Omniwheel Chassis' Model and Plugin for Gazebo Simulator

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Abstract

Increasing a mobility of a robot in a limited space or in a presence of a large number of people is an important task. Mecanum wheels could provide the required high flexibility locomotion in any direction. This article presents a virtual model of an omniwheel robot in the Gazebo simulator. Freely rotating rollers were implemented to simulate the robot motion. We developed a four-wheel mecanum mobile robot plugin controls the robot by publishing linear velocity data along X and Y axes, and angular velocity data along Z-axis. The plugin could optionally publish a standard ground-truth odometry of the Gazebo or a calculated in real time wheel odometry. The open source code is extendable for similarly structured platforms and is available for a download via GitLab.

Keywords: Mecanum Wheels, Mobile Platform, Gazebo Simulator

1. Introduction

In the last decade, mobile robots with omnidirectional motion capabilities have been widely applied in various areas of a human life[1]. These mobile platforms are broadly employed in autonomous driving[2], manufacturing[3], industry[4], medical applications[5], social robotics[6], search and rescue[7], agriculture[8], education[9] and others. Omnidirectional movement is the ability to travel in any desired direction at any specified orientation[10]. To perform such locomotion an omnidirectional robot could use a special design of wheels called mecanum[11]. Mecanum wheels gain advantages in terms of maneuverability in narrow and crowded spaces[12]. A robot motion controller is decoupled and could perform translational and rotational motions.

Prior to a construction stage, it is important to model and simulate a new robot behavior in a virtual environment in order to decide on its efficiency and attempt to improve robot's mechanical and software features. Typically, roboticists prefer using standard simulators (e.g., ROS/Gazebo[13], Webots[14] or CoppeliaSim/V-REP[15]) while using simulators with a high-level of abstraction or developing in-house simulators are already considered to be an out-of-date approaches.

This paper presents a virtual model development of a four-wheeled omniwheel mobile robot LIRS-ArtBul[16] in the Gazebo simulator. Each mecanum wheel model has freely rotating rollers in order to perform omnidirectional motion. A motion control scheme was wrapped into a special four-wheel mecanum ROS plugin, which is fully configurable and can be easily reconfigured for researchers' tasks.

2. Modeling wheels and rollers

To achieve a high quality of a virtual model, it is important to take into account all the parameters and features of a corresponding real robot when creating its virtual representation for the simulator. The main task was to develop a model of an omniwheel robot with active freely rotating rollers. To create models Blender software was employed. A visual and collision parts of the wheel roller model are shown in Fig.1.

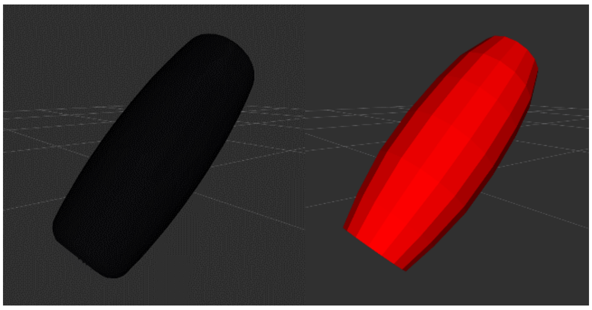

Fig.1.Wheel roller model in RViz: visual appearance (left) and collision (right) parts

To reduce complex collision calculations and increase real time factor (RTF), a low-poly model should be used. Roller's collision mesh with 220 polygons and a roller model for visual part with 7708 polygons allowed increasing RTF to 0.95-0.97. The wheel model in Gazebo is shown in Fig.2, each roller has its own joint and can be freely rotated along the Z-axis.

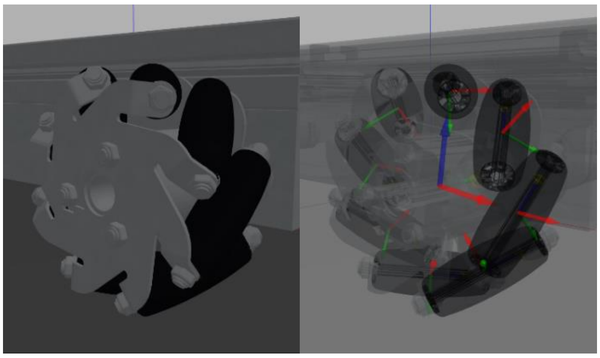

Fig.2.Wheel model in Gazebo

Four controllers of type *joint_velocity_controller* from *effort_controller* plugin were configured, since the real robot has a motor for each wheel. Package *joint_state_publisher* can be used to publish a position and a transformation of moving joints. *joint_state_publisher* connects to all non-fixed joints, but in this case *controller_manager* and *joint_state_publisher* packages publish positions of the duplicated joints to */joint_states* topic and multi-source publisher error occurs. Therefore, rollers' transmission parameters should be configured in URDF file, but controllers should not be created for these joints in YAML file. Then *controller_manager* publishes a position and a transformation of the roller joints and those joints could rotate freely. A mobile chassis with mecanum wheels in Gazebo is shown in Fig.3

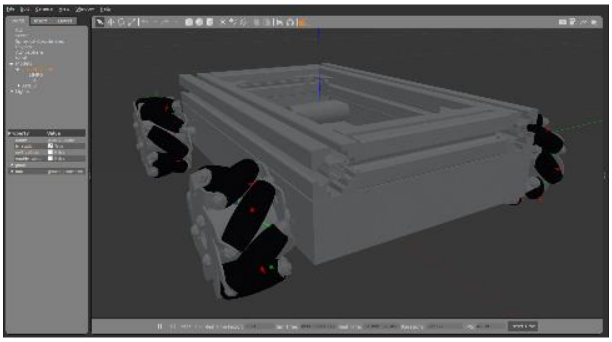

Fig.3.Mobile platform in Gazebo

3. Gazebo plugin for omniwheel robots

A plugin was developed to control the robot in Gazebo. It is suitable for all four-wheel mecanum mobile robots. The robot is controlled by publishing messages with linear velocities along the X and Y axes and an angular velocity along the Z axis to */cmd_vel* topic. From obtained data, the wheel velocities are calculated according to the equations (1) – (4)[17][18]:

$$v_{LF} = \frac{1}{R_{wheel}} \cdot \left(v_x - v_y - \left(\frac{s_{RL}}{2} + \frac{s_{FR}}{2}\right) \cdot v_z\right) \tag{1}$$

$$v_{RF} = \frac{1}{R_{wheel}} \cdot \left(v_x + v_y + \left(\frac{s_{RL}}{2} + \frac{s_{FR}}{2}\right) \cdot v_z\right) \tag{2}$$

$$v_{LR} = \frac{1}{R_{wheel}} \cdot \left(v_x + v_y - \left(\frac{s_{RL}}{2} + \frac{s_{FR}}{2}\right) \cdot v_z\right) \tag{3}$$

$$v_{RR} = \frac{1}{R_{wheel}} \cdot \left(v_x - v_y + \left(\frac{s_{RL}}{2} + \frac{s_{FR}}{2}\right) \cdot v_z\right) \tag{4}$$

where v_{LF}, v_{RF}, v_{LR}, v_{RR} – target rotation velocities of the left front, the right front, the left rear and the right rear wheels respectively in rad/s; R_{wheel} – the wheel radius; v_x is a target linear velocity along X-axis in m/s; v_y is a target linear velocity along Y-axis in m/s; v_z is a target angular velocity along Z-axis in rad/s; s_{RL} is the distance between the right and left wheels; s_{FR} is the distance between the front and rear wheels. Then the target wheel velocity is published to */command* topic of each controller. The plugin allows to select one of two types of published odometry:

1. Ground-truth odometry from Gazebo,
2. Wheel odometry.

In the first case, the position of the robot in the Gazebo is published. In the second case, the plugin searches for the necessary joints in the */joint_states* topic and their current rotation velocity, then calculates the robot velocity using the equations (5) – (7)[19]:

$$v_{xc} = (v_{LFC} + v_{RFC} + v_{LRC} + v_{RRC}) \cdot \frac{R_{wheel}}{4} \quad (5)$$

$$v_{yc} = (-v_{LFC} + v_{RFC} + v_{LRC} - v_{RRC}) \cdot \frac{R_{wheel}}{4} \quad (6)$$

$$v_{zc} = (-v_{LFC} + v_{RFC} - v_{LRC} + v_{RRC}) \cdot \frac{R_{wheel}}{2(s_{RL} + s_{FR})} \quad (7)$$

where v_{xc} is a current linear velocity along X-axis in m/s; v_{yc} is a current linear velocity along Y-axis in m/s; v_{zc} is an current angular velocity along Z-axis in rad/s; v_{LFC}, v_{RFC}, v_{LRC}, v_{RRC} are current rotation velocities of the left front, the right front, the left rear and the right rear wheels respectively; R_{wheel} is the wheel radius; s_{RL} is the distance between the right and left wheels; s_{FR} is the distance between front and rear wheels. Then the current robot position is calculated and the obtained data are published. This allows to choose between the accurate and the realistic odometry. Flowchart of received / sent messages by the plugin is shown in Fig.4

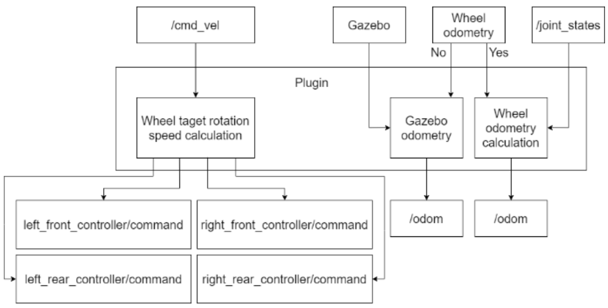

Fig.4.Flowchart of received/sent messages by the plugin

The plugin needs to set a command topic and an odometry topic, an odometry frame, the robot base frame, an update rate, to select the type of odometry, to specify names of the wheel controllers, half the length between the front and rear, right and left wheels and the wheel radius.

4. Conclusion

The article presented the virtual mecanum wheel mobile platform development. A high-poly and detailed model was developed for a visual part of the wheel, and a low-poly model was modeled for the collision part. This allowed to significantly increase the RTF of the Gazebo simulation. The developed plugin controls the model and is suitable for all four wheeled robots with mecanum wheels. The plugin publishes target speeds to wheel controller topics and can publish two types of odometry.

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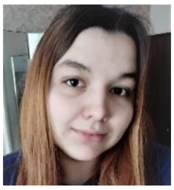

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