

ROS Noetic Assignment

Differential Drive Kinematics on Turtlesim

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Table of Contents

1. Introduction
2. Robot Kinematic Model
3. Forward Kinematics Node
4. Inverse Kinematics + Go-To-Goal Controller
5. Custom Message Definition
6. Package Structure
7. Execution Procedure
8. Results
9. Conclusion

1. Introduction

This assignment implements a differential-drive robot controller on the ROS Noetic platform using the Turtlesim simulator. The objective is to:

- Convert wheel angular velocities to linear and angular twist commands (Forward Kinematics).
- Convert robot velocity commands into left and right wheel velocities (Inverse Kinematics).
- Implement a proportional Go-To-Goal controller.
- Verify robot motion using Turtlesim and custom ROS topics.

2. Robot Kinematic Model

The differential-drive robot model relates wheel angular velocities (ω_L, ω_R) to body velocities (v, ω).

Forward Kinematics:

$$v = (r/2) * (\omega_R + \omega_L)$$

$$\omega = (r/L) * (\omega_R - \omega_L)$$

Inverse Kinematics:

$$\omega_R = (1/r)(v + (L/2)*\omega)$$

$$\omega_L = (1/r)(v - (L/2)*\omega)$$

Default Parameters:

- Wheel Radius $r = 0.05$ m

- Wheel Base $L = 0.20$ m

3. Forward Kinematics Node

The FK node subscribes to wheel angular velocities and publishes geometry_msgs/Twist to /turtle1/cmd_vel. It implements the forward kinematic equations and ensures the turtle moves according to the wheel inputs.

4. Inverse Kinematics + Go-To-Goal Controller

The Go-To-Goal controller computes linear velocity v and angular velocity ω based on:

ρ = distance to goal

α = heading error

β = orientation error

Control Law:

$$v = K\rho * \rho$$

$$\omega = K\alpha * \alpha + K\beta * \beta$$

Recommended Gains:

$$K\rho = 1.5, K\alpha = 4.0, K\beta = -1.0$$

The node also publishes wheel velocity debug values through /wheel_vel_dbg.

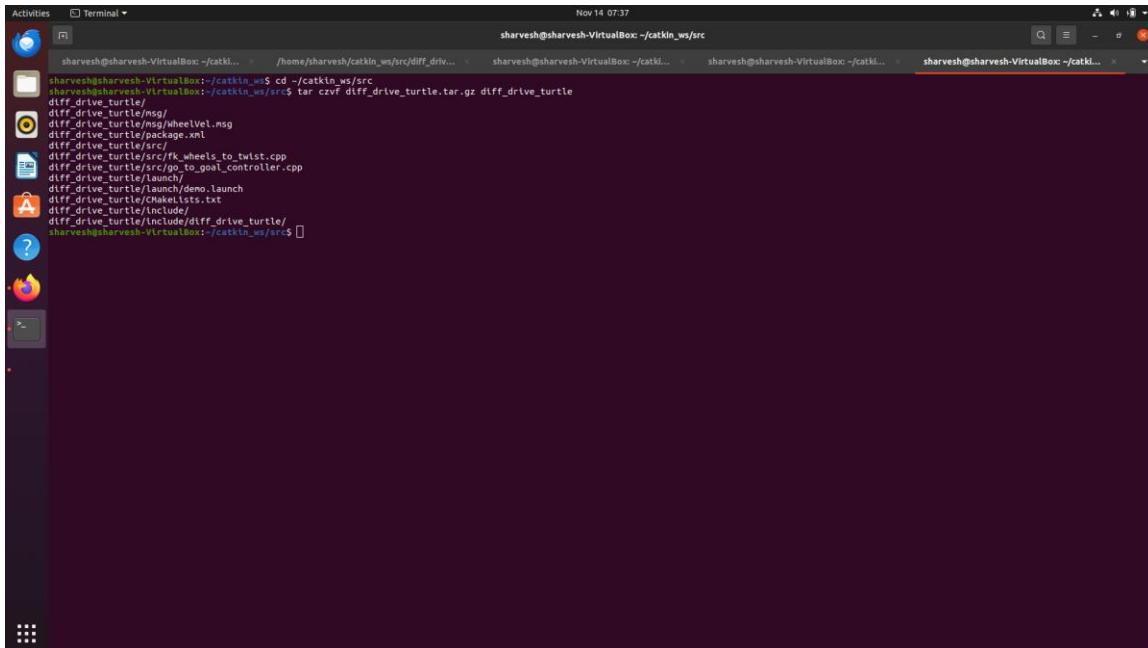
5. Custom Message Definition

msg/WheelVel.msg:

float64 omega_left

float64 omega_right

6. Package Structure

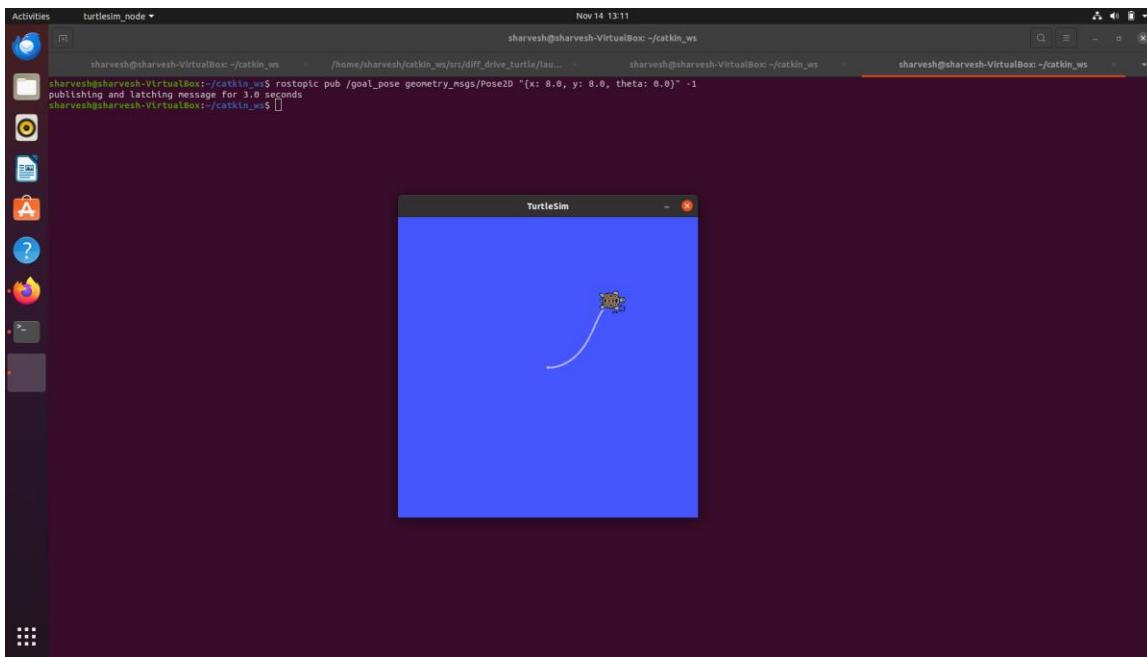


```
sharvesh@sharvesh-VirtualBox: ~/catkin_ws/src$ cd ~/catkin_ws/src
sharvesh@sharvesh-VirtualBox: ~/catkin_ws/src$ tar czvf diff_drive_turtle.tar.gz diff_drive_turtle
diff_drive_turtle/nsg/
diff_drive_turtle/nsg/wheelvel.msg
diff_drive_turtle/package.xml
diff_drive_turtle/src/fk_wheels_to_twist.cpp
diff_drive_turtle/src/go_to_goal_controller.cpp
diff_drive_turtle/launch/
diff_drive_turtle/launch/demo.launch
diff_drive_turtle/include/diff_drive_turtle.h
diff_drive_turtle/include/diff_drive_turtle/
sharvesh@sharvesh-VirtualBox: ~/catkin_ws/src$
```

7. Execution Procedure

1. Open terminal and start roscore.
2. Run the diff_drive_turtle demo launch file:
roslaunch diff_drive_turtle demo.launch
3. Send a goal pose to /goal_pose.
4. Observe robot motion in turtlesim.
5. Echo /wheel_vel_dbg to verify IK output.

8. Results



```
Activities Terminal Nov 14 13:14 sharvesh@harvesh-VirtualBox:~/catkin_ws sharvesh@harvesh-VirtualBox:~/catkin_ws$ cd ~/catkin_ws sharvesh@harvesh-VirtualBox:~/catkin_ws$ catkin_make Base path: /home/sharvesh/catkin_ws Source space: /home/sharvesh/catkin_ws/src Build space: /home/sharvesh/catkin_ws/build Devel space: /home/sharvesh/catkin_ws/devel Install space: /home/sharvesh/catkin_ws/install #### Running command: "make cmake_check_build_system" in "/home/sharvesh/catkin_ws/build" #### #### Running command: "make -j8 -l8" in "/home/sharvesh/catkin_ws/build" #### [ 0%] Built target std_msgs_generate_messages_py [ 0%] Built target std_msgs_generate_messages_nodejs [ 0%] Built target rospack_msgs_generate_messages_py [ 0%] Built target rospp_generate_messages_eus [ 0%] Built target rosgraph_msgs_generate_messages_cpp [ 0%] Built target rosrpc_msgs_generate_messages_nodejs [ 0%] Built target std_msgs_generate_messages_lisp [ 0%] Built target std_msgs_generate_messages_eus [ 0%] Built target roscpp_generate_messages_nodejs [ 0%] Built target roscpp_generate_messages_cpp [ 0%] Built target std_msgs_generate_messages_cpp [ 0%] Built target rospack_msgs_generate_messages_eus [ 0%] Built target rosrpc_msgs_generate_messages_lisp [ 10%] Built target dc_motor_simulator [ 21%] Built target dc_motor_controller [ 21%] Built target diff_drive_turtle_generate_messages_check_deps_WheelVel [ 33%] Built target controller [ 42%] Built target diff_drive_turtle_generate_messages_py [ 52%] Built target simulator [ 57%] Built target diff_drive_turtle_generate_messages_nodejs [ 63%] Built target diff_drive_turtle_generate_messages_cpp [ 68%] Built target diff_drive_turtle_generate_messages_lisp [ 70%] Built target diff_drive_turtle_generate_messages_eus [ 89%] Built target fk_wheels_to_twist_node [100%] Built target go_to_goal_controller_node [100%] Built target diff_drive_turtle_generate_messages sharvesh@harvesh-VirtualBox:~/catkin_ws$ source devel/setup.bash sharvesh@harvesh-VirtualBox:~/catkin_ws$ ]
```

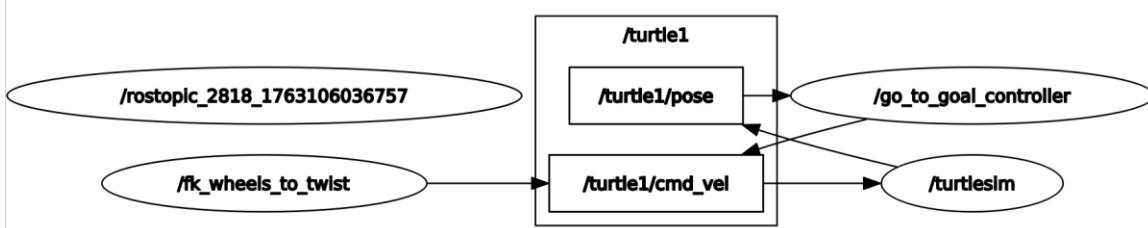
```

0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
sharvesh@sharvesh-VirtualBox:~/catkin_ws$ cd ~/catkin_ws/src
sharvesh@sharvesh-VirtualBox:~/catkin_ws/src$ tree diff_drive_turtle
diff_drive_turtle
├── CMakeLists.txt
├── include
│   └── diff_drive_turtle
├── launch
│   └── demo.launch
├── msg
│   └── WheelVel.msg
└── package.xml
src
└── fk_wheels_to_twist.cpp
    └── go_to_goal_controller.cpp

5 directories, 6 files
sharvesh@sharvesh-VirtualBox:~/catkin_ws/src$ 
```

```

sharvesh@sharvesh-VirtualBox:~/catkin_ws$ source ~/catkin_ws/devel/setup.bash
sharvesh@sharvesh-VirtualBox:~/catkin_ws$ rostopic pub /fk_wheels_to_twist/wheel_vel_in diff_drive_turtle/WheelVel "{omega_left: 2.0, omega_right: 2.0}" -r 5
rostopic echo /turtle1/cmd_vel 
```



```

^Csharvesh@sharvesh-VirtualBox:~/catkin_ws/src$ rosnode list
/fk_wheels_to_twist
/go_to_goal_controller
/rosout
/rostopic_2818_1763106036757
/turtlesim
sharvesh@sharvesh-VirtualBox:~/catkin_ws/src$ 
```

```

sharvesh@sharvesh-VirtualBox:~/catkin_ws$ cd ~/catkin_ws
sharvesh@sharvesh-VirtualBox:~/catkin_ws$ source devel/setup.bash
sharvesh@sharvesh-VirtualBox:~/catkin_ws$ roslaunch diff_drive_turtle demo.launch
... logging to /home/sharvesh/.ros/log/2117da20-c12d-11f0-9585-dfc4e258eb0d/roslaunch-sharvesh-VirtualBox-3370.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

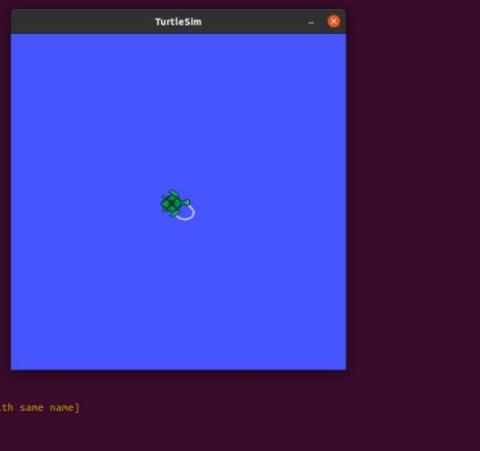
started roslaunch server http://sharvesh-VirtualBox:37077/
SUMMARY
=====
PARAMETERS
* /fk_wheels_to_twist/wheel_base: 0.2
* /fk_wheels_to_twist/wheel_zradius: 0.05
* /go_to_goal_controller/K_alpha: 4.0
* /go_to_goal_controller/K_beta: 1.0
* /go_to_goal_controller/K_rho: 1.5
* /go_to_goal_controller/goal_theta: 0.0
* /go_to_goal_controller/goal_x: 5.5
* /go_to_goal_controller/goal_y: 5.5
* /go_to_goal_controller/wheel_base: 0.2
* /go_to_goal_controller/wheel_radius: 0.05
* /rosdistro: noetic
* /rosversion: 1.17.4

NODES
/
  fk_wheels_to_twist (diff_drive_turtle/fk_wheels_to_twist_node)
  go_to_goal_controller (diff_drive_turtle/go_to_goal_controller_node)
  turtlesim (turtlesim/turtlesim_node)

ROS_MASTER_URI=http://localhost:11311

process[turtlesim-1]: started with pid [3384]
process[fk_wheels_to_twist-2]: started with pid [3385]
process[go_to_goal_controller-3]: started with pid [3386]
[WARN] [1763106716.155716397]: Shutdown request received.
[WARN] [1763106716.167740922]: Reason given for shutdown: [//fk_wheels_to_twist] Reason: new node registered with same name]
[fk_wheels_to_twist-2] process has finished cleanly
log file: /home/sharvesh/.ros/log/2117da20-c12d-11f0-9585-dfc4e258eb0d/fk_wheels_to_twist-2*.log
[INFO] [1763106716.745329647]: Starting turtlesim with node name /turtlesim
[INFO] [1763106716.778679843]: Spawning turtle [turtle1] at x=[5.544445], y=[5.544445], theta=[0.000000]

```



9. Conclusion

The assignment successfully demonstrates a complete differential-drive robot simulation using ROS Noetic. Forward kinematics, inverse kinematics, and Go-To-Goal control were implemented and verified through the Turtlesim environment. Custom ROS messages, debugging tools, and launch files were created, forming a fully functional robotics simulation package.