SYMBIOSIS INSTITUTE OF TECHNOLOGY, PUNE

DEPARTMENT OF ROBOTICS AND AUTOMATION ENGINEERING

ACADEMIC YEAR: 2024-25 SEM: V

ASSIGNMENT NO: 3

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BATCH: RA1

Aim

Create a Four wheeled robot and write a controller program for moving the robot in a path described by letter S pattern. Dimensions of path can be as per your choice.

Apparatus

Webot Software.

Theory

Definitions

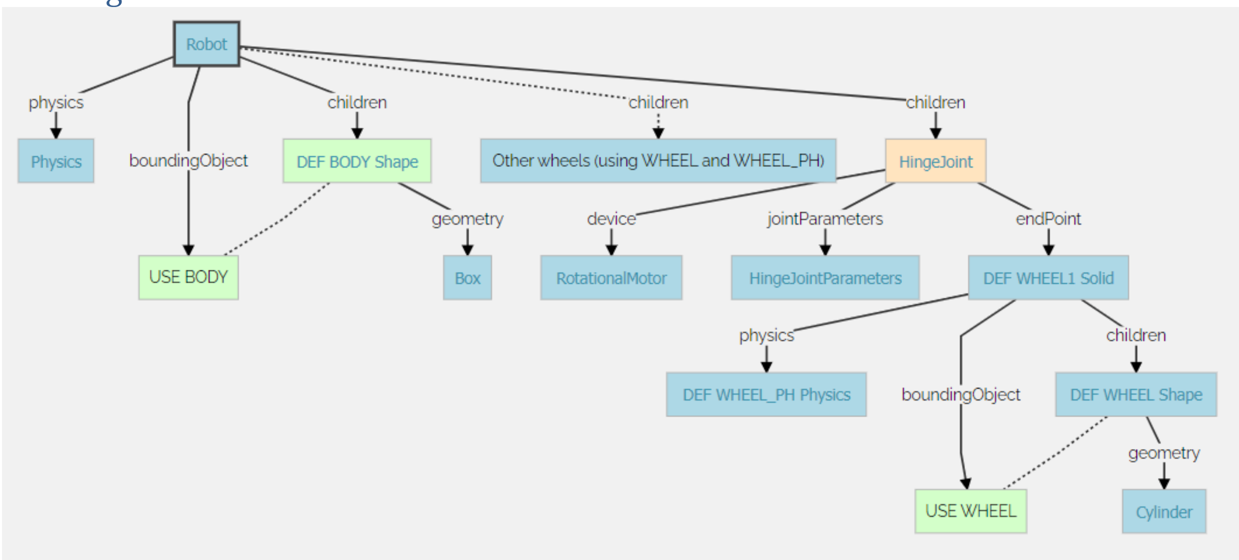
1. Compound Solids**:** Compound Solids are complex 3D objects composed of multiple simpler shapes (e.g., boxes, spheres) combined into a single entity. They are used to create detailed and intricate structures or robots efficiently.

2. Physics Attribute: The "physics" attribute defines the physical properties of a 3D object, including mass, friction, and density, affecting how it interacts with forces and other objects in the simulation. This attribute is crucial for realistic simulations of movement and collisions.

Concepts

1. Compound Solids:
   - Compound solids can have a hierarchical structure where each shape (or sub-part) can be independently positioned, rotated, and scaled. Transformations of individual parts are relative to the parent object, allowing for detailed and flexible designs.
   - Application: Ideal for constructing robots or complex objects that require multiple components working together as a single entity, such as a robot with multiple limbs or a vehicle with various parts.
2. Physics Attribute:
   - Mass: Specifies the weight of an object. This affects how it responds to forces, gravity, and collisions. The mass is crucial for realistic simulation of dynamics and interactions.
   - Friction: Controls how much an object resists sliding across surfaces. Higher friction values mean more resistance, affecting how an object moves and stops. It impacts interactions with other objects and surfaces in the simulation.
   - Bounciness (Restitution): Determines how much an object bounces back after a collision. A higher restitution value results in more bouncing, whereas a lower value means less bounce. This attribute influences the realism of collisions.

Block Diagram



Code

```
#include <webots/motor.h>
#include <webots/robot.h>
#include <math.h>

#define TIME_STEP 64
#define WHEEL_RADIUS 0.03
#define WHEEL_DISTANCE 0.15
#define SPEED 5.0

void set_velocity(WbDeviceTag *wheels, double left_speed, double right_speed) {
  wb_motor_set_velocity(wheels[0], left_speed);
  wb_motor_set_velocity(wheels[1], right_speed);
  wb_motor_set_velocity(wheels[2], left_speed);
  wb_motor_set_velocity(wheels[3], right_speed);
}

void move_in_curve(WbDeviceTag *wheels, double radius, double speed, int duration_steps) {
  double left_speed, right_speed;
  if (radius > 0) {
    left_speed = speed * (radius - WHEEL_DISTANCE / 2) / radius;
    right_speed = speed;
  } else {
    left_speed = speed;
    right_speed = speed * (fabs(radius) - WHEEL_DISTANCE / 2) / fabs(radius);
  }

  set_velocity(wheels, left_speed, right_speed);

  for (int i = 0; i < duration_steps; i++) {
    wb_robot_step(TIME_STEP);
  }
}


void move_straight(WbDeviceTag *wheels, double speed, int duration_steps) {
```

```
  set_velocity(wheels, speed, speed);

  for (int i = 0; i < duration_steps; i++) {
    wb_robot_step(TIME_STEP);
  }
}

int main(int argc, char **argv) {
  wb_robot_init();

  WbDeviceTag wheels[4];
  char wheels_names[4][8] = {"wheel1", "wheel2", "wheel3", "wheel4"};
  for (int i = 0; i < 4; i++) {
    wheels[i] = wb_robot_get_device(wheels_names[i]);
    wb_motor_set_position(wheels[i], INFINITY);
    wb_motor_set_velocity(wheels[i], 0.0);
  }

  // First curve to the left
  move_in_curve(wheels, 0.3, SPEED, 100);

  // First straight segment
  move_straight(wheels, SPEED, 50);

  // Second curve to the right
  move_in_curve(wheels, -0.3, SPEED, 100);

  // Second straight segment
  move_straight(wheels, SPEED, 50);

  set_velocity(wheels, 0.0, 0.0);

  wb_robot_cleanup();
  return 0;
}
```

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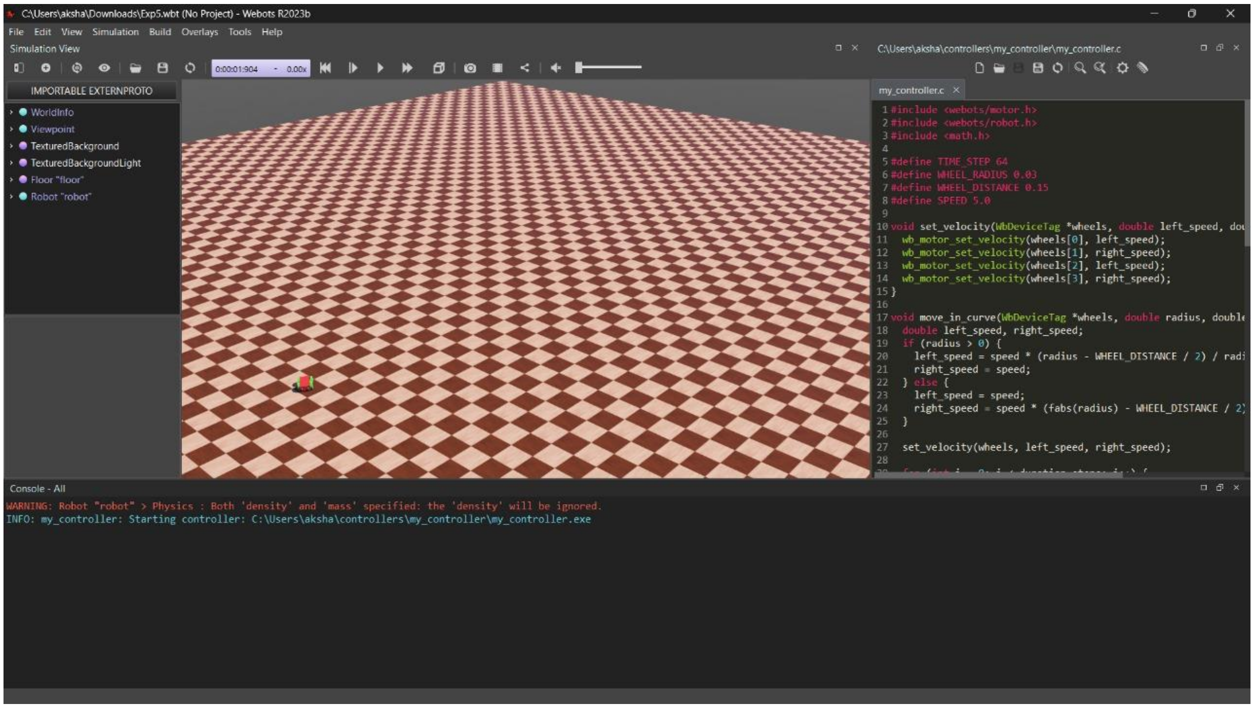
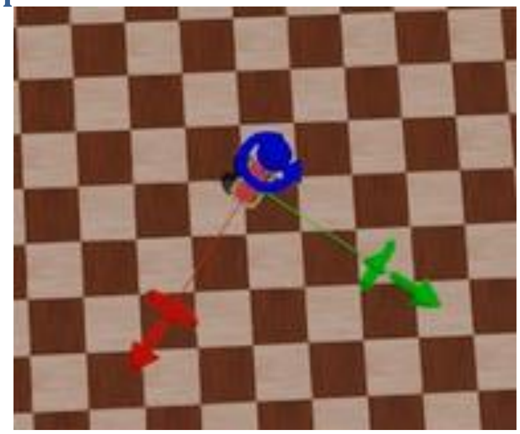
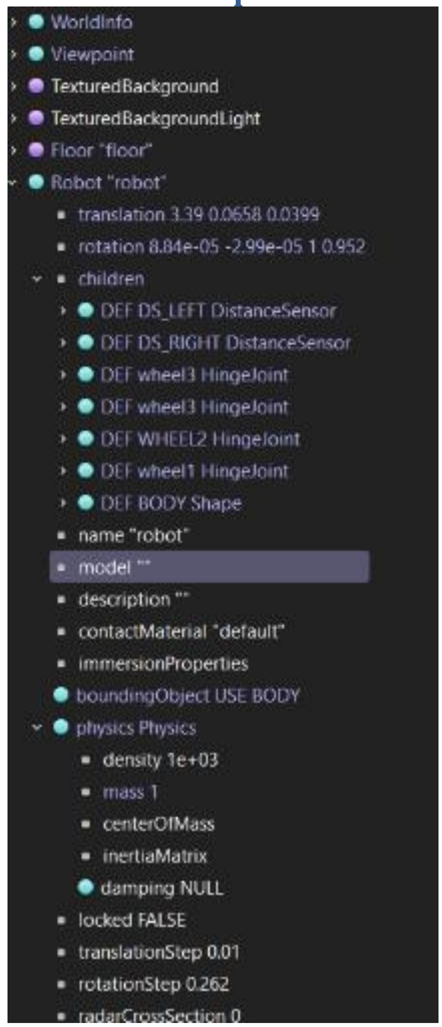
Snapshots

Full Window



Separate	Screen tree expanded
	

.wbt file text

#VRML_SIM R2023b utf8

EXTERNPROTO "https://raw.githubusercontent.com/cyberbotics/webots/R2023b/projects/objects/backgrounds/protos/TexturedBackground.proto"
EXTERNPROTO "https://raw.githubusercontent.com/cyberbotics/webots/R2023b/projects/objects/backgrounds/protos/TexturedBackgroundLight.proto"
IMPORTABLE EXTERNPROTO "https://raw.githubusercontent.com/cyberbotics/webots/R2023b/projects/objects/floors/protos/Floor.proto"

```
WorldInfo {
  basicTimeStep 16
}
Viewpoint {
  orientation 0.2039394214808927 0.07850035542877248 -0.9758311362954121 2.422955999005014
  position 7.201754588050023 6.443783992372531 4.2710864401683075
}
TexturedBackground {
```

```
}
TexturedBackgroundLight {
}
Floor {
  size 20 20
}
Robot {
  translation 3.145779062530971 -0.15380445838964368 0.039861748318522676
  rotation -6.318126273669078e-05 3.2305505546762035e-05 0.9999999974822411 0.5103846873684099
  children [
    DEF DS_LEFT DistanceSensor {
      translation 0.1 0.03 0
      rotation 0 0 1 0.3
      children [
        Shape {
          appearance PBRAppearance {
            baseColor 0.184314 0.596078 0.847059
            roughness 1
            metalness 0
          }
          geometry Box {
            size 0.01 0.01 0.01
          }
        }
      ]
      name "ds_left"
    }
    DEF DS_RIGHT DistanceSensor {
      translation 0.1 -0.03 0
      rotation 0 0 1 -0.3
      children [
        Shape {
          appearance PBRAppearance {
            baseColor 0.184314 0.596078 0.847059
            roughness 1
            metalness 0
          }
          geometry Box {
            size 0.01 0.01 0.01
          }
        }
      ]
      name "ds_right"
    }
    DEF wheel3 HingeJoint {
      jointParameters HingeJointParameters {
        position 216.78436461470744
        axis 0 1 0
        anchor -0.05 0.06 0
      }
      device [
        RotationalMotor {
          name "wheel4"
        }
```

```
      ]
      endPoint Solid {
        translation -0.05 -0.059999999999999915 0
        rotation -0.005116485626049331 0.7070962269966853 -0.7070988243109239 3.1518254979621867
        children [
          DEF WHEEL Shape {
            appearance PBRAppearance {
              baseColor 0.305882 0.898039 0.25098
              roughness 1
              metalness 0
            }
            geometry Cylinder {
              height 0.02
              radius 0.04
              subdivision 24
            }
          }
        ]
        name "solid(2)"
        boundingObject USE WHEEL
        physics Physics {
        }
        linearVelocity 0.1495653104913532 0.09580767446054654 -8.640038943760136e-08
        angularVelocity -2.0812135036806008 3.705550882181786 -0.15450166432670304
      }
    }
    DEF wheel3 HingeJoint {
      jointParameters HingeJointParameters {
        position 374.49254454761564
        axis 0 1 0
        anchor -0.05 0.06 0
      }
      device [
        RotationalMotor {
          name "wheel3"
        }
      ]
      endPoint Solid {
        translation -0.05 0.06 0
        rotation 0.2292414157428503 -0.6882749788910735 0.6882775070716072 2.6908986588306867
        children [
          DEF WHEEL Shape {
            appearance PBRAppearance {
              baseColor 0.305882 0.898039 0.25098
              roughness 1
              metalness 0
            }
            geometry Cylinder {
              height 0.02
              radius 0.04
              subdivision 24
            }
          }
        ]
```

```
    name "solid(1)"
    boundingObject USE WHEEL
    physics Physics {
    }
    linearVelocity 0.16555368314422597 0.10478775464808344 9.079943514990084e-08
    angularVelocity -2.4486652264616016 4.359367650758182 -0.15503885841759882
  }
}
DEF WHEEL2 HingeJoint {
  jointParameters HingeJointParameters {
    position 216.78435247107421
    axis 0 1 0
    anchor 0.05 -0.06 0
  }
  device [
    RotationalMotor {
      name "wheel2"
    }
  ]
  endPoint Solid {
    translation 0.05 -0.06 0
    rotation -0.005112192184552419 0.7070962425254029 -0.707098839836076 3.151816911339367
    children [
      DEF WHEEL Shape {
        appearance PBRAppearance {
          baseColor 0.305882 0.898039 0.25098
          roughness 1
          metalness 0
        }
        geometry Cylinder {
          height 0.02
          radius 0.04
          subdivision 24
        }
      }
    ]
    name "wheel2"
    boundingObject DEF WHEEL Shape {
      appearance PBRAppearance {
        baseColor 0.305882 0.898039 0.25098
        roughness 1
        metalness 0
      }
      geometry Cylinder {
        height 0.02
        radius 0.04
        subdivision 24
      }
    }
    physics Physics {
    }
    linearVelocity 0.15704516524752424 0.08248317586020212 1.6375557285906726e-07
    angularVelocity -2.081213752172123 3.7055494805892972 -0.15449952080699775
  }
```

```
  }
  DEF wheel1 HingeJoint {
    jointParameters HingeJointParameters {
      position 374.49253405423354
      axis 0 1 0
      anchor 0.05 0.06 0
    }
    device [
      RotationalMotor {
        name "wheel1"
      }
    ]
    endPoint Solid {
      translation 0.05 0.06 0
      rotation 0.22923761476118534 -0.688275611873372 0.6882781400559935 2.6909058812279154
      children [
        DEF WHEEL Shape {
          appearance PBRAppearance {
            baseColor 0.305882 0.898039 0.25098
            roughness 1
            metalness 0
          }
          geometry Cylinder {
            height 0.02
            radius 0.04
            subdivision 24
          }
        }
      ]
      boundingObject USE WHEEL
      physics Physics {
      }
      linearVelocity 0.17303599283048796 0.09146201929852489 -1.6452438349863968e-07
      angularVelocity -2.4486643882810335 4.359366846554412 -0.1550379825570716
    }
  }
  DEF BODY Shape {
    appearance PBRAppearance {
      baseColor 0.917647 0.145098 0.145098
      roughness 1
      metalness 0
    }
    geometry Box {
      size 0.2 0.1 0.05
    }
  }
]
boundingObject USE BODY
physics Physics {
  mass 1
}
controller "my_controller"
linearVelocity 0.1612994235730195 0.09363546781350215 1.2980489776736747e-07
angularVelocity -3.7080873061557037e-06 9.044703152605652e-07 -0.15282492631922012
```

}

Learning Outcomes

By designing and programming a four-wheeled robot to follow an S-shaped path, students will gain hands-on experience with robotics motion control, path planning, and sensor integration. This exercise enhances problem-solving skills and deepens understanding of concepts like kinematics, real-time control systems, and programming for autonomous navigation.