

AAE3004

Dynamical Systems and Control

Lab 1b: Autonomous ROS car control project

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AAE3004 Lab 1 Project Report Requirement

Assessment rubrics	Mark range ^{Note 1}	Outcomes
Excellent	[8,10]	<ul style="list-style-type: none"> Be able to successfully apply control theory (e.g. PID) to improve ROS car performance^{Note 2} Be able to present ROS car project learning experience appropriately, including but not limited to new skills/knowledge, troubleshooting, etc.
Good	[6-8]	<ul style="list-style-type: none"> Be able to apply control theory (e.g. PID) to improve ROS car performance^{Note 3} Be able to present ROS car project learning experience, including but not limited to new skills/knowledge, troubleshooting, etc.
Satisfactory	[4-6]	<ul style="list-style-type: none"> Be able to present ROS car project learning experience, including but not limited to new skills/knowledge, troubleshooting, etc.
Unsatisfactory	[0,4]	<ul style="list-style-type: none"> Not able to apply control theory to ROS car, nor present ROS car project learning experience, including but not limited to new skills/knowledge, troubleshooting, etc.

Note 1: Full mark: 10

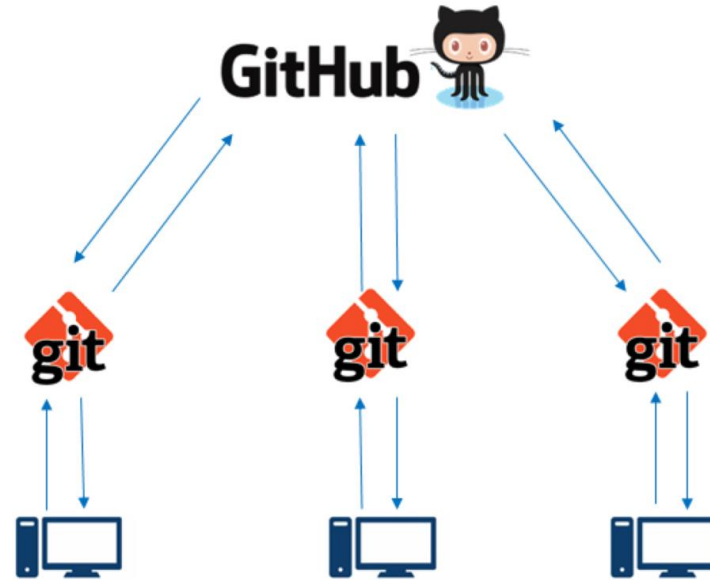
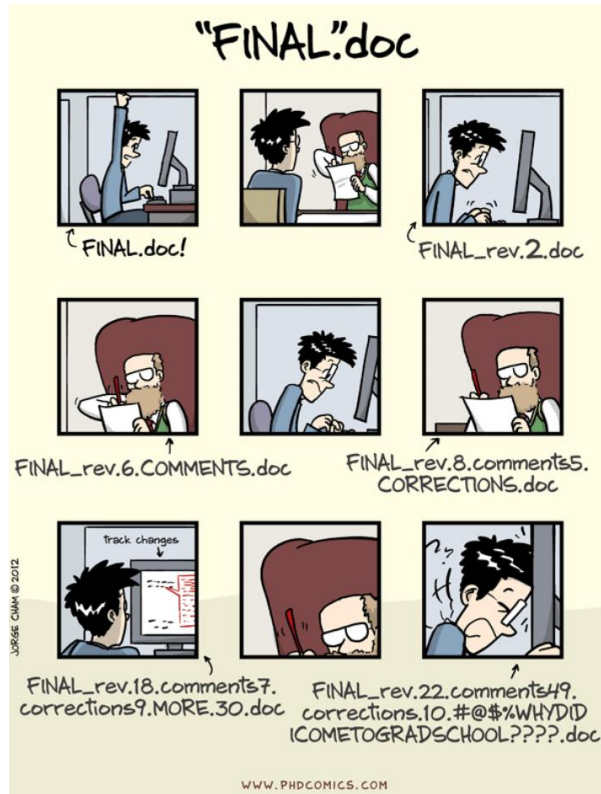
Note 2: Open problem, No standard solution.

Note 3: Trials might be unsuccessful.

- How to use github
- Code Structure——ROS
- Code Structure——STM32

How to use github ?

Has this happened to you?



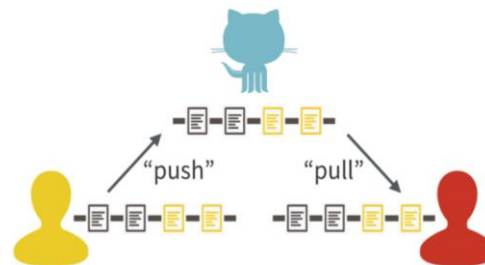
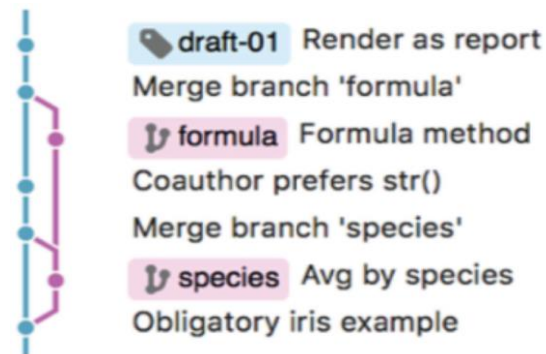
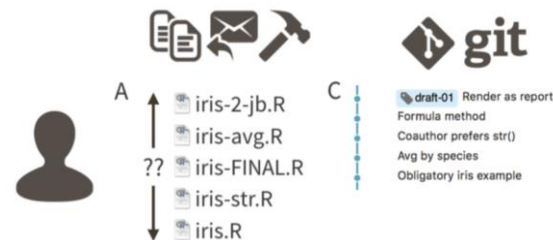
Git and **GitHub** allow for easy management and sharing of data analytic content.

What Git can do ?

Git allows for tracking of a project through **commit** messages

You can use **branches** when working as a team or on a new feature

GitHub allows for easy **collaboration** on projects



What Git can do ?

You can also submit issues if you're having trouble with software

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<> Code **Issues 2** Pull requests Actions Projects Wiki Security Insights

Label issues and pull requests for new contributors Dismiss

Now, GitHub will help potential first-time contributors [discover issues](#) labeled with **good first issue**

Filters

Labels 9 Milestones 0 New issue

☐ 2 Open ✓ 0 Closed

Author Label Projects Milestones Assignee Sort

☐ **The recommended software version list** 1
#2 opened 2 days ago by sdjkjsdh

☐ **The reported error is 'Unable to locate package ros-noetic-desktop-full'** 2
#1 opened 2 days ago by sdjkjsdh

ProTip! `no:milestone` will show everything without a milestone.

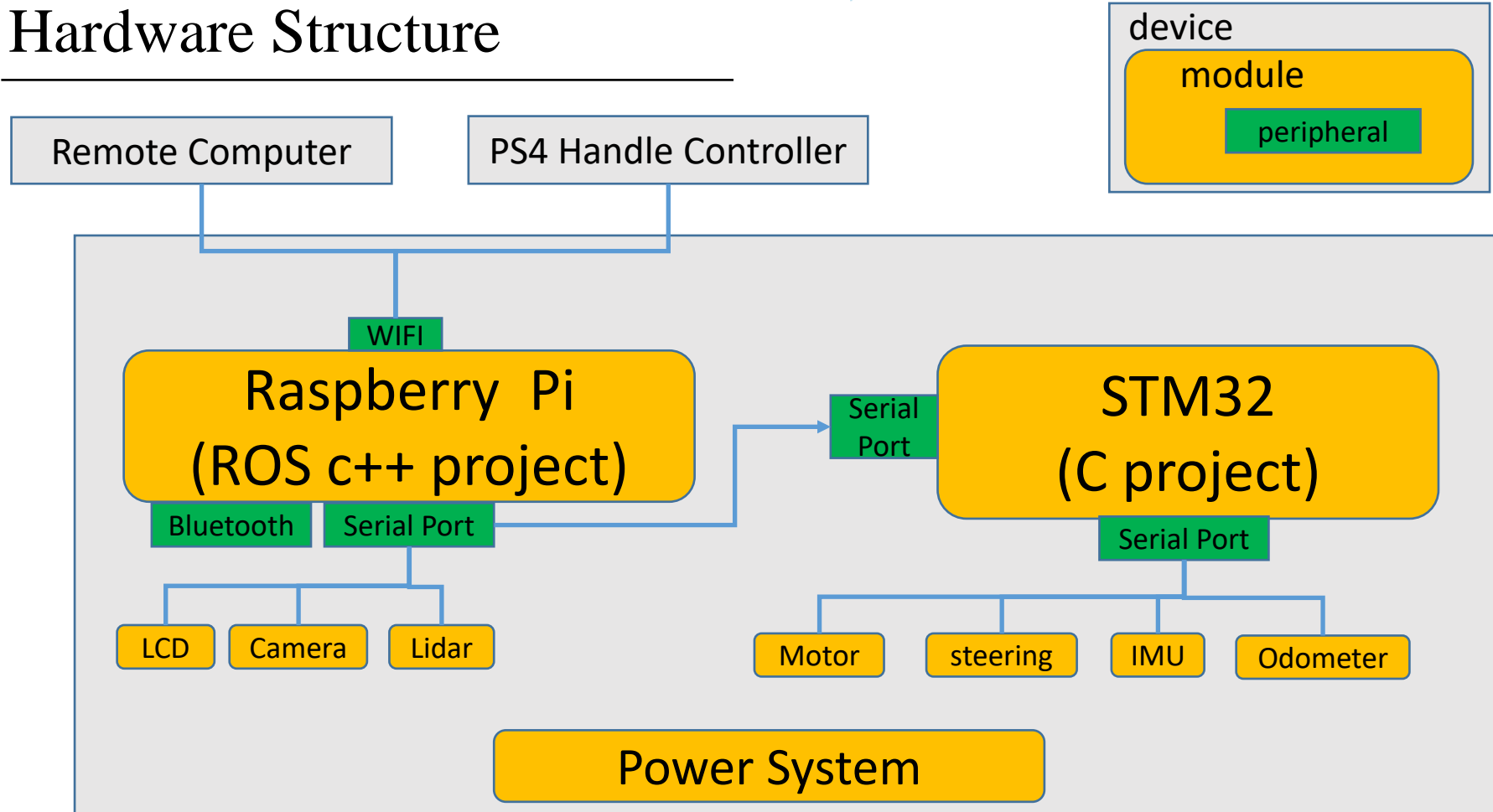
References

- <https://happygitwithr.com/>
 - Extremely useful tool for learning Git and GitHub—based off using R/Rstudio for analyses
- <https://learngitbranching.js.org/>
 - Can help you visualize the process of using Git
- “Excuse Me, Do You Have a Moment to Talk About Version Control?” (Bryan 2017)
 - Great paper for telling you why you should use Git and GitHub

AAE3004

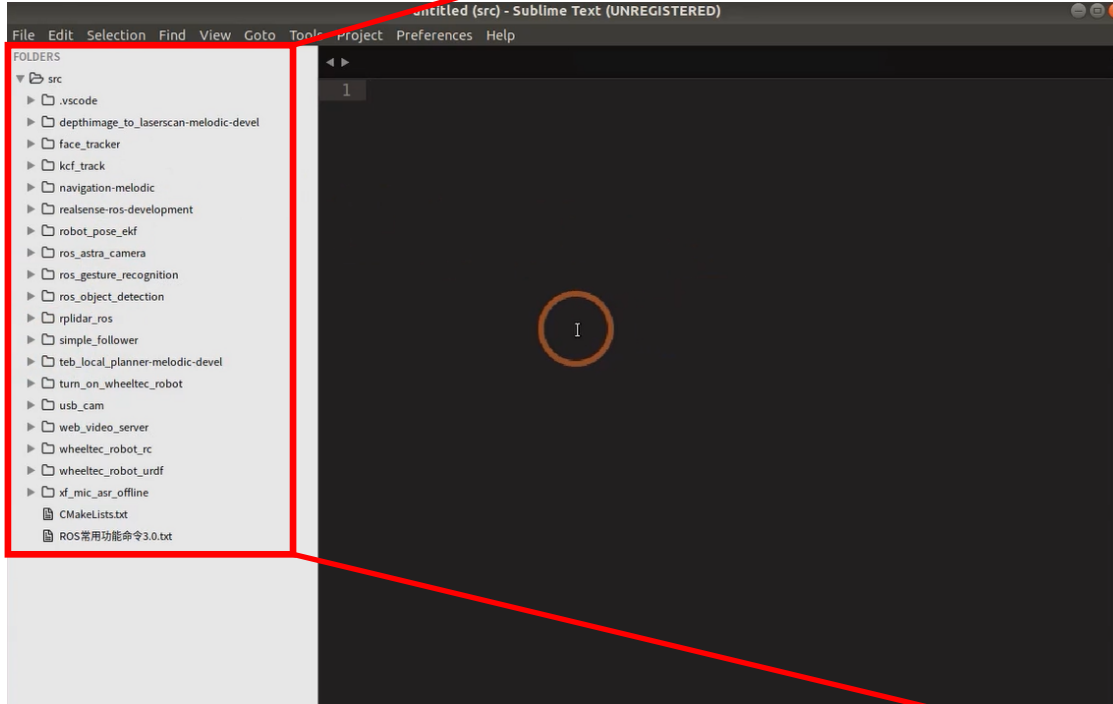
Code Structure—ROS

Hardware Structure

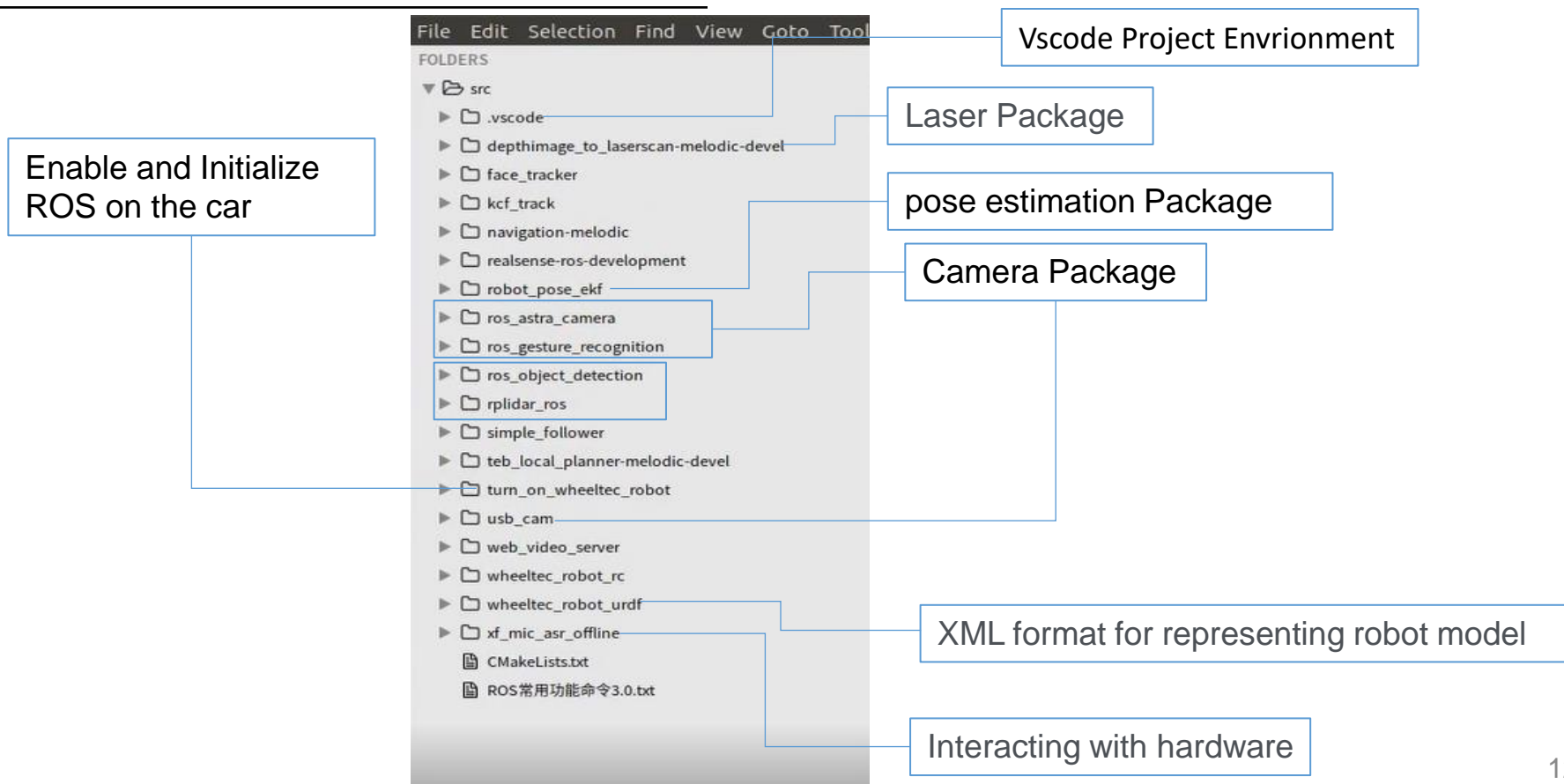


software structure of ROS

- Suppose you have completed the steps in Section 6.3 and 6.4 of the 'User Guide'



software structure of ROS



how to check specific code

A demo: Check real-time information of odometer by ROS topic

- Login in by SSH command
- Start the initialization node:

```
$ roslaunch turn_on_wheeltec_robot turn_on_wheeltec_robot.launch
```

- Check the existing topics:

```
$ rostopic list
```

```
passoni@passoni:~$ rostopic list
/PowerVoltage
/amcl_pose
/cmd_vel
/joint_states
/mobile_base/sensors/imu_data
/odom
/pose
/robot_pose_ekf/odom_combined
/rosout
/rosout_agg
/tf
/tf_static
passoni@passoni:~$
```

/odom: a ros topic for odometer

```

z: 0.0
covariance: [1e-09, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.001, 1e-09,
0.0, 0.0, 0.0, 0.0, 0.0, 1000000.0, 0.0, 0.0, 0.0, 0.0, 0.0,
1000000.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1000000.0, 0.0, 0.0, 0.0,
0.0, 0.0, 0.0, 1e-09]
---
header:
seq: 1358
stamp:
secs: 1607512247
nsecs: 890342829
frame_id: "odom_combined"
child_frame_id: "base_footprint"
pose:
pose:
position:
x: 0.0
y: 0.0
z: 0.0
orientation:
x: 0.0
y: 0.0
z: 0.0
w: 1.0
covariance: [1e-09, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.001, 1e-09,
0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1000000.0, 0.0, 0.0, 0.0, 0.0, 0.0,
1000000.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1000000.0, 0.0, 0.0, 0.0,
0.0, 0.0, 0.0, 1e-09]
twist:
twist:
linear:
x: 0.0
y: 0.0
z: 0.0
angular:
x: 0.0
y: 0.0
z: 0.0
covariance: [1e-09, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.001, 1e-09,
0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1000000.0, 0.0, 0.0, 0.0, 0.0, 0.0,
1000000.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1000000.0, 0.0, 0.0, 0.0,
0.0, 0.0, 0.0, 1e-09]
---

```

check the odometer information:

\$ rostopic echo /odom

Information Structure:

- **Header:** sequence number and timestamp
- **child_frame_id:** local coordinate id
- **pose:** 3D odometer move distance
- **twist:** 3D linear/angular velocity
- **Covariance:** uncertainty

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FOLDERS

- src
 - .vscode
 - depthimage_to_laserscan-melodic-devel
 - face_tracker
 - kcf_tracker
 - navigation-melodic
 - realSense-ros-development
 - robot_pose_ekf
 - ros_astra_camera
 - ros_astra_launch
 - ros_gesture_recognition
 - ros_object_detection
 - rplidar_ros
 - simple_follower
 - teb_local_planner-melodic-devel
 - turn_on_wheeltec_robot
 - include
 - launch
 - 3d_mapping.launch
 - 3d_navigation.launch
 - ar_label.launch
 - mapping.launch
 - navigation.launch
 - pure3d_mapping.launch
 - pure3d_navigation.launch
 - turn_on_wheeltec_robot.launch
 - map
 - param_common
 - param_mini_mec
 - param_mini_omni
 - param_senior_mec_EightDrive

```

1  2  3  4  5  6  7  8  9  10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75
base_to_laser" args="0.087 0.00 0.23 3.14 0 0 base_footprint
laser 100" />
55 <node pkg="tf" type="static_transform_publisher" name="
base_to_camera" args="0.187 0.00 0.32 0 0 0 base_footprint
camera_link 100" />
56 </group>
57 <!-- car_mode and tf top_omni-->
58 <group if="$(eval car_mode == 'top_omni')">
59 <node pkg="tf" type="static_transform_publisher" name="
base_to_laser" args="0.149 0.00 0.23 3.14 0 0 base_footprint
laser 100" />
60 <node pkg="tf" type="static_transform_publisher" name="
base_to_camera" args="0.25 0.00 0.32 0 0 0 base_footprint
camera_link 100" />
61 </group>
62
63 <!-- turn on base serial 开启底层单片机的控制节点 -->
64 <include file="$(find turn_on_wheeltec_robot)/launch/include/
base_serial.launch" />
65 <!-- turn on ekf 卡尔曼滤波 -->
66 <include file="$(find turn_on_wheeltec_robot)/launch/include/
robot_pose_ekf.launch" />
67
68 <!-- URDF 标准化机器人描述格式 -->
69 <group if="$(eval car_mode == 'mini_mec')">
70 <param name = "robot_description" textfile = "$(find
wheeltec_robot_urdf)/urdf/mini_mec_robot.urdf"/>
71 </group>
72 <group if="$(eval car_mode == 'senior_mec_no')">
73 <param name = "robot_description" textfile = "$(find
wheeltec_robot_urdf)/urdf/senior_mec_robot.urdf"/>
74 </group>
75 <group if="$(eval car_mode == 'senior_mec_dl')">

```

- Remember the topic we started is **turn_on_wheeltec_robot.launch**
- find .launch file in the ROS function package
- Redirected to **the base_serial.launch**

File Edit Selection Find View Goto Tools Project Preferences Help

- ▶ navigation-melodic
- ▶ realsense-ros-development
- ▶ robot_pose_ekf
- ▶ ros_astra_camera
- ▶ ros_astra_launch
- ▶ ros_gesture_recognition
- ▶ ros_object_detection
- ▶ rplidar_ros
- ▶ simple_follower
- ▶ teb_local_planner-melodic-devel
- ▼ turn_on_wheeltec_robot
 - ▶ include
 - ▶ launch
 - ▶ map
 - ▶ param_common
 - ▶ param_mini_mec
 - ▶ param_mini_omni
 - ▶ param_senior_mec_EightDrive
 - ▶ param_senior_mec_dl
 - ▶ param_senior_mec_no
 - ▶ param_senior_omni
 - ▶ param_top_mec_EightDrive
 - ▶ param_top_mec_bs
 - ▶ param_top_mec_dl
 - ▶ param_top_omni
- ▼ src
 - Quatation_Solution.cpp
 - wheeltec_robot.cpp
 - CMakeLists.txt
 - package.xml
 - send_mark.py
 - wheeltec_udev.sh
- ▶ usb_cam

```
1 <launch>
2 <!-- 打开节点wheeltec_robot, 初始化串口等操作 -->
3 <node pkg="turn_on_wheeltec_robot" type="wheeltec_robot_node" name="
  wheeltec_robot" output="screen">
4   <param name="uart_port_name" type="string" value="/dev/
  wheeltec_controller"/>
5   <param name="serial_baud_rate" type="int" value="115200"/>
6   <param name="robot_frame_id" type="string" value="base_footprint"
  />
7   <param name="smoother_cmd_vel" type="string" value="
  smoother_cmd_vel"/>
8   <param name="product_number" type="
  />
9 </node>
10 </launch>
```

Display the result in terminal

The node package name
It will be called in the command

The code file used for this command
Find the .cpp file in \src

/mnt/src/turn_on_wheeltec_robot/src/wheeltec_robot.cpp (src) - Sublime Text (UNREGISTERED)

File Edit Selection Find View Goto Tools Project Preferences Help

wheeltec_robot.cpp

```

289 _Last_Time = ros::Time::now();
290 while(ros::ok())
291 {
292     _Now = ros::Time::now();
293     Sampling_Time = (_Now - _Last_Time).toSec();
294     //Sampling_time是采样时间, 虽然下位机发送的数据频率是固定的, 这里计算里程增量以
295     if (true == Get_Sensor_Data()) //从串口读取下位机发过来的全部数据
296     {
297         Robot_Pos.X+=(Robot_Vel.X * cos(Robot_Pos.Z) - Robot_Vel.Y * sin(R
298         Robot_Pos.Y+=(Robot_Vel.X * sin(Robot_Pos.Z) + Robot_Vel.Y * cos(R
299         Robot_Pos.Z+=Robot_Vel.Z * Sampling_Time; //角位移
300         Quaternion Solution(Mpu6050.angular_velocity.x, Mpu6050.angular_ve
301         Mpu6050.linear_acceleration.x, Mpu6050.linear_accelerati
302         Publish_Odom(); //发布里程计话题
303         Publish_Pose(); //发布话题
304         Publish_ImuSensor(); //发布话题
305         Publish_Voltage(); //发布电源电压
306     }
307     _Last_Time = _Now; //记录时间
308     ros::spinOnce(); //循环等待回调函数
309 }
310 }
311 /*****
312 Date: May 31, 2020
313 Function: 构造函数, 只执行一次, 用于初始
314 *****/
315 turn_on_robot::turn_on_robot():Sampl
316 {
317     memset(&Robot_Pos, 0, sizeof(Robot_Pos));
318     memset(&Robot_Vel, 0, sizeof(Robot_Vel));
319     memset(&Receive_Data, 0, sizeof(Receive_Data)); //构造函数初始化
320     memset(&Send_Data, 0, sizeof(Send_Data));
321     memset(&Mpu6050_Data, 0, sizeof(Mpu6050_Data));

```

navigation-melodic
realsense-ros-development
robot_pose_ekf
ros_astra_camera
ros_astra_launch
ros_gesture_recognition
ros_object_detection
rplidar_ros
simple_follower
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include
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map
param_common
param_mini_mec
param_mini_omni
param_senior_mec_EightDrive
param_senior_mec_dl
param_senior_mec_no
param_senior_omni
param_top_mec_EightDrive
param_top_mec_bs
param_top_mec_dl
param_top_omni
src
Quaternion_Solution.cpp
wheeltec_robot.cpp
CMakeLists.txt
package.xml
send_mark.py
wheeltec_udev.sh
usb_cam

- Publish_Odom(): odometer information
- Publish_Pose(): posture information
- Publish_ImuSensor(): imu information
- Publish_Voltage(): power system information

/mnt/src/turn_on_wheeltec_robot/src/wheeltec_robot.cpp (src) - Sublime Text (UNREGISTERED)

File Edit Selection Find View Goto Tools Project Preferences Help

wheeltec_robot.cpp x

```

116 /*****
117 Date: May 31, 2020
118 Function: 发布里程计相关信息
119 *****/
120 void turn_on_robot::Publish_Odom()
121 {
122     geometry_msgs::Quaternion odom_quat = tf::createQuaternionMsgFromYaw
123     nav_msgs::Odometry odom; //里程计话题消息数据类型
124     odom.header.stamp = ros::Time::now(); //当前时间
125     odom.header.frame_id = "odom_combined";
126     odom.pose.pose.position.x = Robot_Pos.X; //位置
127     odom.pose.pose.position.y = Robot_Pos.Y;
128     //odom.pose.pose.position.z = 0;
129     odom.pose.pose.position.z = Robot_Pos.Z;
130     odom.pose.pose.orientation = odom_quat;
131     //设置速度
132     odom.child_frame_id = robot_frame_id;
133     odom.twist.twist.linear.x = Robot_Vel.X; //X方向前进速度
134     odom.twist.twist.linear.y = Robot_Vel.Y; //Y方向前进速度
135     odom.twist.twist.angular.z = Robot_Vel.Z; //角速度
136     //这个矩阵有两种，分机机器人静止和动起来的时候用 这是扩展卡尔曼滤波的，官网提供的2
137     if(Robot_Vel.X== 0&&Robot_Vel.Z== 0) //如果velocity是零，说明编码器的误差
138     memcpy(&odom.pose.covariance, odom_pose_covariance2, sizeof(odom_pose
139     memcpy(&odom.twist.covariance, odom_twist_covariance2, sizeof(odom_tw
140     else //如果小车velocity非零，考虑到运动中编码器可能带来的滑动误差，认为imu的数
141     memcpy(&odom.pose.covariance, odom_pose_covariance, sizeof(odom_pose
142     memcpy(&odom.twist.covariance, odom_twist_covariance, sizeof(odom_tw
143     odom_publisher.publish(odom); //发布这个话题 消息类型是nav_msgs::Odometry
144 }
145
146 void turn_on_robot::Publish_Pose()
147 {
148     geometry_msgs::Quaternion odom_quat = tf::createQuaternionMsgFromYaw

```

Line 120, Column 21

Spaces: 2 C++

Open the function to
check the cpp code



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Code Structure—STM32

Install the uVision IDE follow the user guide on github

User manual for uVision installation

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STM32 source code_F407VET6_2021.09.27.zip	Add files via upload	27 days ago
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The STM32 project is used to interacting with hardware and written by c

compile

C:\Users\Lenovo\OneDrive - The Hong Kong Polytechnic University (1)\Desktop\STM32 source code_F407VET6_2021.09.27\USER\WHEELTEC.uvprojx - µVision

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Load FreeRTOS

download

Project: WHEELTEC

- FreeRTOS
 - USER
 - HARDWARE
 - SYSTEM
 - CORE
 - FWLIB
 - FreeRTOS_CORE
 - FreeRTOS_PORTABLE
 - Balance
 - ICM20948
 - I2C.c
 - ICM20948.c

debug

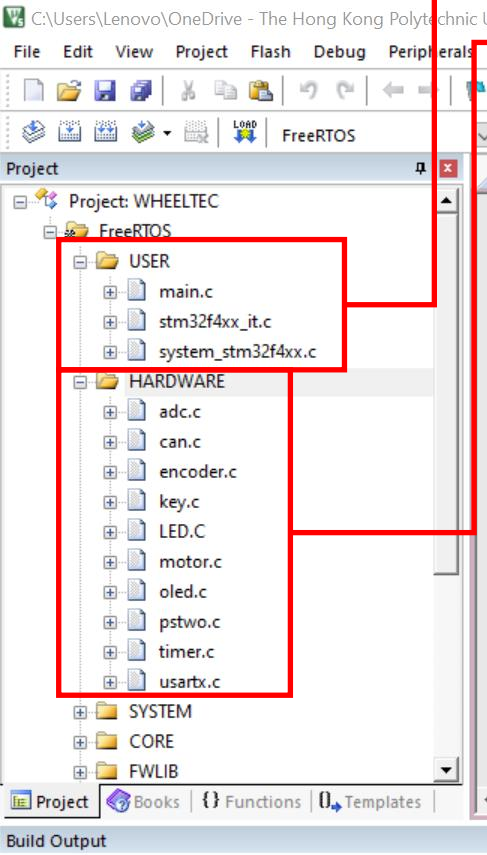
```
374  (k)´ú±i±*´îÈ«±i
375  (k-1)´ú±iÈiÖ»´îpÄÈ«±i  ÖÖ´ÈÄäîÈ
376  pwm´ú±iÖÖÄîÈä´ö
377  ÖÜiÖÄÇuÄÈÜqÈ¿ÖÖÈ±Ö»´îpí´ÄiÄ±È-Ö»È´ÖÄPI¿ÖÖÈ
378  pwm+=Kp[e¿´k¿Ö-e(k-1)]+Ki*e(k)
379  *****
380  int Incremental_PI_A (float Encoder,float Target)
381  {
382      static float Bias,Pwm,Last_bias;
383      Bias=Target-Encoder; //Calculate the deviation //´üÈÈÄÈ«±i
384      Pwm+=Velocity_KP*(Bias-Last_bias)+Velocity_KI*Bias;
385      if(Pwm>16800) Pwm=16800;
386      if(Pwm<-16800) Pwm=-16800;
387      Last_bias=Bias; //Save the last deviation //±¿ÈÈiÖ»´îÈ«±i
388      return Pwm;
389  }
390  Incremental PI B (float Encoder,float Target)
391  {
392      Pwm+=Velocity_KP*(Bias-Last_bias)+Velocity_KI*Bias;
393      if(Pwm>16800) Pwm=16800;
394      if(Pwm<-16800) Pwm=-16800;
395      Last_bias=Bias; //Save the last deviation //±¿ÈÈiÖ»´îÈ«±i
396      return Pwm;
397  }
```

Code structure tree

project Environment Initializaiton

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航空及民航工程學系

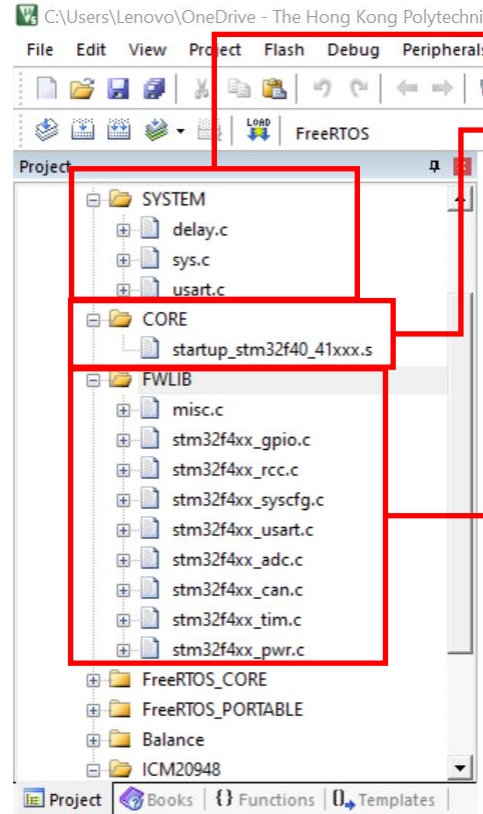
Peripheral configuration and function



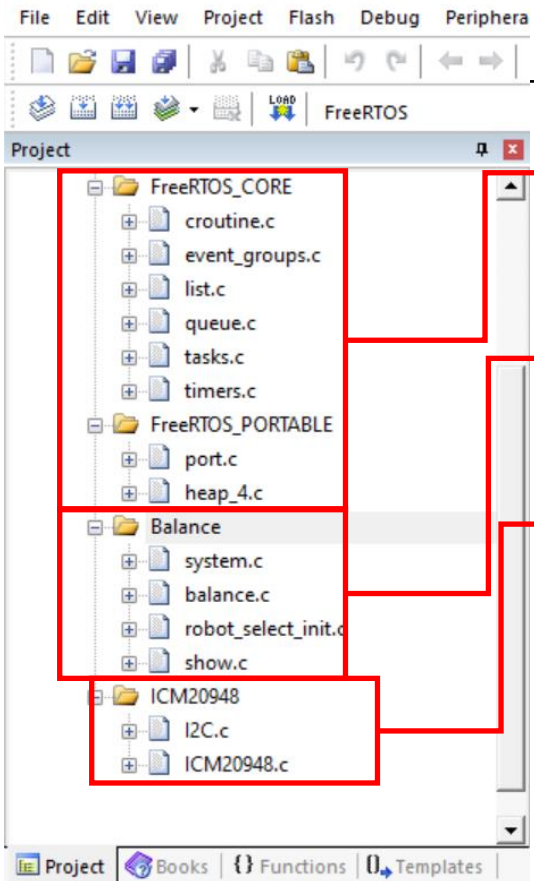
System time and communication

Chip configuration

Chip internal module configuration



'main.c' is the project entry point



General code function package,
defining data structure, timer, code scheduling, etc

Codes related to car movement,
motor control, sensor data collect and display

Communication Bus





Changing the car parameters

PID controller
STM32
source code
Kp
Ki








```
system.c* robot_select_init.c
16 Updated: 2021-01-29
17
18 All rights reserved
19 *****/
20
21 #include "system.h"
22
23 //Robot software fails to flag bits
24 //u8 Flag_Stop=1;
25
26 //The ADC value is variable in segments, depending on the number of car models. Currently there are 6 car models
27 //ADC0: 0~1023; u8 Flag_Stop=1; u8 Flag_Stop=1; u8 Flag_Stop=1; u8 Flag_Stop=1; u8 Flag_Stop=1; u8 Flag_Stop=1;
28
29 int Divisor_Mode;
30
31 // Robot type variable
32 //u8 Flag_Stop=1;
33 //0=Meo_Car1=1=Omni_Car2=2=Akm_Car3=3=Diff_Car4=4=FourWheel_Car5=5=Tank_Car
34 u8 Car_Mode=0;
35
36 //Servo control PWM value, Ackerman car special
37 //u8 Flag_Stop=1;
38 int Servo;
39
40 //Default speed of remote control car, unit: mm/s
41 //0~1023; u8 Flag_Stop=1;
42 float RC_Velocity=1000;
43
44 //Vehicle three-axis target moving speed, unit: m/s
45 //0~1023; u8 Flag_Stop=1;
46 float Move_X, Move_Y, Move_Z;
47
48 //PID parameters of Speed control
49 //u8 Flag_Stop=1;
50 float Velocity_KP=300, Velocity_KI=300;
51
52 //Smooth control of intermediate variables, dedicated to omni-directional moving cars
53 //u8 Flag_Stop=1;
54 Smooth_Control smooth_control;
55
56 //The parameter structure of the motor
57 //u8 Flag_Stop=1;
58 Motor_parameter MOTOR_A, MOTOR_B, MOTOR_C, MOTOR_D;
59
60 //u8 Flag_Stop=1;
61 //u8 Flag_Stop=1;
```


A demonstration video also on github

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