Gets the left wheel motor.
- `leftMotor = robot.getDevice('left wheel motor')`: يحصل على محرك العجلة اليسرى.
- `rightMotor = robot.getDevice('right wheel motor')`: Gets the right wheel motor.
- `rightMotor = robot.getDevice('right wheel motor')`: يحصل على محرك العجلة اليمنى.

5. **Setting Motor Positions:**

   - `leftMotor.setPosition(float('inf'))`: Sets the left motor position to infinity, enabling speed control.
   - `leftMotor.setPosition(float('inf'))`: يضبط موضع المحرك الأيسر إلى ما لا نهاية، مما يتيح التحكم في السرعة.
   - `rightMotor.setPosition(float('inf'))`: Sets the right motor position to infinity, enabling speed control.
   - `rightMotor.setPosition(float('inf'))`: يضبط موضع المحرك الأيمن إلى ما لا نهاية، مما يتيح التحكم في السرعة.

6. **Moving Forward:**

   - The loop `for step in range(10)` runs for 10 iterations, moving the robot forward by setting both wheel speeds to 50% of the maximum speed.
   - الحلقة `for step in range(10)` تستمر لـ 10 تكرارات، تحرك الروبوت للأمام عن طريق ضبط سرعتي العجلتين إلى 50% من السرعة القصوى.

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7. **Turning Right:**

   - The loop `` `for step in range(10)` `` runs for 10 iterations, turning the robot right by setting the left wheel speed to 50% of the maximum speed and the right wheel speed to 0.
   - الحلقة `` `for step in range(10)` `` تستمر لـ 10 تكرارات، تدور الروبوت إلى اليمين عن طريق ضبط سرعة العجلة اليسرى إلى 50% من السرعة القصوى وسرعة العجلة اليمنى إلى الصفر.

8. **Stopping the Robot:**

   - The loop `` `while robot.step(TIME_STEP) != -1` `` runs indefinitely, keeping the robot stopped by setting both wheel speeds to 0.
   - الحلقة `` `while robot.step(TIME_STEP) != -1` `` تستمر بلا نهاية، تحافظ على الروبوت متوقفًا عن طريق ضبط سرعتي العجلتين إلى الصفر.


4000

1

Webots

robot simulation

https://cyberbotics.com/

2

spyder The Scientific Python Development Environment

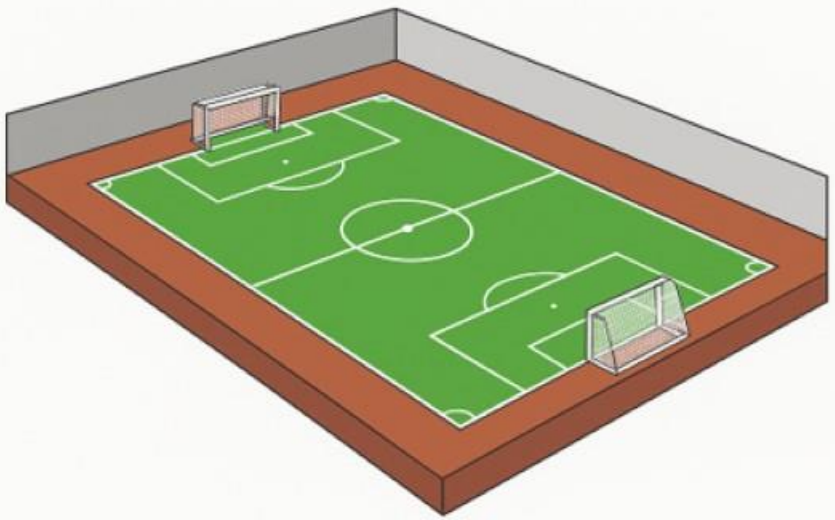
https://www.spyder-ide.org/

Webots Robo Soccer Workshop

RoboCup 2023, World Championship, France Bordeaux - Soccer SSL, MSL, Humanoid, TIGERs Mannheim - 720

The Soccer Stadium

Example: ملعب كرة القدم
Soccer Field



Understanding the Soccer Ball in Robo Soccer

- In Robo Soccer, the ball is not just a shape — it's a special object that **sends a signal.**
- The robot cannot see like a human — it uses sensors to **detect signals from the ball.**

- 📷 Image of the 3D soccer ball in Webots.
- Label: Radius = 0.021m, Image: football_base_color.png

Why Infrared?

- Infrared (IR) signals are used like a flashlight — invisible to us, but the robot can detect it.
- The ball sends an IR signal. The robot listens to that signal and figures out the ball's direction.

Field	Meaning
`Emitter`	Sends out IR signals
`type`	Infrared — invisible beam
`range`	Signal range (e.g., 0.6 meters)
`channel`	Must match robot's IR receiver

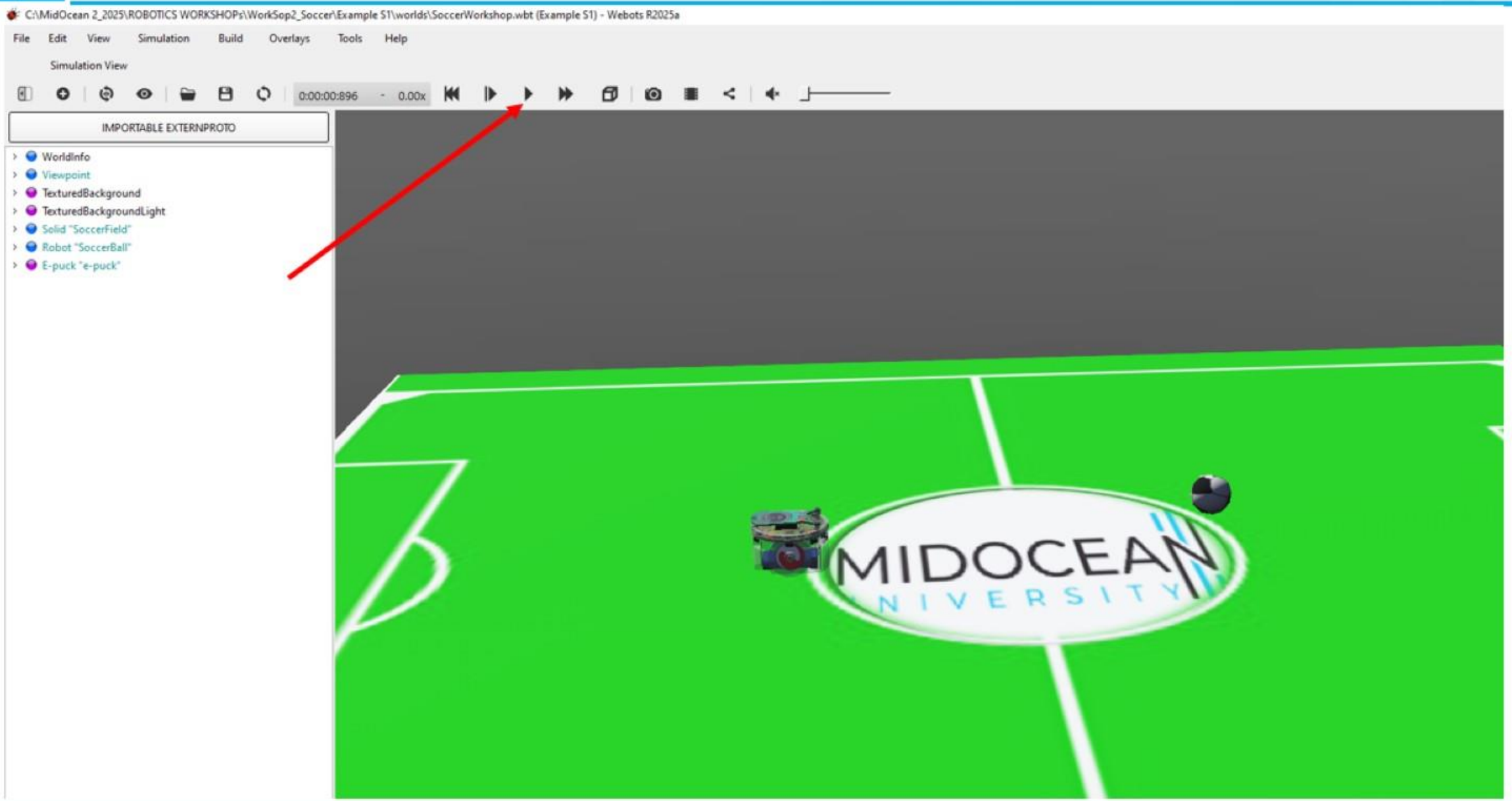
```
Emitter {
  name "ball emitter"
  type "infra-red"
  range 0.6
  channel 4
}
```

Download Folder Example S1

Open Folder : **Example S1**

- controllers
- My_First_Soccer_CODE FILES
- protos
- worlds

- .SoccerWorkshop
- football_base_color
- soccer-256
- SoccerWorkshop


C:\MidOcean 2_2025\ROBOTICS WORKSHOPs\WorkSop2_Soccer\Example S1\worlds\SoccerWorkshop.wbt (Example S1) - Webots R2025a
File
Edit
View
Simulation
Build
Overlays
Tools
Help
Simulation View
0:00:00:896
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IMPORTABLE EXTERNPROTO
WorldInfo
Viewpoint
TexturedBackground
TexturedBackgroundLight
Solid "SoccerField"
Robot "SoccerBall"
E-puck "e-puck"
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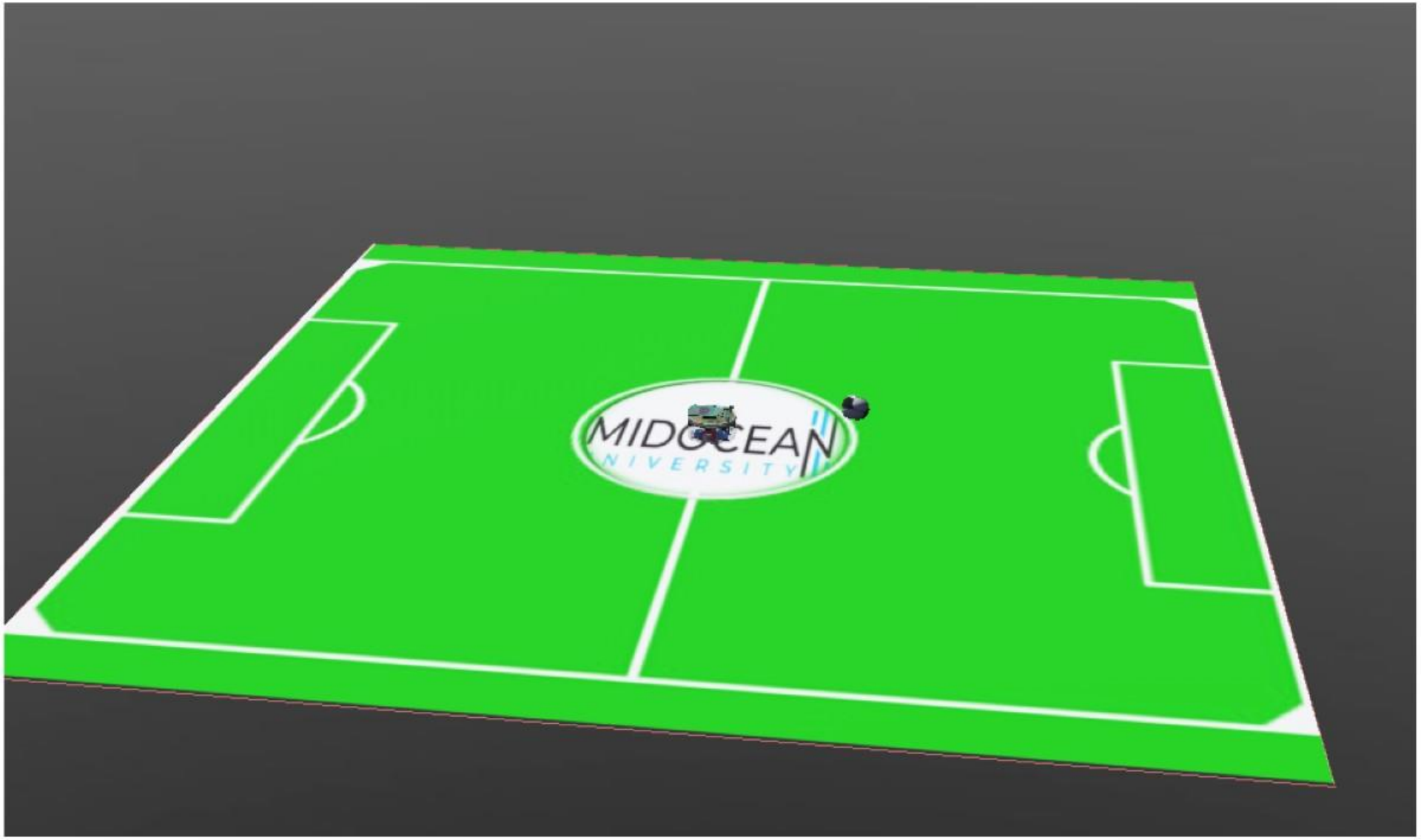
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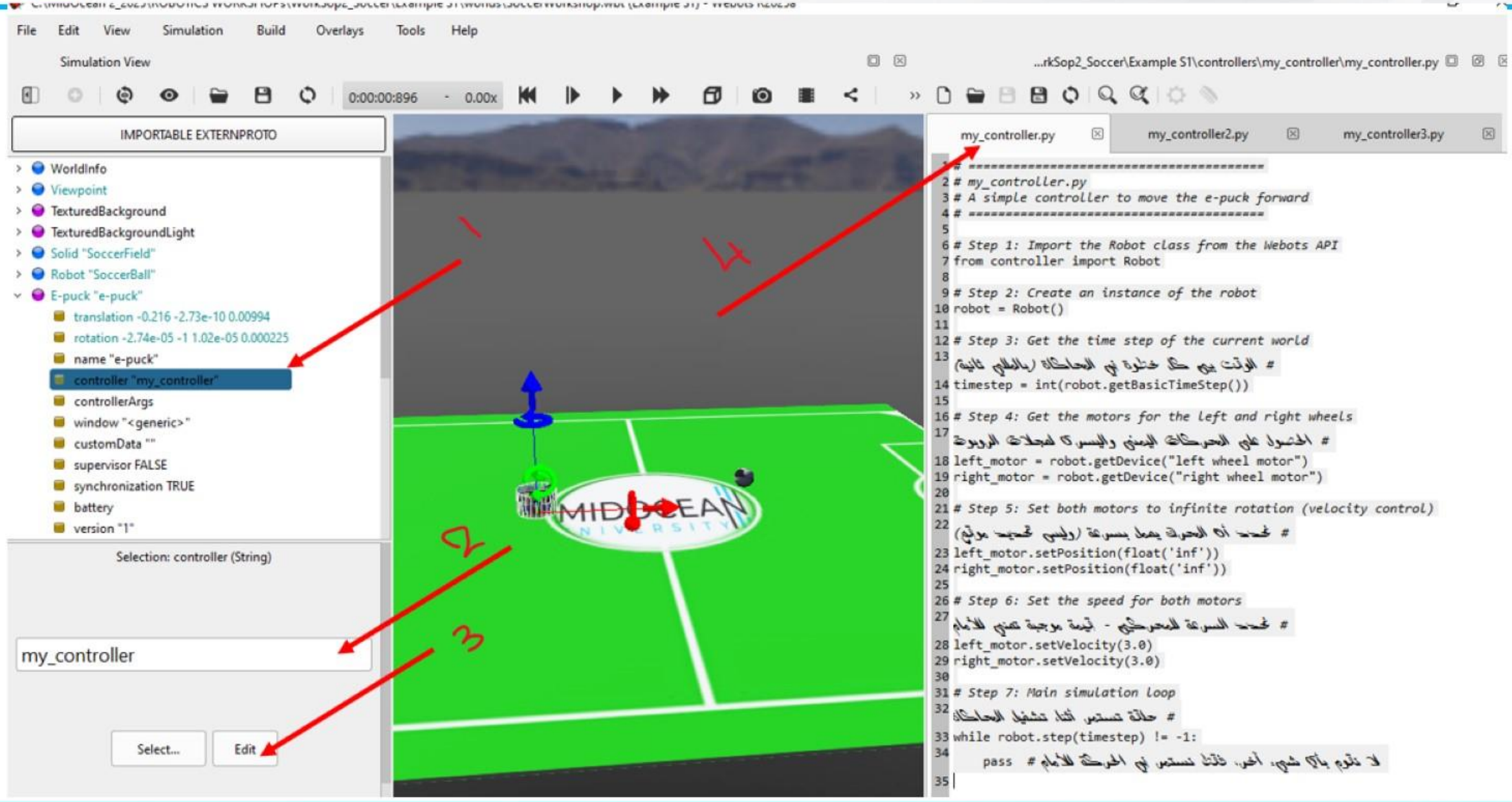
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TexturedBackgroundLight
Solid "SoccerField"
Robot "SoccerBall"
E-puck "e-puck"
translation -0.216 -2.73e-10 0.00994
rotation -2.74e-05 -1 1.02e-05 0.000225
name "e-puck"
controller "my_controller"
controllerArgs
window "<generic>"
customData ""
supervisor FALSE
synchronization TRUE
battery
version "1"
Selection: controller (String)
my_controller
Select...
Edit
1
2
3
4
my_controller.py
my_controller2.py
my_controller3.py
# ==
# my_controller.py
# A simple controller to move the e-puck forward
# ==
# Step 1: Import the Robot class from the Webots API
from controller import Robot
# Step 2: Create an instance of the robot
robot = Robot()
# Step 3: Get the time step of the current world
# الوقت بين كل خطوة في المحاكاة (بالملي ثانية)
timestep = int(robot.getBasicTimeStep())
# Step 4: Get the motors for the left and right wheels
# الحصول على المحركات اليمنى واليسرى لعجلات الروبوت #
left_motor = robot.getDevice("left wheel motor")
right_motor = robot.getDevice("right wheel motor")
# Step 5: Set both motors to infinite rotation (velocity control)
# تحديد أن المحرك يعمل بسرعة (وليس تحديد موقع)
left_motor.setPosition(float('inf'))
right_motor.setPosition(float('inf'))
# Step 6: Set the speed for both motors
# تحديد السرعة للمحركين - قيمة موجبة تعني للأمام #
left_motor.setVelocity(3.0)
right_motor.setVelocity(3.0)
# Step 7: Main simulation loop
# حلقة تستمر أثناء تشغيل المحاكاة #
while robot.step(timestep) != -1:
    pass # لا نقوم بأي شيء آخر، فقط نستمر في الحركة للأمام

```python
# Simple example: Move the robot forward

from controller import Robot

robot = Robot()                     # Initialize robot
timestep = int(robot.getBasicTimeStep())  # Get simulation time step

# Get access to the motors
left_motor = robot.getDevice("left wheel motor")
right_motor = robot.getDevice("right wheel motor")

# Set motors to velocity control mode
left_motor.setPosition(float('inf'))
right_motor.setPosition(float('inf'))

# Set motors speed (3 = medium speed)
left_motor.setVelocity(3.0)
right_motor.setVelocity(3.0)

# Run the simulation loop
while robot.step(timestep) != -1:
    pass  # Robot keeps moving forward
```

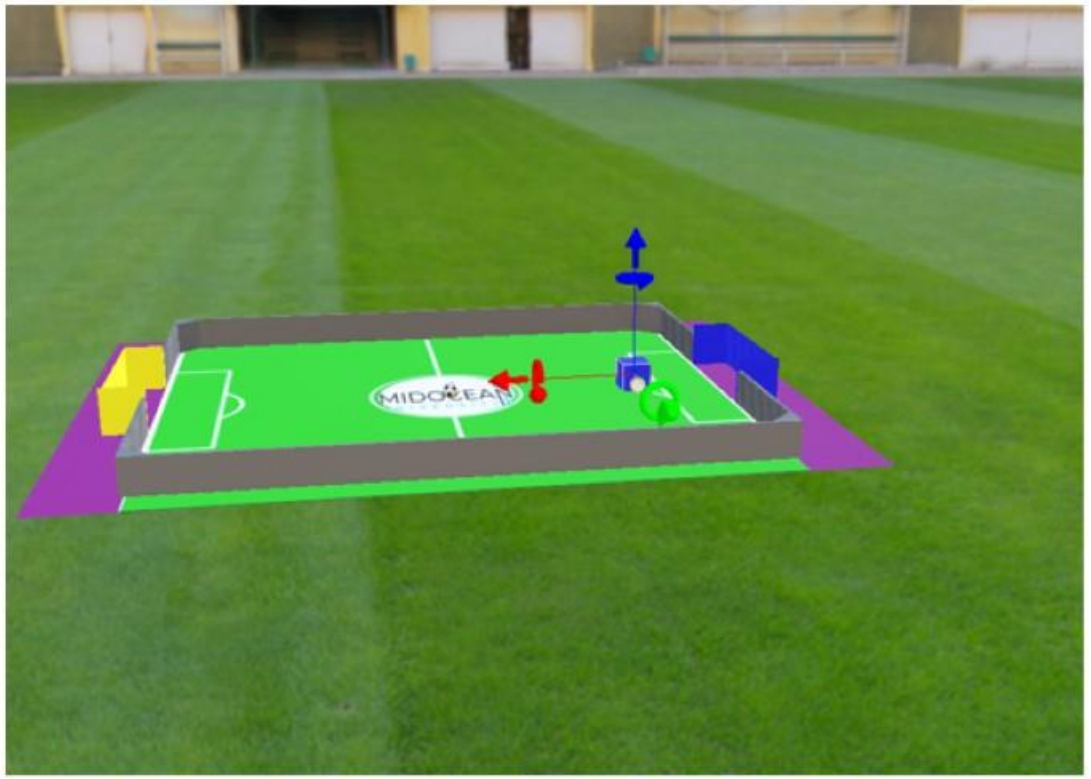
```python
# ----------------------------------------
# Step 1: Import the Robot class from the Webots API
# استيراد كائن "Robot" من مكتبة Webots للتحكم في الروبوت
# "Robot" هو الكائن الأساسي الذي نستخدمه للتفاعل مع أي روبوت داخل المحاكاة
from controller import Robot

# ----------------------------------------
# Step 2: Create an instance of the robot
# إنشاء نسخة (كائن) من الروبوت للتحكم به
# هذا السطر يُنشئ الاتصال بين الكود وبين الروبوت داخل المحاكاة
robot = Robot()

# ----------------------------------------
# Step 3: Get the time step of the current world
# الحصول على "الخطوة الزمنية" للمحاكاة
# الوقت بين كل تحديث للمحاكاة (بوحدة الملي ثانية)
# مثال: إذا كانت القيمة 32 فهذا يعني أن المحاكاة تُحدّث 31 مرة في الثانية
timestep = int(robot.getBasicTimeStep())

# ----------------------------------------
# Step 4: Get the motors for the left and right wheels
# الحصول على المحركات اليمنى واليسرى لعجلات الروبوت
# نستخدم أسماء الأجهزة كما هي معرفة في ملف المحاكاة (.wbt)
# في e-puck الأسماء تكون "left wheel motor" و "right wheel motor"
left_motor = robot.getDevice("left wheel motor")
right_motor = robot.getDevice("right wheel motor")

# ----------------------------------------
# Step 5: Set both motors to infinite rotation (velocity control mode)
# ضبط المحركات بحيث تعمل بالسرعة فقط وليس بالموضع
# في Webots إذا وضعنا setPosition(float('inf')) "فهذا يعني "تحكم بالسرعة
# أما إذا وضعنا قيمة رقمية فهذا يعني "تحكم بالموضع" (زاوية دوران محددة)
left_motor.setPosition(float('inf'))
right_motor.setPosition(float('inf'))

# ----------------------------------------
# Step 6: Set the speed for both motors
# تحديد السرعة للمحركين
# القيم الموجبة → الروبوت يتحرك للأمام
# القيم السالبة → الروبوت يتحرك للخلف
# السرعة القصوى للمحركات e-puck 6.28 تقريباً rad/s
# 3.0 = هنا نضع سرعة متوسطة rad/s
left_motor.setVelocity(3.0)  # السرعة للمحرك الأيسر
right_motor.setVelocity(3.0) # السرعة للمحرك الأيمن

# ----------------------------------------
# Step 7: Main simulation loop
# الحلقة الرئيسية التي تعمل طول مدة تشغيل المحاكاة
# robot.step(timestep) → يُعيد -1 إذا توقفت المحاكاة، وإلا يستمر
# هنا لا نغير السرعة داخل الحلقة، فنترك الروبوت يتحرك للأمام دائماً
while robot.step(timestep) != -1:
    pass  # لا نقوم بأي تعليمات إضافية هنا، فقط نستمر بالحركة للأمام

# 👂 ملاحظات تعليمية:
# - لتدوير الروبوت لليسار: اجعل سرعة المحرك الأيسر أقل من الأيمن
#   مثال: left_motor.setVelocity(2.0); right_motor.setVelocity(4.0)
# - لتدويره لليمين: اجعل سرعة المحرك الأيمن أقل من الأيسر
# - لإيقافه: ضع السرعة = 0.0 لكلا المحركين
```

Download Folder Example S2

The main objective is to write a code allows a soccer robot (B1) in Webots to:

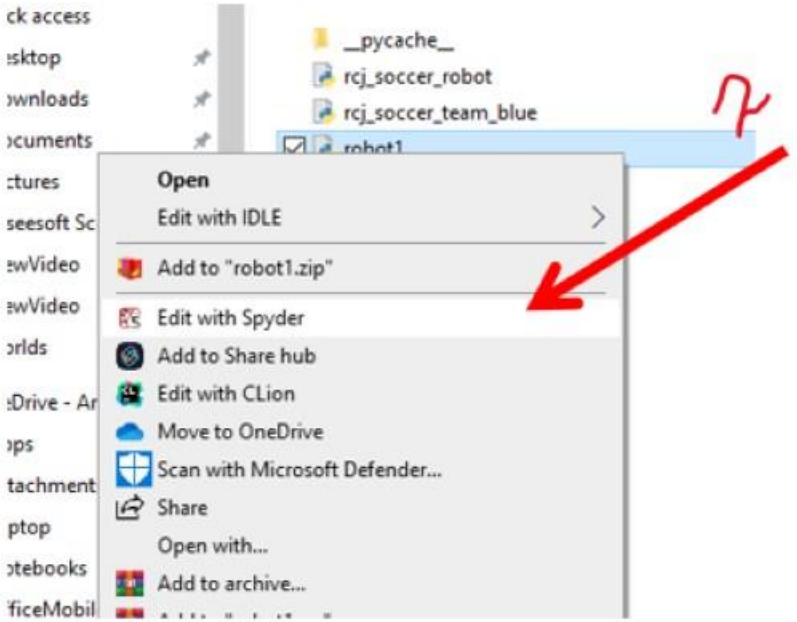
- Look for the ball using an infrared (IR) sensor,
- Decide if the ball is in front, to the left, or to the right,
- Move straight if the ball is in front,
- Turn if the ball is not in front,
- Stop if the ball is not detected.

Example S2



Inside folder rcj_soccer_team_blue:

__pycache__	2025-07-20 12:16 PM	File folder
rcj_soccer_robot	2024-09-04 5:00 PM	Python File
rcj_soccer_team_blue	2024-09-04 5:00 PM	Python File
robot1	2024-09-04 5:00 PM	Python File
utils	2024-09-04 5:00 PM	Python File



```
# Step 1: Import the Webots Robot API
# This gives us access to Webots features like sensors and motors.
from controller import Robot
```

We start by importing Robot so we can connect our code to the robot in the Webots simulator.

```
# Step 2: Import a helper function to decide the direction of the ball
import utils
```

utils is a file we created that contains a simple function to help us decide:

- Should we move forward?
- Or should we turn left or right?

This is based on the position (vector) of the ball.

`utils` هو ملف يحتوي على دالة بسيطة تساعد الروبوت على تحديد:

- هل يجب أن يتحرك للأمام؟
- أم يلف لليسار أو اليمين؟

وذلك بناءً على موقع الكرة بالنسبة للروبوت.

```
# Step 3: Import the RCJSoccerRobot class
# This class connects all the sensors and motors in a simple way.
from rcj_soccer_robot import RCJSoccerRobot, TIME_STEP
```

RCJSoccerRobot is a ready-made robot class that connects:

- IR ball sensor
- Compass
- GPS
- Sonar sensors
- Motors (wheels)

TIME_STEP controls how often the robot updates (like frames in a video).

`RCJSoccerRobot` هو كائن جاهز يتصل تلقائيًا بـ:

- حساس الكرة بالأشعة تحت الحمراء (IR).
- البوصلة (Compass).
- الـ GPS.
- حساسات السونار (Sonar).
- المحركات (Motors).

أما `TIME_STEP` فهو يحدد كل كم ميلي ثانية يجب أن يُحدّث الروبوت بياناته (مثل إطارات الفيديو).

```
# Step 4: Create a Webots robot object
robot_api = Robot()
```

We ask Webots to give us access to the actual physical robot in the simulation.
This robot has all the hardware (sensors and motors) ready.

```
# Step 5: Create our smart robot with all sensors and motors enabled
robot = RCJSoccerRobot(robot_api)
```

Now we wrap the robot in our smart RCJSoccerRobot so we can easily:

- Read data from sensors (like IR ball, GPS),
- Control the motors (to move).

نلف كائن الروبوت داخل كلاس `RCJSoccerRobot` ليصبح من السهل علينا:

- قراءة بيانات الحساسات،
- والتحكم بالمحركات.

```
# Step 6: Start an infinite loop to control the robot
# This loop runs again and again, like a heartbeat.
while robot_api.step(TIME_STEP) != -1:
```

- This line starts a **loop that runs forever** (until you stop the simulation).
- Inside this loop, we check sensors and move the robot.
- The robot updates every TIME_STEP milliseconds.

```
# Step 7: Check if the robot sees the ball using its IR sensor
if robot.is_new_ball_data():
```

نتأكد إذا كان هناك بيانات جديدة من حساس الـ IR تعني أن الروبوت اكتشف وجود الكرة.

- The robot has an IR receiver to **detect the soccer ball**.
- This line checks if there is **new information** about where the ball is.

```
# Step 8: Get the ball's direction
ball_data = robot.get_new_ball_data()
```

- We read the direction of the ball from the IR receiver.
- This gives us a **3D vector** like [x, y, z] showing where the ball is.

نقرأ موقع الكرة كنقطة في الفضاء (متجه ثلاثي الأبعاد مثل: x, y, z)، يحدد اتجاه الكرة بالنسبة للروبوت.

```
# Step 9: Use our helper function to decide where to go
# 0 = forward, 1 = turn left, -1 = turn right
direction = utils.get_direction(ball_data["direction"])
```

- We pass the direction vector to a helper function.
- This function returns:
  - 0 → ball is in front
  - 1 → ball is on the left
  - -1 → ball is on the right

نستخدم الدالة `get_direction` لتحديد اتجاه الكرة:

- `0` → الكرة أمام الروبوت.
- `1` → الكرة على اليسار.
- `1-` → الكرة على اليمين.

```
# Step 10: Decide how fast to spin each wheel
if direction == 0:
    left_speed = 7
    right_speed = 7
```

•If the ball is in front, go **straight**.
•Both wheels spin forward at the same speed.

إذا كانت الكرة أمام الروبوت مباشرة:

- نحرك العجلتين بنفس السرعة إلى الأمام.

```
else:
    left_speed = direction * 4
    right_speed = direction * -4
```

•If the ball is not in front:
    •If direction = 1, turn left: left wheel slower than right.
    •If direction = -1, turn right: right wheel slower than left.
•This makes the robot **rotate toward the ball**.

إذا كانت الكرة على اليمين أو اليسار:

- نُبطئ عجلة ونُسرع الأخرى حتى يدور الروبوت باتجاه الكرة.

```
# Step 11: Apply the speeds to the wheels to move the robot
robot.left_motor.setVelocity(left_speed)
robot.right_motor.setVelocity(right_speed)
```

We finally set the motors so the robot moves in the right direction.

نرسل الأوامر النهائية لتشغيل المحركات وتحريك الروبوت حسب السرعات التي حسبناها.

```
else:
    # Step 12: If no ball is seen, stop the robot
    robot.left_motor.setVelocity(0)
    robot.right_motor.setVelocity(0)
```

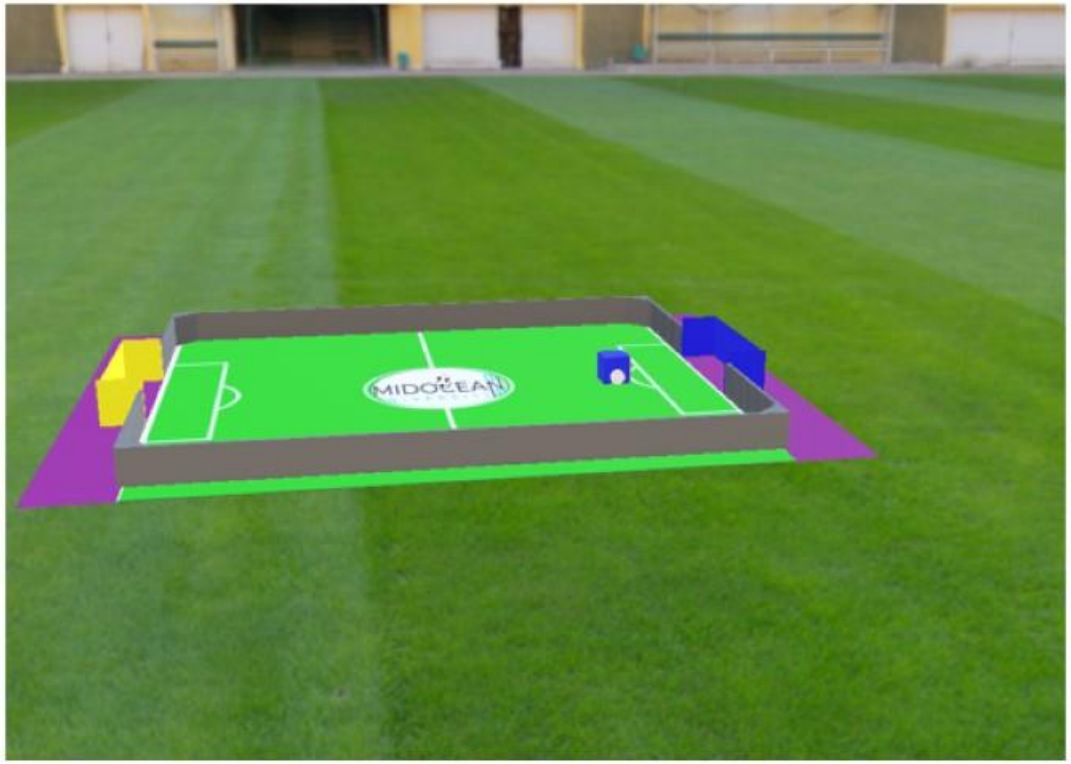
- If the robot doesn't see the ball, it **stops moving**.
- This prevents the robot from getting lost or spinning around randomly.

إذا لم تكن الكرة مرئية، نوقف كلا المحركين حتى لا يتحرك الروبوت بشكل عشوائي.

Summary of What the Robot Does:

1. Looks for the ball using IR.
2. If it sees the ball:
    1. Moves straight if it's in front.
    2. Turns left or right to face the ball.
3. If it doesn’t see the ball:
    1. Stops.

LIVE DEMO Example 2

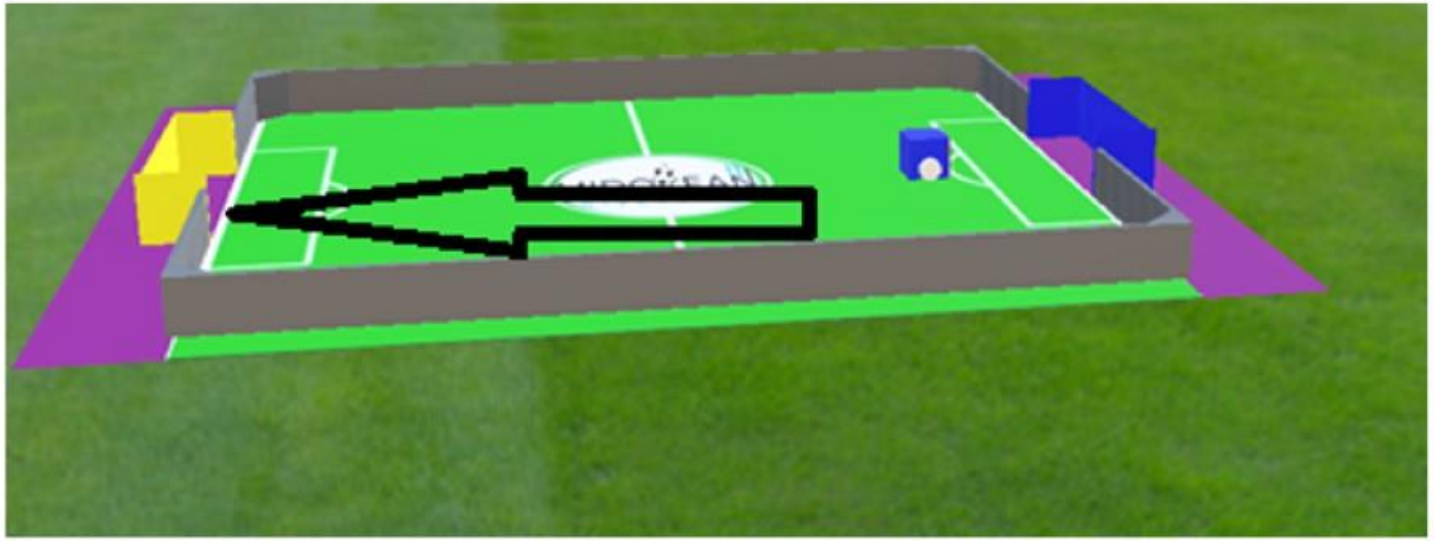


robot1.py

```
# Dr.Khaled Eskaf
#Professor of Intelligent Systems
#khaled.eskaf@mail.mcgill.ca



# rcj_soccer_player controller - ROBOT B1
# وحدة التحكم بالروبوت B1

# ---------------------------
# Import the Webots Robot API
# استيراد واجهة برمجة التطبيقات الخاصة بـ Webots للتحكم بالروبوت
from controller import Robot

# ---------------------------
# Import helper function to decide direction
# استيراد ملف utils الذي يحتوي على دالة تساعد الروبوت في تحديد اتجاه الكرة
import utils

# ---------------------------
# Import base robot configuration (sensors, motors, etc.)
# استيراد الكلاس RCJSoccerRobot الذي يربط بين الحساسات والمحركات
# واستيراد TIME_STEP لتحديد الزمن بين كل خطوة في الحلقة
from rcj_soccer_robot import RCJSoccerRobot, TIME_STEP

# ---------------------------
# Create an instance of the Robot class from Webots
```

Download Folder Example S3

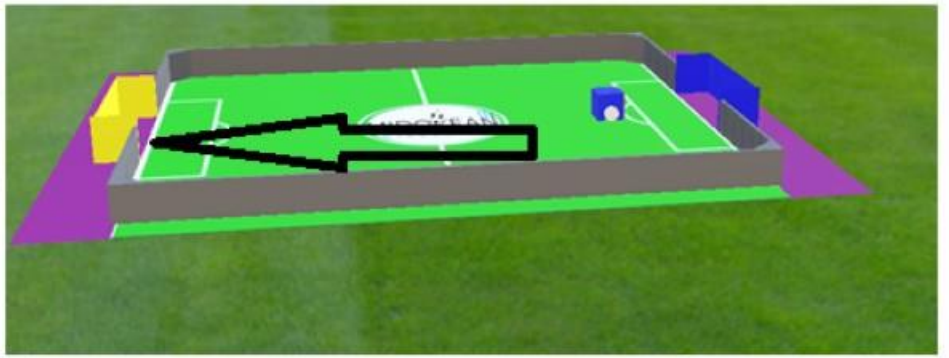
How Robot B1 Finds the Yellow Goal (Only) – No Ball



First: Understand the Field Orientation

In setup:

- **Blue team (B1)** starts on the **right side** of the field.
- **Yellow goal** is on the **left side**.
- The robot's **compass** tells it what direction it is facing.
- The **goal** never moves—it's fixed.



1. The Field Has a Fixed Layout

Team	Start Side	Goal Direction
B1 (Blue)	Right	Moves **left** to score into the **yellow goal**
Y1 (Yellow)	Left	Moves **right** to score into the **blue goal**

- The goal **does not move.**
- The robot must know where it is on the field and which **side to attack.**

Robot B1 always tries to move **left** (toward the Yellow goal on the left side of the field).

How the robot **goes to the yellow goal? ====➔using the compass,**

🧠 **Step 1: 🎯 What is the robot trying to do?**

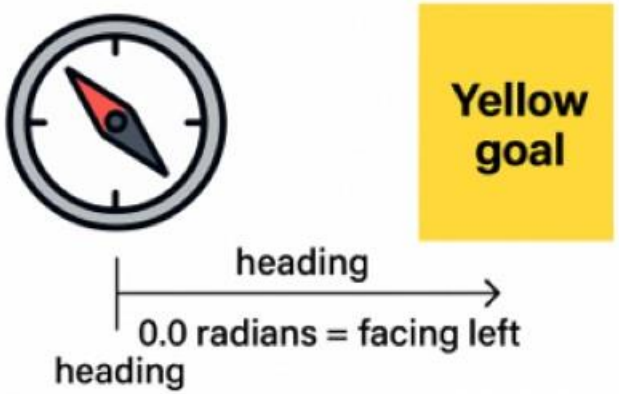
- The robot wants to score a goal 🥅 in the **yellow goal**.
- The **yellow goal** is always on the **left** side of the soccer field.
- So, the robot must **face left** before moving forward.

🧭 **Step 2: How does the robot know where it's facing?**

- The robot uses a **compass sensor** (like the compass on a phone).
- When the robot reads its compass, it gets an angle called heading.

📏 The target heading is:

- 0.0 radians = facing **left** (toward the yellow goal).



🔄 Step 3: How does the robot turn or move?

•The robot checks:

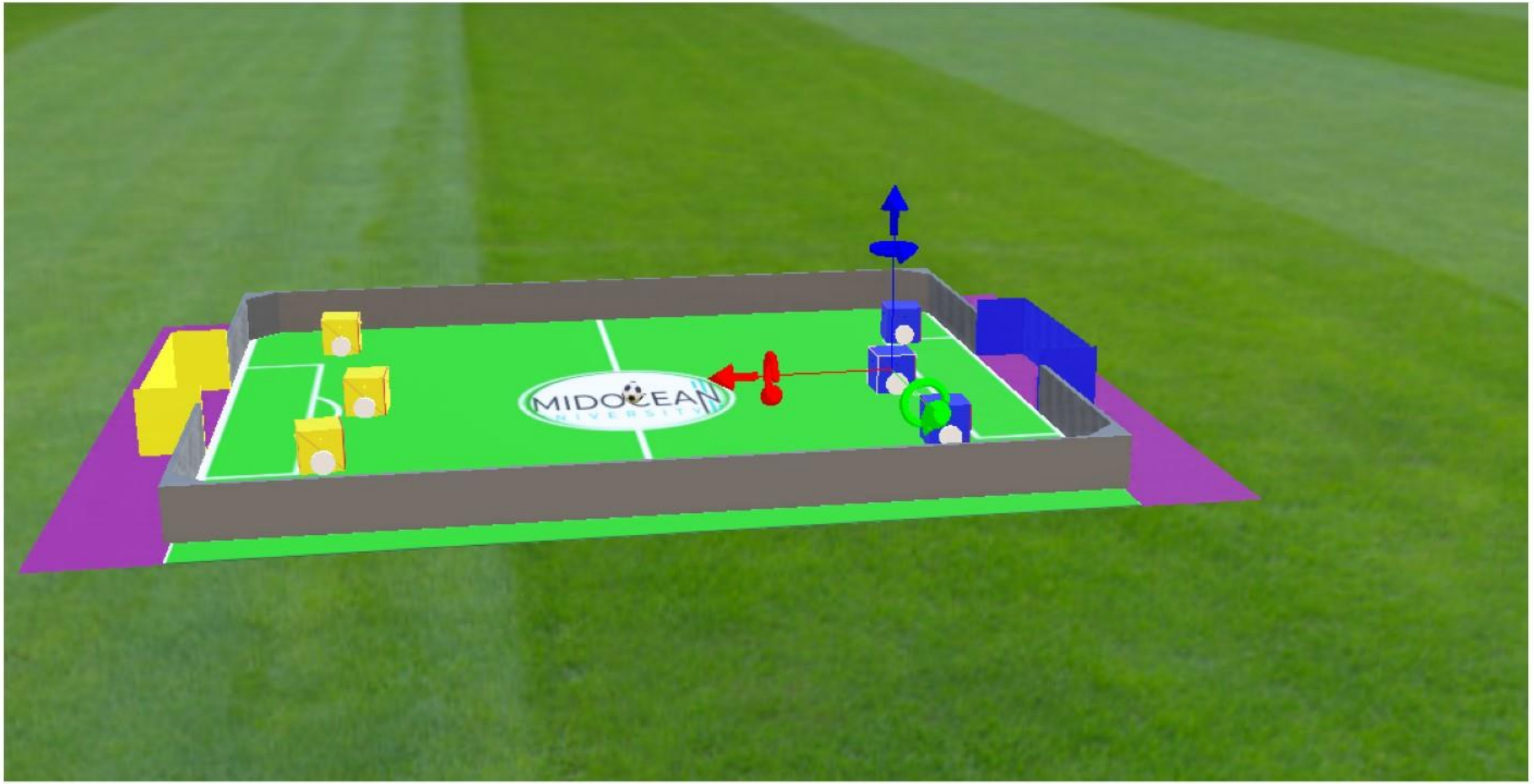
- If it's already looking at the yellow goal → move forward.
- If it’s a little turned → rotate slowly left or right.
- It keeps checking and adjusting.

```
if abs(angle_diff) < 0.1:
    move forward
elif angle_diff > 0.1:
    turn left
else:
    turn right
```

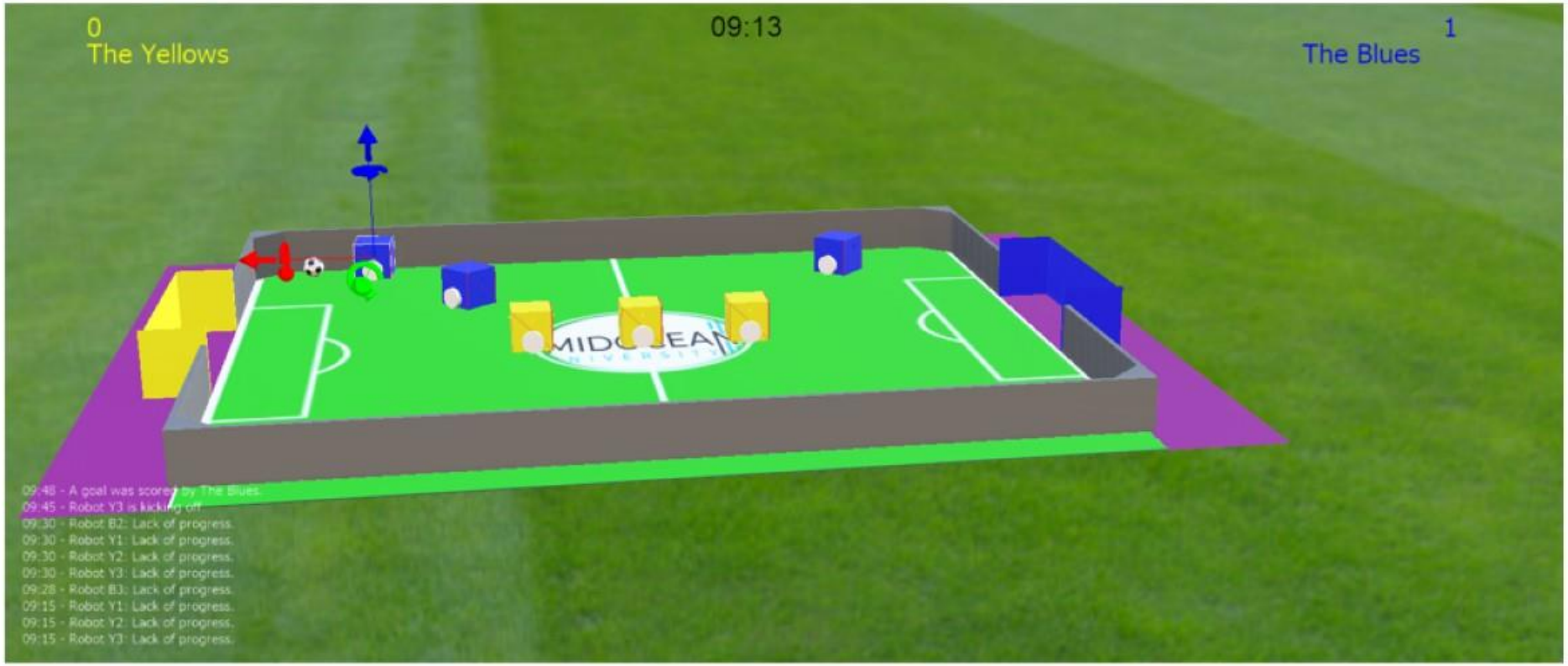
✅ Summary for Students (In Arabic + English):

English	العربية
The robot wants to go to the yellow goal.	الروبوت يريد الذهاب إلى المرمى الأصفر.
It uses the compass to know its direction.	يستخدم البوصلة ليعرف اتجاهه الحالي.
If it is not facing the goal, it turns.	إذا لم يكن يواجه المرمى، فإنه يدور.
Once it faces the goal, it moves forward.	عندما يواجه المرمى، يتحرك للأمام.

Download Folder Example S4



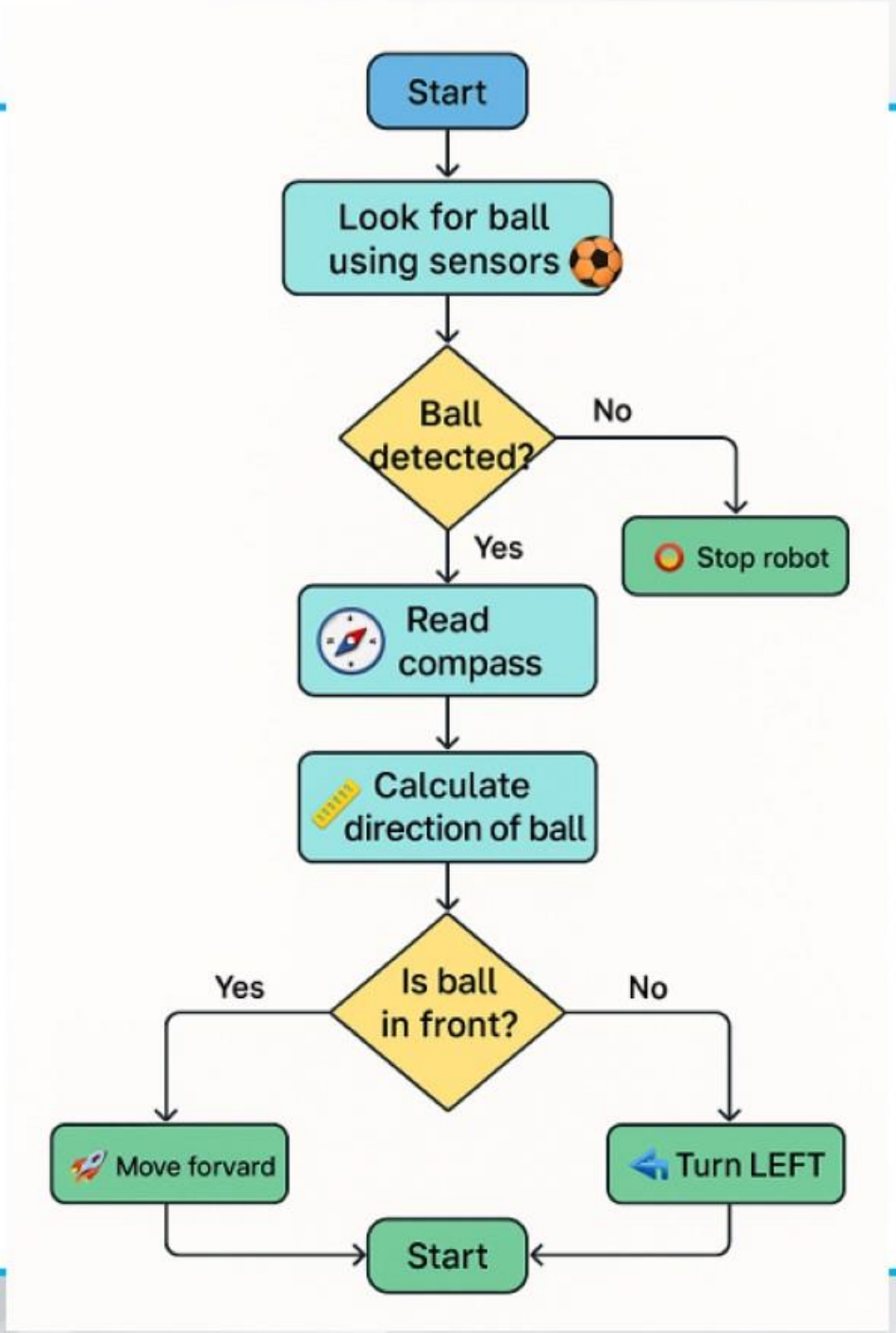
Example S4

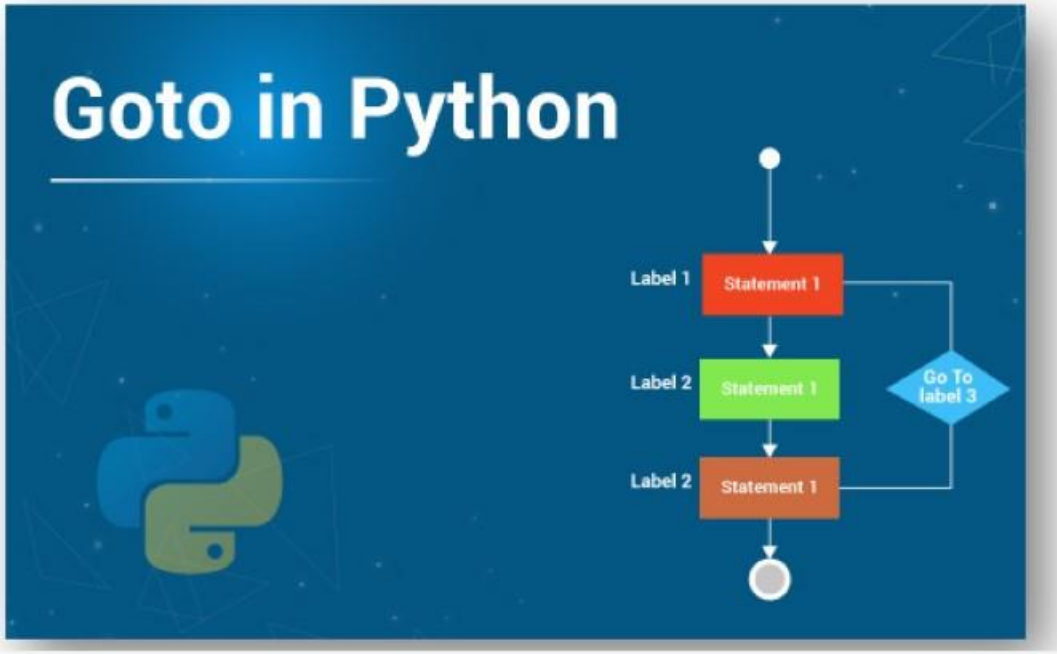

0
The Yellows
09:13
1
The Blues
09:48 - A goal was scored by The Blues.
09:45 - Robot Y3 is kicking off.
09:30 - Robot B2: Lack of progress.
09:30 - Robot Y1: Lack of progress.
09:30 - Robot Y2: Lack of progress.
09:30 - Robot Y3: Lack of progress.
09:28 - Robot B3: Lack of progress.
09:15 - Robot Y1: Lack of progress.
09:15 - Robot Y2: Lack of progress.
09:15 - Robot Y3: Lack of progress.

What are we trying to do?

We are programming a small soccer robot to:

1. Look for the soccer ball using its infrared sensor.
2. Decide where the ball is (front, left, or right).
3. Turn or move toward the ball to try and "catch" it.
4. Print useful info like its direction, compass heading, and location.


Start
Look for ball using sensors
Ball detected?
No
Stop robot
Yes
Read compass
Calculate direction of ball
Is ball in front?
Yes
No
Move forvard
Turn LEFT
Start



[redacted] › Example 4 › controllers › rcj_soccer_team_blue

Name	Date modified	Type	Size
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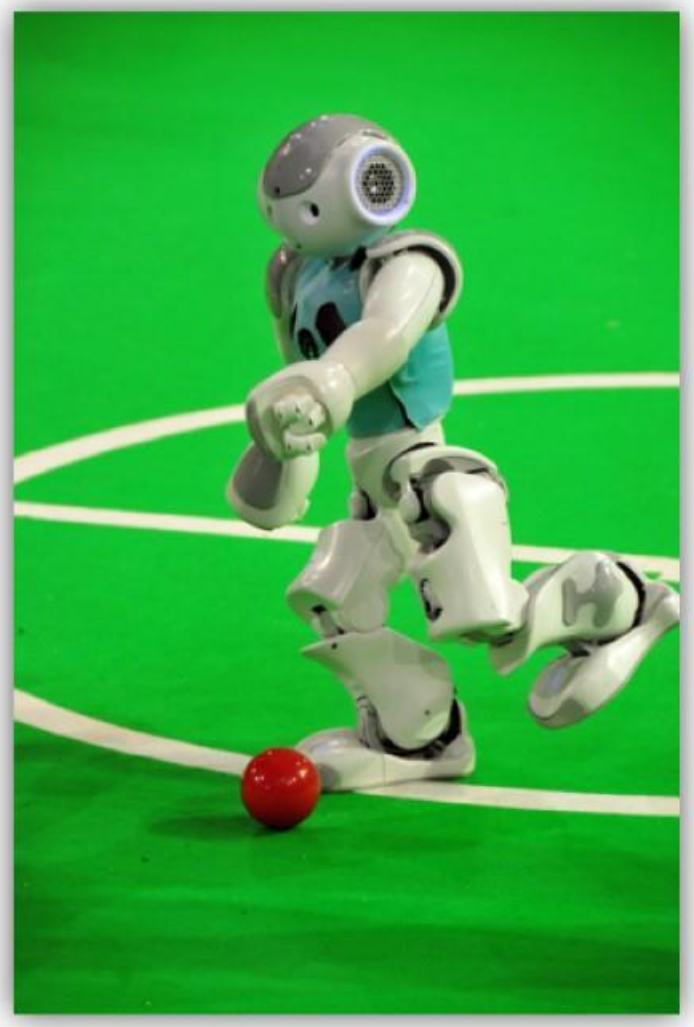
rcj_soccer_robot	2025-08-02 11:03 PM	Python File	6 KB
rcj_soccer_team_blue	2025-08-02 11:04 PM	Python File	1 KB
robot1	2025-08-03 12:46 AM	Python File	5 KB
robot2	2025-08-03 12:17 AM	Python File	3 KB
robot3	2025-08-03 12:25 AM	Python File	4 KB
utils	2025-08-02 11:04 PM	Python File	1 KB



Improve the robot's behavior

✅ **GOAL: Make Robot B1 Play Smarter in Soccer**

🧠 **First: What does the current robot do?**

- It looks for the ball using an IR sensor.
- If the ball is in front → move forward.
- If the ball is on the left or right → turn.
- It doesn't know how far it is from the goal.
- It doesn't try to avoid other robots or walls.

- يبحث عن الكرة باستخدام حساس الأشعة تحت الحمراء.
- إذا كانت الكرة أمامه ← يتحرك للأمام.
- إذا كانت الكرة على اليسار أو اليمين ← يلف.
- لا يعرف كم يبعد عن المرمى.
- لا يتجنب الروبوتات الأخرى أو الجدران.

MIDOCEAN
UNIVERSITY

🎯 Final Assignment – Robot Soccer Competition

📅 **Deadline:** [16-August-2025 at 11.30 PM]

📍 **Submission via Moodle**

Final Assignment – Robot Soccer Competition.DOC

Day

02

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Thank You