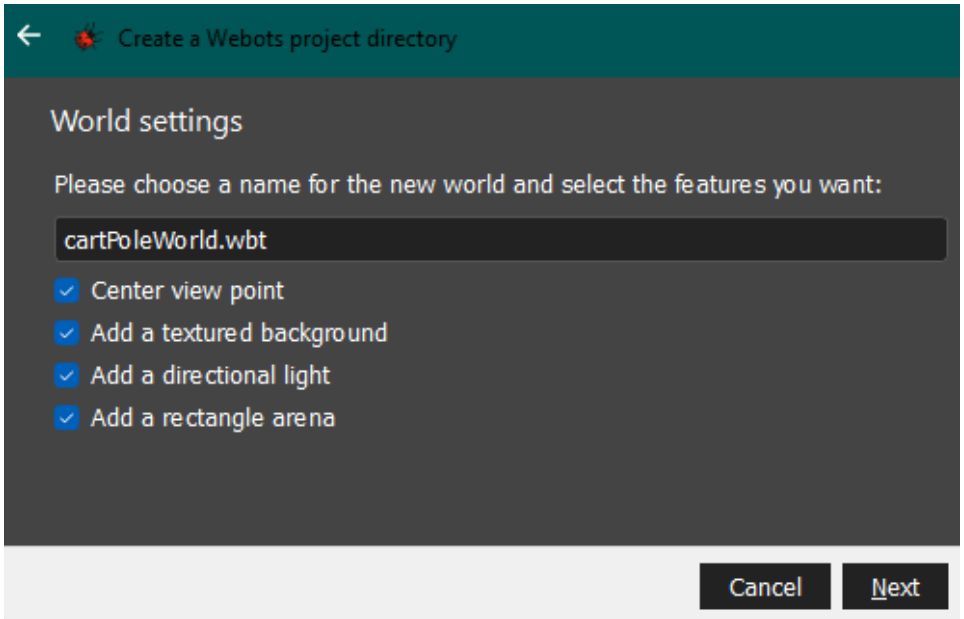
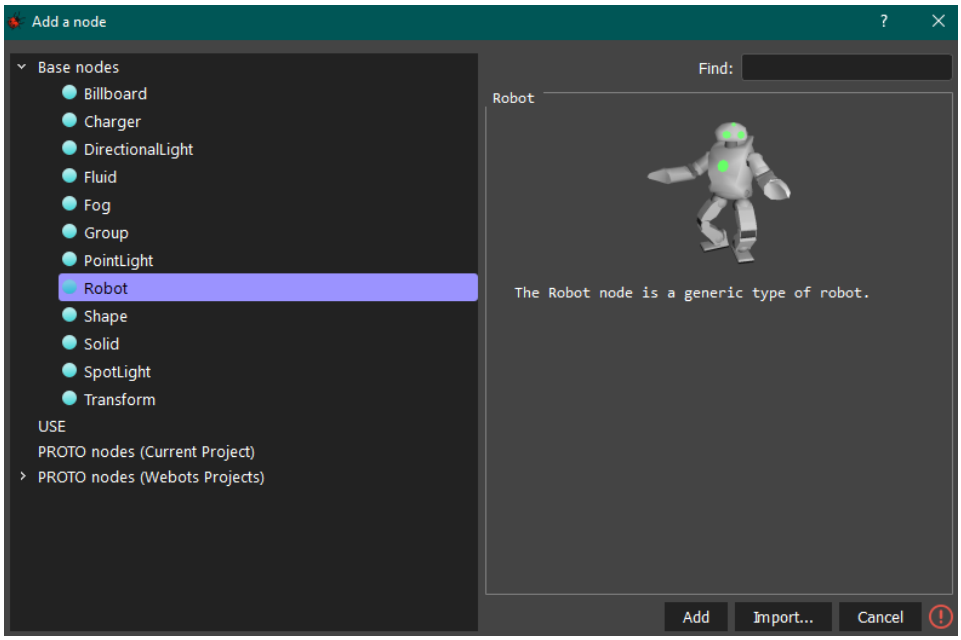
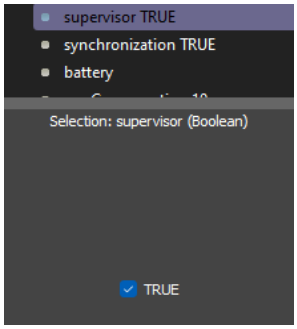
1. Mebuat project baru dengan tambahan *rectangle arena*.



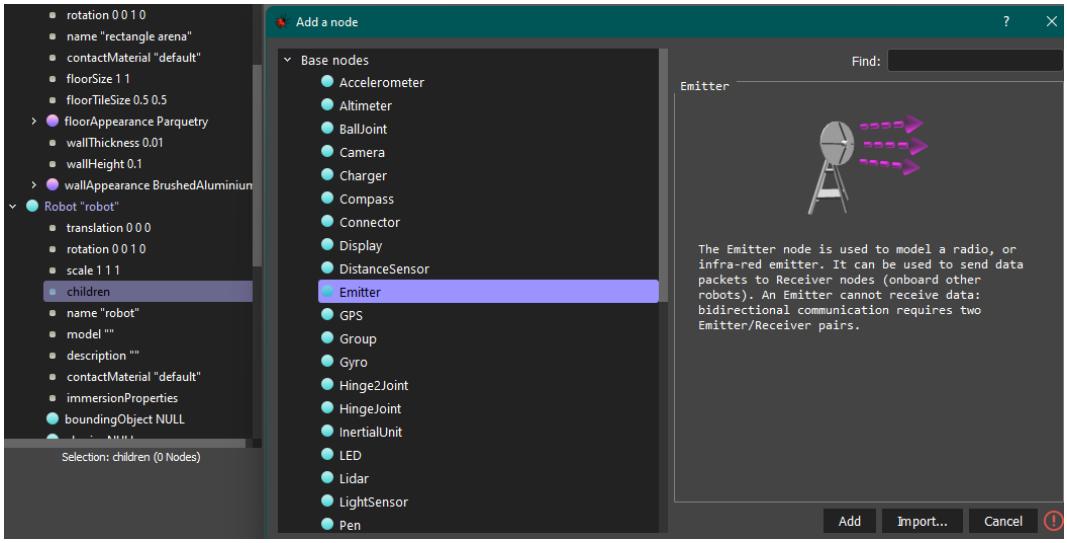
2. Klik *add node* pada toolbar dan tambahkan “robot” node.

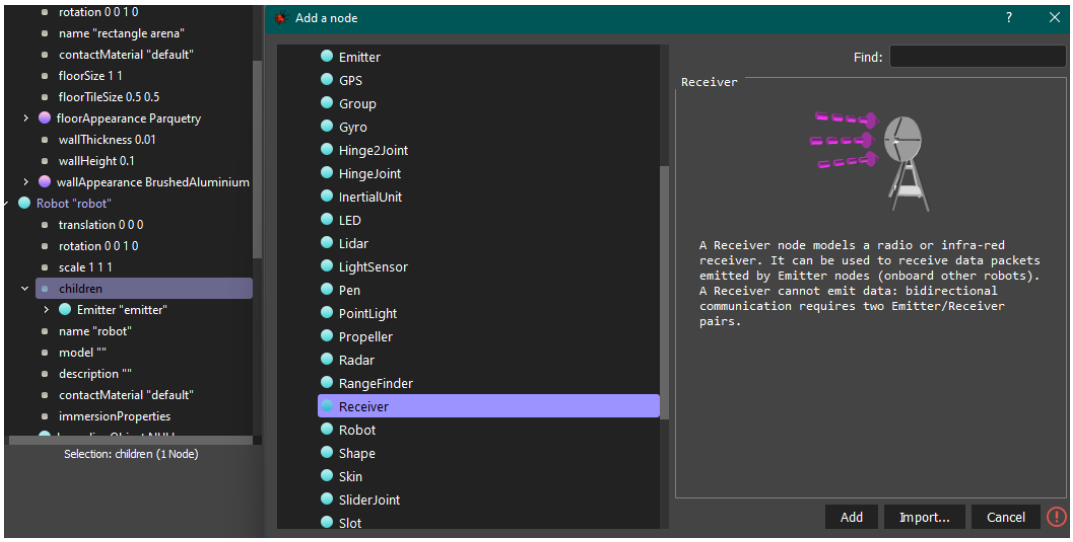


3. Mengubah Boolean supervisor pada node “robot” menjadi TRUE.

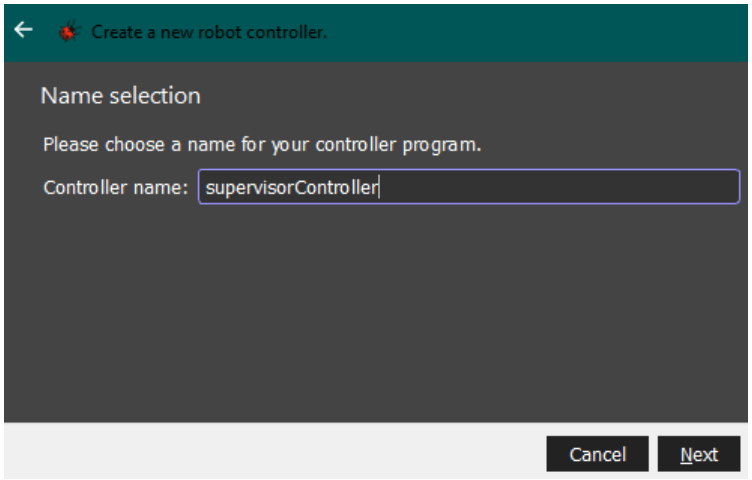


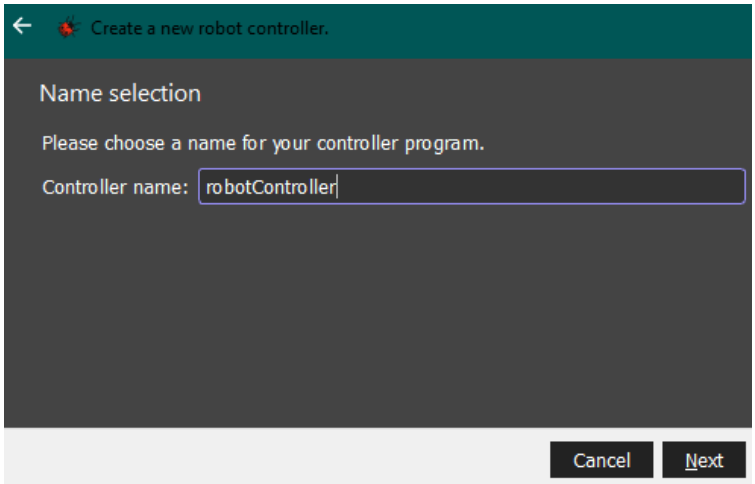
4. Menambahkan node *Emitter* dan *Receiver* pada children “robot”.



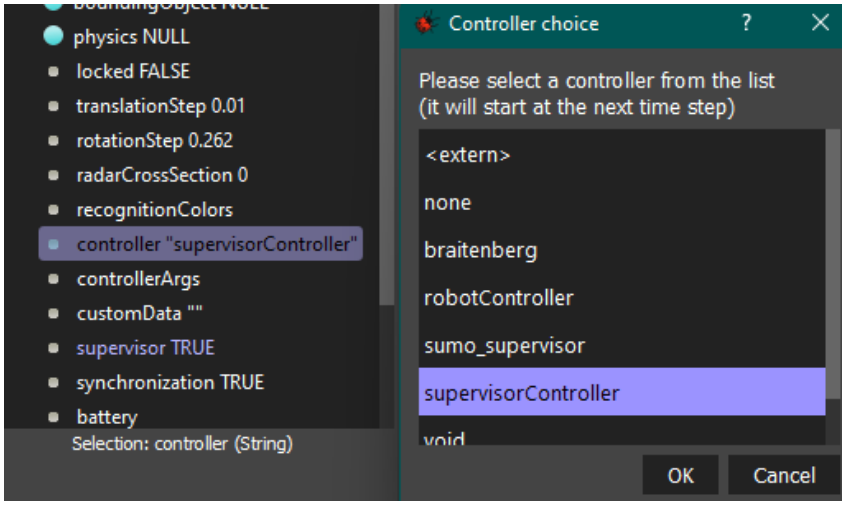


5. Menambahkan 2 Controller baru yang menggunakan Python diberikan nama "supervisorController" dan "robotController".

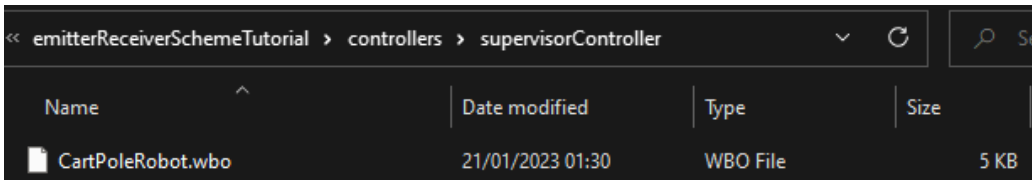




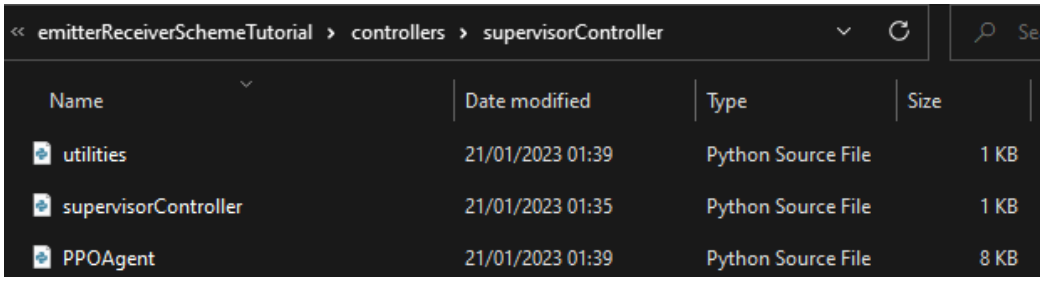
6. Mengubah controller “robot” node jadi menggunakan supervisorController.



7. [Klik disini](#) untuk mendownload file CartPole robot definition, lalu dilanjutkan dengan pemilihan *directory* Controllers/supervisorController/.



8. [Klik disini](#) untuk melakukan download PPO Agent dan [klik disini](#) untuk melakukan download *utilities script*, lalu pindahkan ke *directory* Controllers/supervisorController/.



9. Mengubah isi dari file robotSupervisorController.py dan juga robotController.py

supervisorController.py | robotController.py

```python
import numpy as np
from deepbots.supervisor.controllers.supervisor_emitter_receiver import SupervisorCSV
from PPOAgent import PPOAgent, Transition
from utilities import normalizeToRange


class CartPoleSupervisor(SupervisorCSV):
        def __init__(self):
                super().__init__()
                self.observationSpace = 4  # The agent has 4 inputs
                self.actionSpace = 2  # The agent can perform 2 actions

                self.robot = None
                self.respawnRobot()
                self.poleEndpoint = self.supervisor.getFromDef("POLE_ENDPOINT")
                self.messageReceived = None        # Variable to save the messages received from the robot

                self.episodeCount = 0  # Episode counter
                self.episodeLimit = 10000  # Max number of episodes allowed
                self.stepsPerEpisode = 200  # Max number of steps per episode
                self.episodeScore = 0  # Score accumulated during an episode
                self.episodeScoreList = []  # A list to save all the episode scores, used to check if task is so

        def respawnRobot(self):
                if self.robot is not None:
                        # Despawn existing robot
                        self.robot.remove()

                # Respawn robot in starting position and state
                rootNode = self.supervisor.getRoot()  # This gets the root of the scene tree
                childrenField = rootNode.getField('children')  # This gets a list of all the children, ie. objec
                childrenField.importMFNode(-2, "CartPoleRobot.wbo")       # Load robot from file and add to seco

                # Get the new robot and pole endpoint references
                self.robot = self.supervisor.getFromDef("ROBOT")
                self.poleEndpoint = self.supervisor.getFromDef("POLE_ENDPOINT")

        def get_observations(self):
                # Position on z axis, third (2) element of the getPosition vector
                cartPosition = normalizeToRange(self.robot.getPosition()[2], -0.4, 0.4, -1.0, 1.0)
                # Linear velocity on z axis
                cartVelocity = normalizeToRange(self.robot.getVelocity()[2], -0.2, 0.2, -1.0, 1.0, clip=True)
                # Angular velocity x of endpoint
```

```python
                endpointVelocity = normalizeToRange(self.poleEndpoint.getVelocity()[3], -1.5, 1.5, -1.0, 1.0, clip=True)

                # Update self.messageReceived received from robot, which contains pole angle
                self.messageReceived = self.handle_receiver()
                if self.messageReceived is not None:
                        poleAngle = normalizeToRange(float(self.messageReceived[0]), -0.23, 0.23, -1.0, 1.0, clip=Tru
                else:
                        # Method is called before self.messageReceived is initialized
                        poleAngle = 0.0

                return [cartPosition, cartVelocity, poleAngle, endpointVelocity]

        def get_reward(self, action=None):
                return 1

        def is_done(self):
                if self.messageReceived is not None:
                        poleAngle = round(float(self.messageReceived[0]), 2)
                else:
                        # method is called before self.messageReceived is initialized
                        poleAngle = 0.0
                if abs(poleAngle) > 0.261799388:  # more than 15 degrees off vertical
                        return True

                if self.episodeScore > 195.0:
                        return True

                cartPosition = round(self.robot.getPosition()[2], 2)  # Position on z axis
                if abs(cartPosition) > 0.39:
                        return True

                return False

        def solved(self):
                if len(self.episodeScoreList) > 100:  # Over 100 trials thus far
                        if np.mean(self.episodeScoreList[-100:]) > 195.0:  # Last 100 episodes' scores average value
                                return True
                return False
```

```python
        def reset(self):
                self.respawnRobot()
                self.supervisor.simulationResetPhysics()  # Reset the simulation physics to start over
                self.messageReceived = None
                return [0.0 for _ in range(self.observationSpace)]

        def get_info(self):
                return None


supervisor = CartPoleSupervisor()
agent = PPOAgent(supervisor.observationSpace, supervisor.actionSpace)

solved = False
# Run outer loop until the episodes limit is reached or the task is solved
while not solved and supervisor.episodeCount < supervisor.episodeLimit:
        observation = supervisor.reset()  # Reset robot and get starting observation
        supervisor.episodeScore = 0

        for step in range(supervisor.stepsPerEpisode):
                # In training mode the agent samples from the probability distribution, naturally implementing exploration
                selectedAction, actionProb = agent.work(observation, type_="selectAction")
                # Step the supervisor to get the current selectedAction's reward, the new observation and whether we reached
                # the done condition
                newObservation, reward, done, info = supervisor.step([selectedAction])

                # Save the current state transition in agent's memory
                trans = Transition(observation, selectedAction, actionProb, reward, newObservation)
                agent.storeTransition(trans)

                if done:
                        # Save the episode's score
                        supervisor.episodeScoreList.append(supervisor.episodeScore)
                        agent.trainStep(batchSize=step + 1)
                        solved = supervisor.solved()  # Check whether the task is solved
                        break

                supervisor.episodeScore += reward  # Accumulate episode reward
                observation = newObservation  # observation for next step is current step's newObservation

        print("Episode #", supervisor.episodeCount, "score:", supervisor.episodeScore)
        supervisor.episodeCount += 1  # Increment episode counter
```

```python
        supervisor.episodeCount += 1  # Increment episode counter

if not solved:
        print("Task is not solved, deploying agent for testing...")
elif solved:
        print("Task is solved, deploying agent for testing...")

observation = supervisor.reset()
while True:
        selectedAction, actionProb = agent.work(observation, type_="selectActionMax")
        observation, _, _, _ = supervisor.step([selectedAction])
```

pervisorController.py × robotController.py ×

```python
from deepbots.robots.controllers.robot_emitter_receiver_csv import RobotEmitterReceiverCSV


class CartpoleRobot(RobotEmitterReceiverCSV):
        def __init__(self):
                super().__init__()
                self.positionSensor = self.robot.getPositionSensor("polePosSensor")
                self.positionSensor.enable(self.get_timestep())
                self.wheel1 = self.robot.getMotor('wheel1')    # Get the wheel handle
                self.wheel1.setPosition(float('inf'))  # Set starting position
                self.wheel1.setVelocity(0.0)  # Zero out starting velocity
                self.wheel2 = self.robot.getMotor('wheel2')
                self.wheel2.setPosition(float('inf'))
                self.wheel2.setVelocity(0.0)
                self.wheel3 = self.robot.getMotor('wheel3')
                self.wheel3.setPosition(float('inf'))
                self.wheel3.setVelocity(0.0)
                self.wheel4 = self.robot.getMotor('wheel4')
                self.wheel4.setPosition(float('inf'))
                self.wheel4.setVelocity(0.0)

        def create_message(self):
                # Read the sensor value, convert to string and save it in a list
                message = [str(self.positionSensor.getValue())]
                return message

        def use_message_data(self, message):
                action = int(message[0])  # Convert the string message into an action integer

                if action == 0:
                        motorSpeed = 5.0
                elif action == 1:
                        motorSpeed = -5.0
                else:
                        motorSpeed = 0.0

                # Set the motors' velocities based on the action received
                self.wheel1.setVelocity(motorSpeed)
                self.wheel2.setVelocity(motorSpeed)
                self.wheel3.setVelocity(motorSpeed)
                self.wheel4.setVelocity(motorSpeed)


# Create the robot controller object and run it
robot_controller = CartpoleRobot()
robot_controller.run()  # Run method is implemented by the framework, just need to call it
```

Hasil Running Project