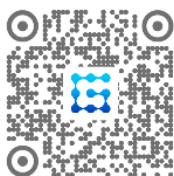


ROS理论与实践

—— 第11讲：机器人综合应用—— “迷宫寻宝”



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 1. “迷宫寻宝” 之任务发布

 2. “迷宫寻宝” 之任务分析

 3. “迷宫寻宝” 之任务实现



1. “迷宫寻宝”之任务发布



1. “迷宫寻宝”之任务发布



传说，有一座奇幻迷宫，其中藏有一处诱人的宝藏，无数“人”进去却再未出来，只有最勇敢、聪明的“人”才能够获取宝藏。

So，你敢接受挑战么？



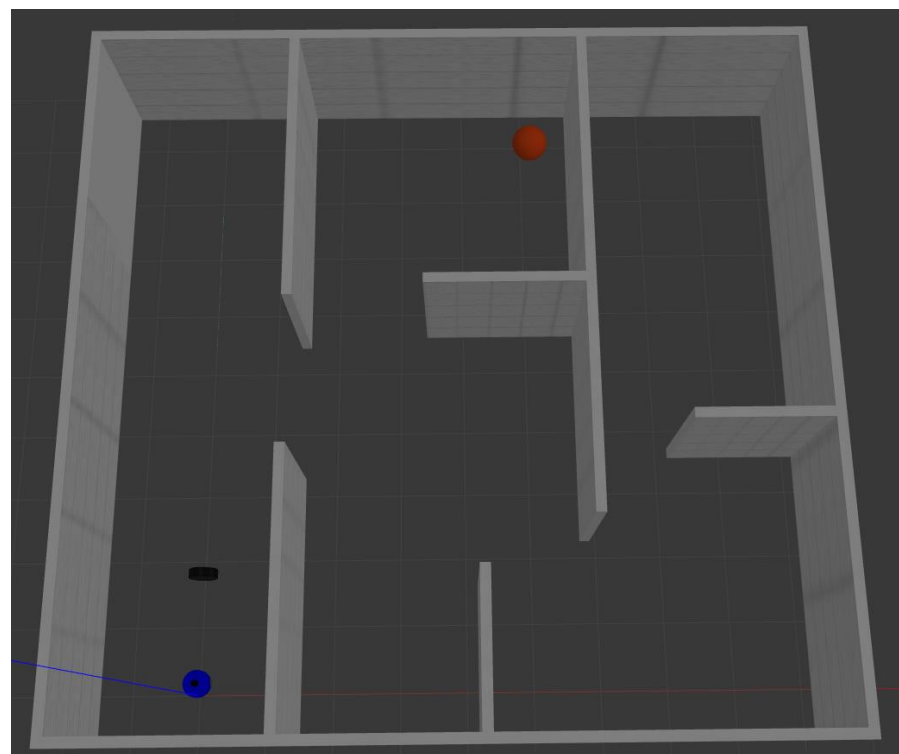
1. “迷宫寻宝”之任务发布

已知迷宫地图的覆盖范围（10*10m），其中某处藏有一处明显标记的宝藏（红色圆球），机器人在环境未知的情况下从起点出发，自主寻找宝藏，寻得宝藏之后需返回起点，任务完成。

- 地图预先使用Gazebo创建完成，并在Gazebo完成所有任务；
- 机器人在起点运动时开始计时，寻得宝藏回到起点后计时终止，须在5min内完成任务；
- 机器人搭载的传感器没有限制；
- 机器人接近宝藏1m范围内即认为获取宝藏；
- 机器人获取宝藏后，需通过语音播报状态信息；
- 宝藏的位置不固定，允许动态调整。

迷宫环境

```
$ roslaunch mbot_gazebo mbot_maze_gazebo.launch
```

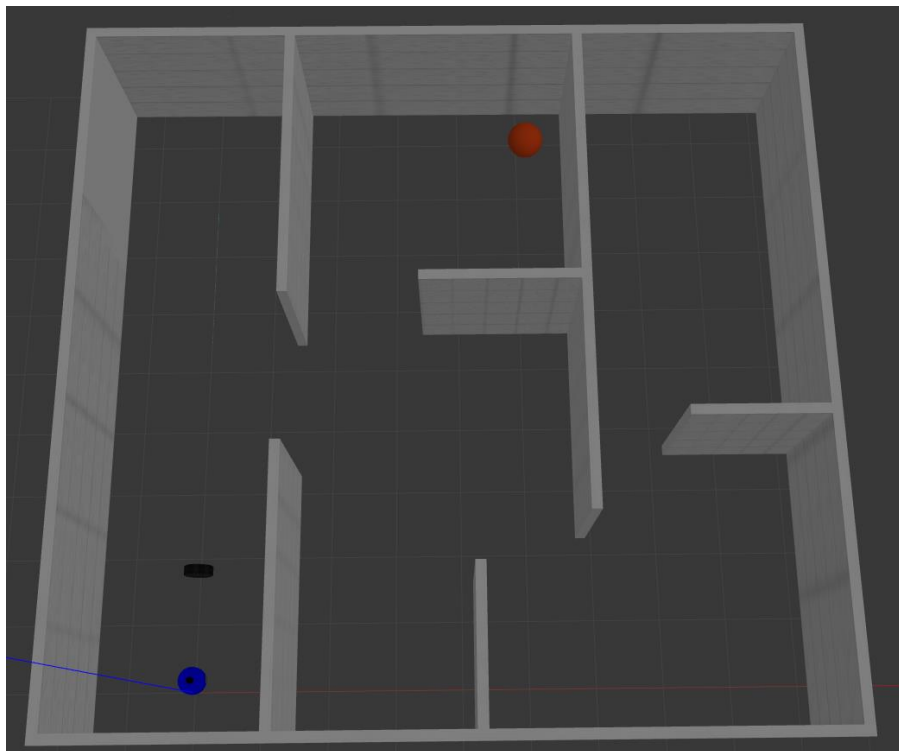




2. “迷宫寻宝”之任务分析



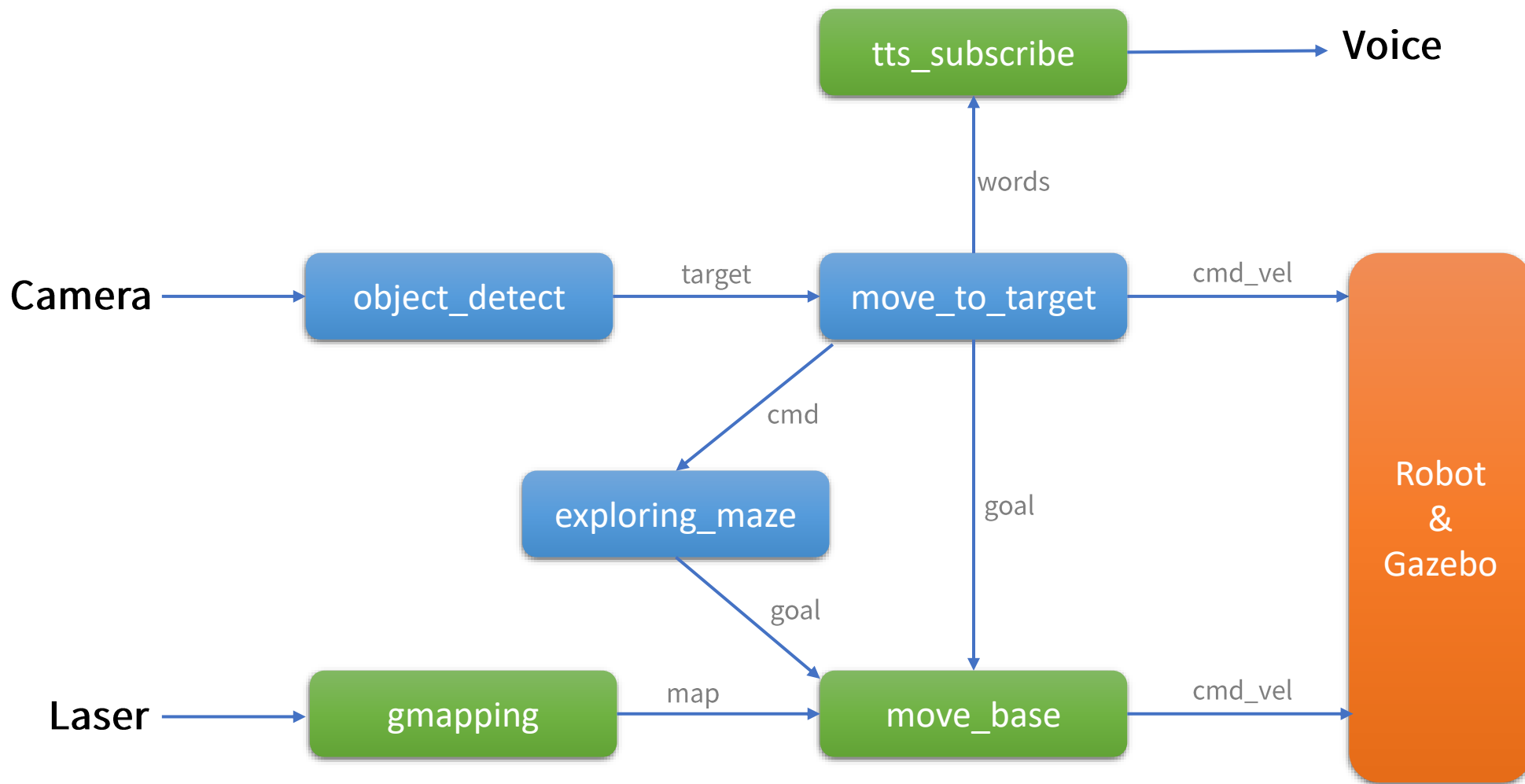
2. “迷宫寻宝”之任务分析



- 机器人建模仿真
- 图像识别
- 语音交互
- 自主导航
- SLAM
- ROS通信机制
- 系统设计与集成



2. “迷宫寻宝” 之任务分析

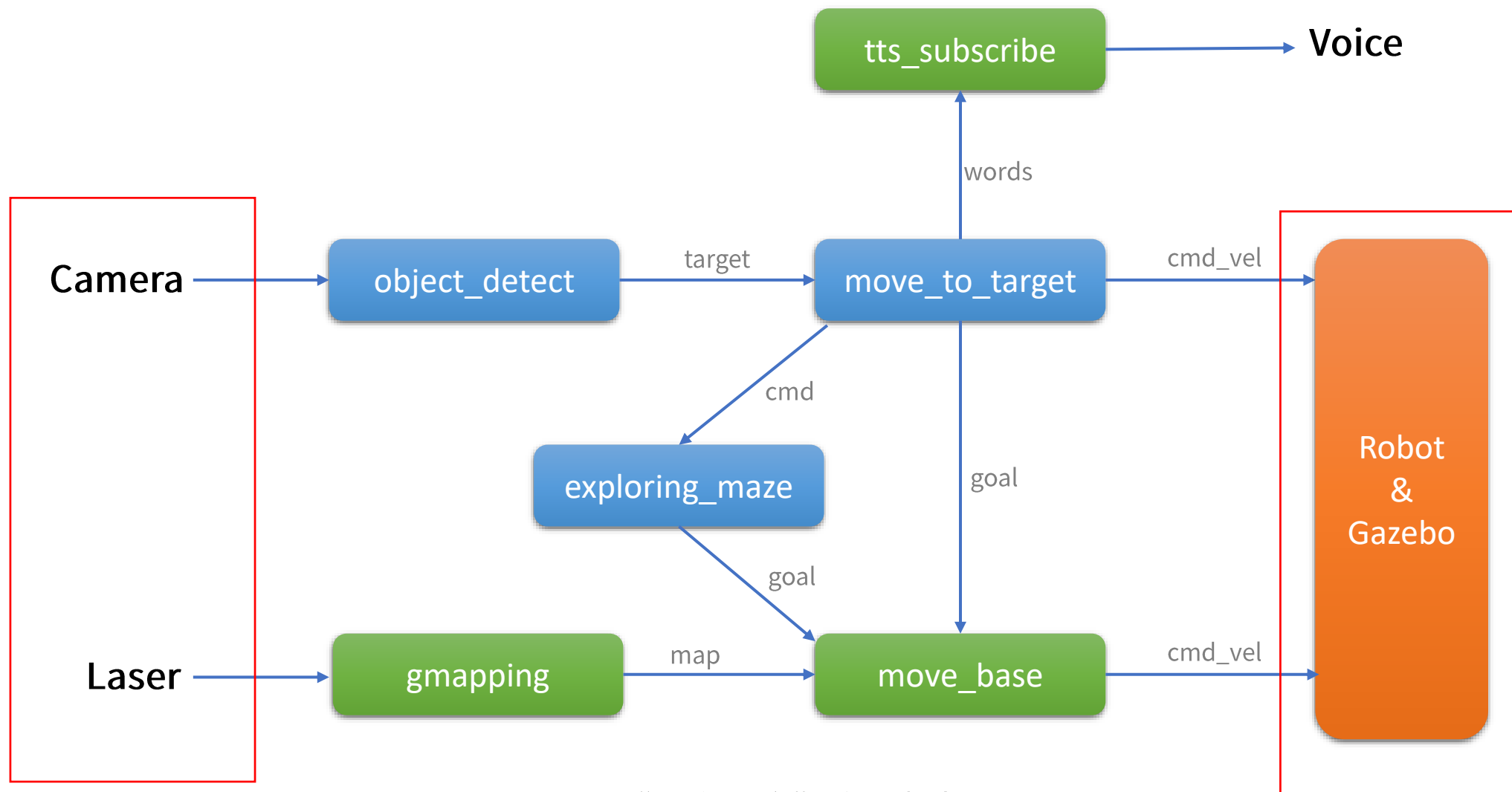


“迷宫寻宝” 实现框架



3. “迷宫寻宝”之任务实现

3. “迷宫寻宝”之任务实现 —— 机器人建模



“迷宫寻宝”实现框架

3. “迷宫寻宝”之任务实现 —— 机器人建模

```
<!-- Camera -->
<joint name="camera_joint" type="fixed">
  <origin xyz="{camera_offset_x} {camera_offset_y} {camera_offset_z}" rpy="0 0 0" />
  <parent link="base_link"/>
  <child link="camera_link"/>
</joint>

<xacro:usb_camera prefix="camera"/>

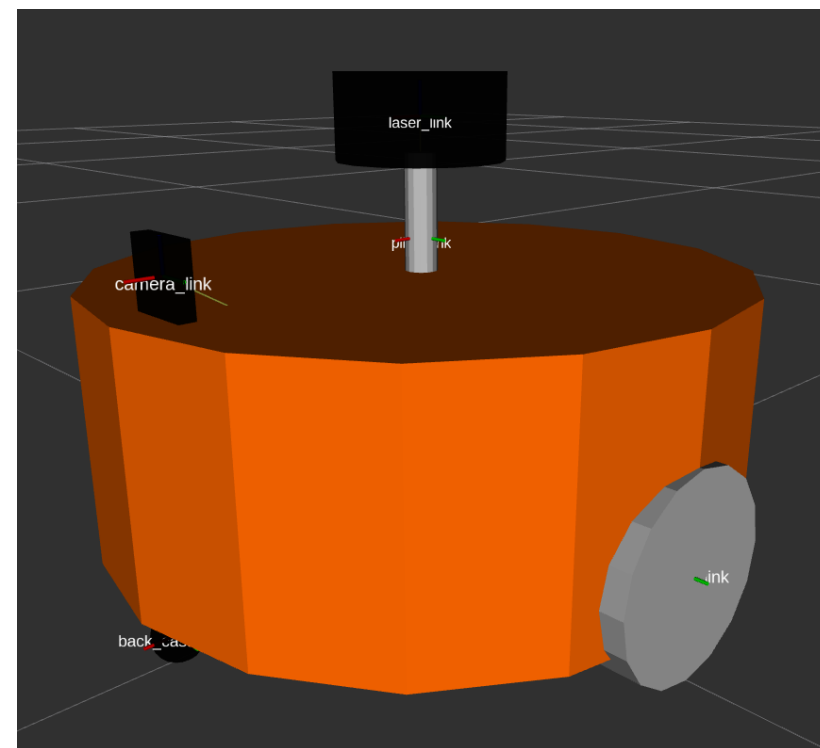
<link name="pillar_link">
  <visual>
    <origin xyz="0 0 0" rpy="0 0 0" />
    <geometry>
      <cylinder length="{pillar_length}" radius="{pillar_radius}" />
    </geometry>
    <material name="gray" />
  </visual>
  <collision>
    <origin xyz="0 0 0" rpy="0 0 0" />
    <geometry>
      <cylinder length="{pillar_length}" radius="{pillar_radius}" />
    </geometry>
  </collision>
  <cylinder_inertial_matrix m="{pillar_mass}" r="{pillar_radius}" h="{pillar_length}" />
</link>

<joint name="pillar_joint" type="fixed">
  <origin xyz="0 0 0.10" rpy="0 0 0" />
  <parent link="base_link"/>
  <child link="pillar_link"/>
</joint>

<!-- lidar -->
<joint name="lidar_joint" type="fixed">
  <origin xyz="{lidar_offset_x} {lidar_offset_y} {lidar_offset_z}" rpy="0 0 0" />
  <parent link="pillar_link"/>
  <child link="laser_link"/>
</joint>

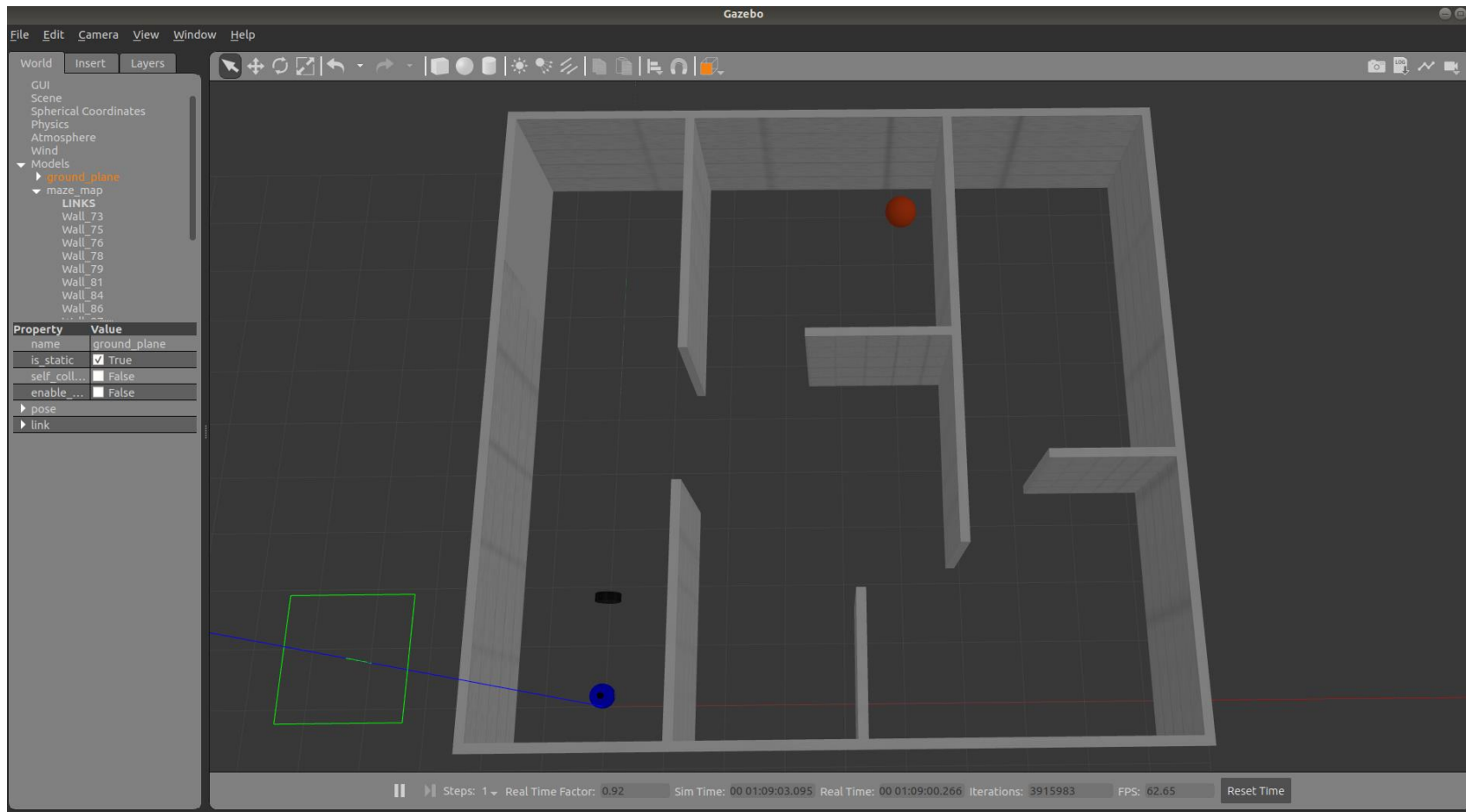
<xacro:rplidar prefix="laser"/>

<mbot_base_gazebo/>
```



mbot_with_camera_laser_gazebo.xacro

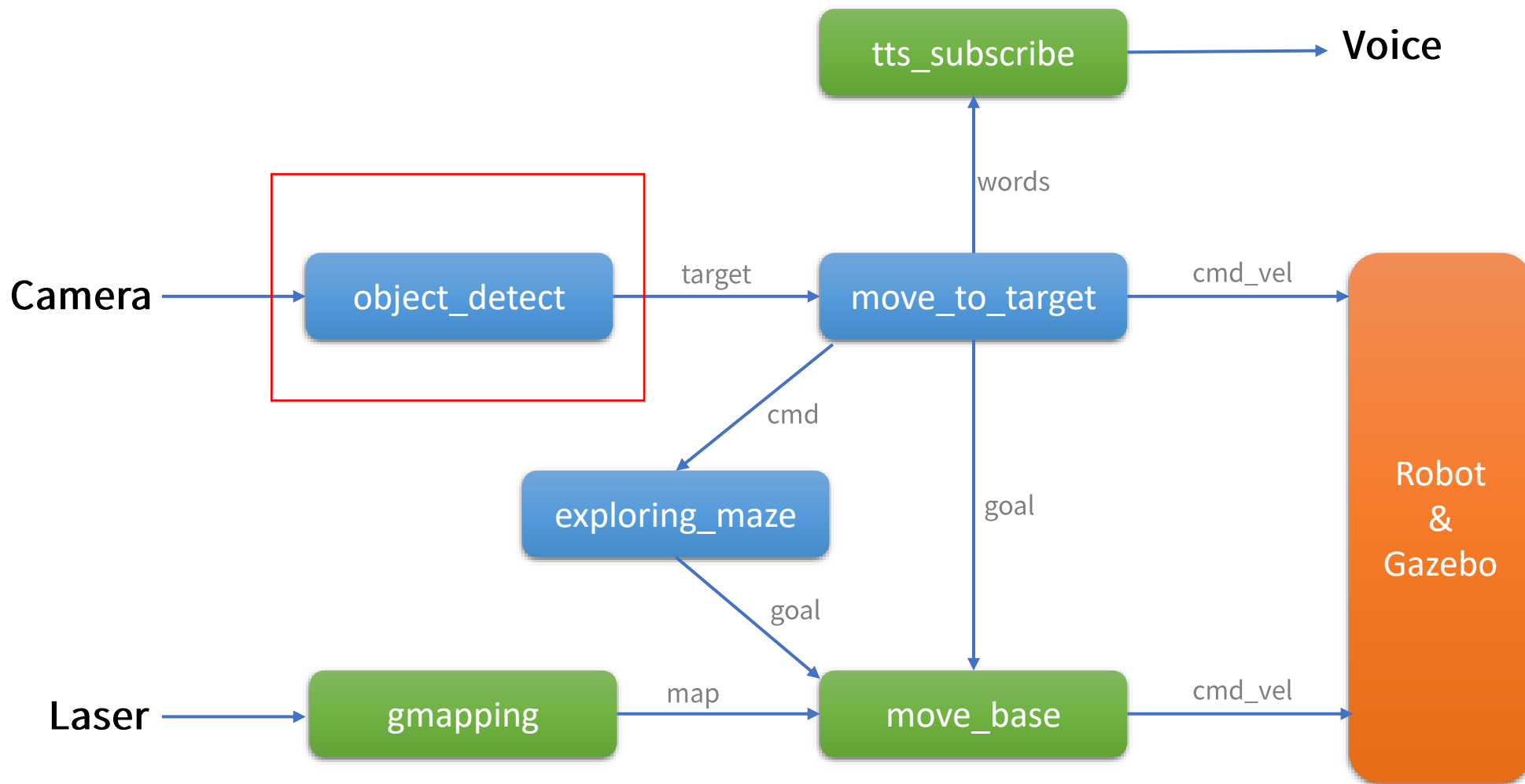
3. “迷宫寻宝”之任务实现 —— 机器人建模



迷宫环境 \$ roslaunch mbot_gazebo mbot_maze_gazebo.launch



3. “迷宫寻宝”之任务实现 —— 宝藏识别



“迷宫寻宝”实现框架



3. “迷宫寻宝”之任务实现 —— 宝藏识别

```
# define the list of boundaries in BGR
boundaries = [[[BLUE_LOW, GREEN_LOW, RED_LOW], [BLUE_HIGH, GREEN_HIGH, RED_HIGH]]]

# loop over the boundaries
# print(boundaries)
for (lower, upper) in boundaries:
    # create NumPy arrays from the boundaries
    lower = np.array(lower, dtype = "uint8")
    upper = np.array(upper, dtype = "uint8")

# find the colors within the specified boundaries and apply the mask
mask = cv2.inRange(cv_image, lower, upper)
output = cv2.bitwise_and(cv_image, cv_image, mask = mask)

cvImg = cv2.cvtColor(output, 6) #cv2.COLOR_BGR2GRAY
npImg = np.asarray( cvImg )
thresh = cv2.threshold(npImg, 1, 255, cv2.THRESH_BINARY)[1]

# find contours in the thresholded image
img, cnts, hierarchy = cv2.findContours(thresh, cv2.RETR_LIST, cv2.CHAIN_APPROX_SIMPLE)
#cnts = cnts[0]

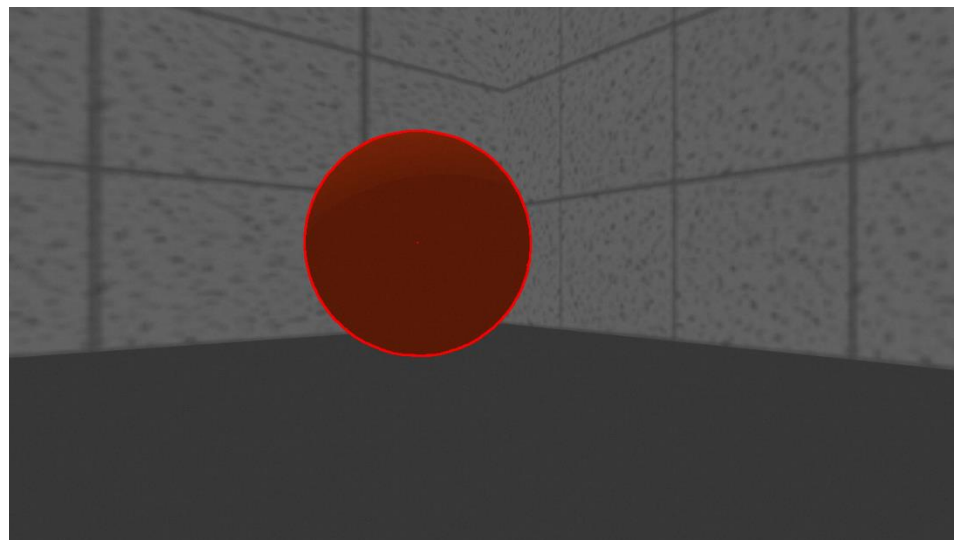
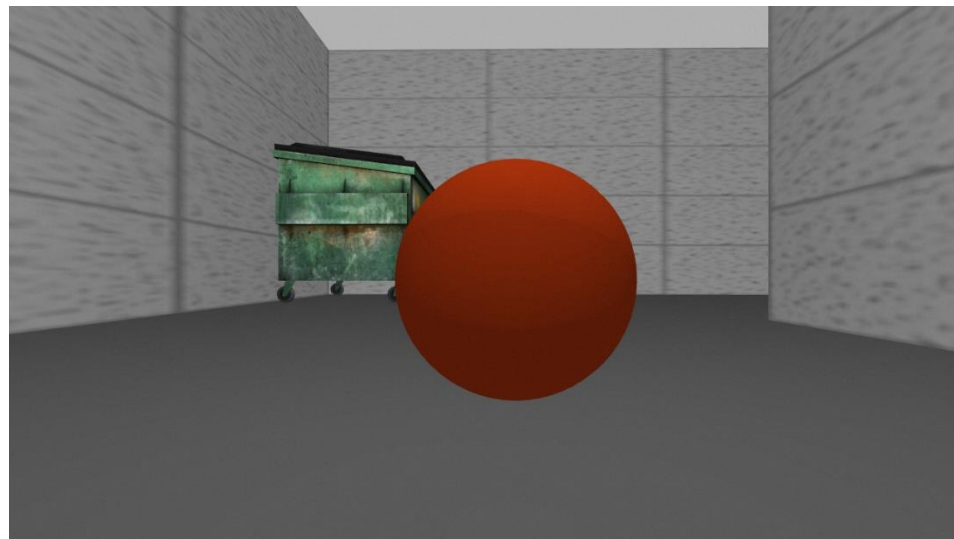
# loop over the contours
for c in cnts:
    # compute the center of the contour
    M = cv2.moments(c)

    if int(M["m00"]) not in range(20000, 100000):
        continue

    cX = int(M["m10"] / M["m00"])
    cY = int(M["m01"] / M["m00"])

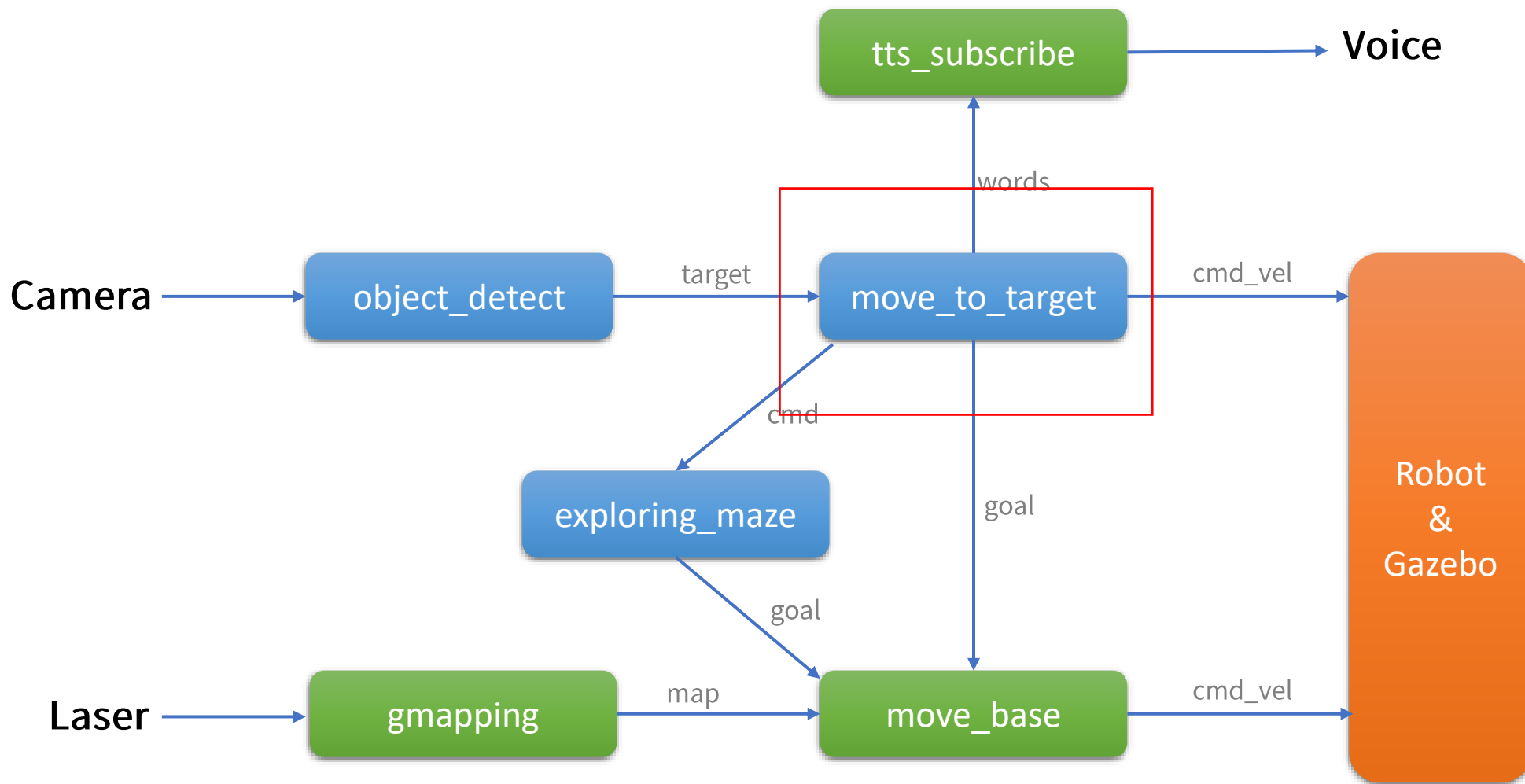
    cv2.drawContours(cv_image, [c], -1, (0, 0, 255), 2)
    cv2.circle(cv_image, (cX, cY), 1, (0, 0, 255), -1)
    objPose = Pose()
    objPose.position.x = cX;
    objPose.position.y = cY;
    objPose.position.z = M["m00"];
    self.target_pub.publish(objPose)
```

object_detect.py





3. “迷宫寻宝”之任务实现 —— 视觉伺服



“迷宫寻宝”实现框架



3. “迷宫寻宝”之任务实现 —— 视觉伺服

```
// 接收到订阅的消息后，会进入消息回调函数
void poseCallback(const geometry_msgs::Pose::ConstPtr& msg)
{
    // 将接收到的消息打印出来
    ROS_INFO("Target pose: x:%0.6f, y:%0.6f, z:%0.6f", msg->position.x, msg->position.y, msg->position.z);

    // 停止机器人导航
    if(status_flag == STATUS_EXPLORING)
    {
        status_flag = STATUS_CLOSE_TARGET;
        std_msgs::Int8 cmd;
        cmd.data = STATUS_CLOSE_TARGET;
        cmd_pub.publish(cmd);

        std_msgs::String msg;
        msg.data = "发现宝藏，向宝藏进发";
        voice_pub.publish(msg);
    }
    else if(status_flag == STATUS_CLOSE_TARGET && msg->position.z > GET_TARGET_SIZE)
    {
        status_flag = STATUS_GO_HOME;
        std_msgs::Int8 cmd;
        cmd.data = STATUS_GO_HOME;
        cmd_pub.publish(cmd);

        std_msgs::String msg;
        msg.data = "拿到宝藏，撤退";
        voice_pub.publish(msg);
    }
    else if(status_flag == STATUS_CLOSE_TARGET)
    {
        // 初始化geometry_msgs::Twist类型的消息
        geometry_msgs::Twist vel_msg;
        vel_msg.linear.x = (100000 - msg->position.z) / 100000 * 0.3;
        vel_msg.angular.z = (640 - msg->position.x) / 640 * 0.3;

        // 发布消息
        vel_pub.publish(vel_msg);
        ROS_INFO("Publsh velocity command[%0.2f m/s, %0.2f rad/s]", vel_msg.linear.x, vel_msg.angular.z);
    }
}
```



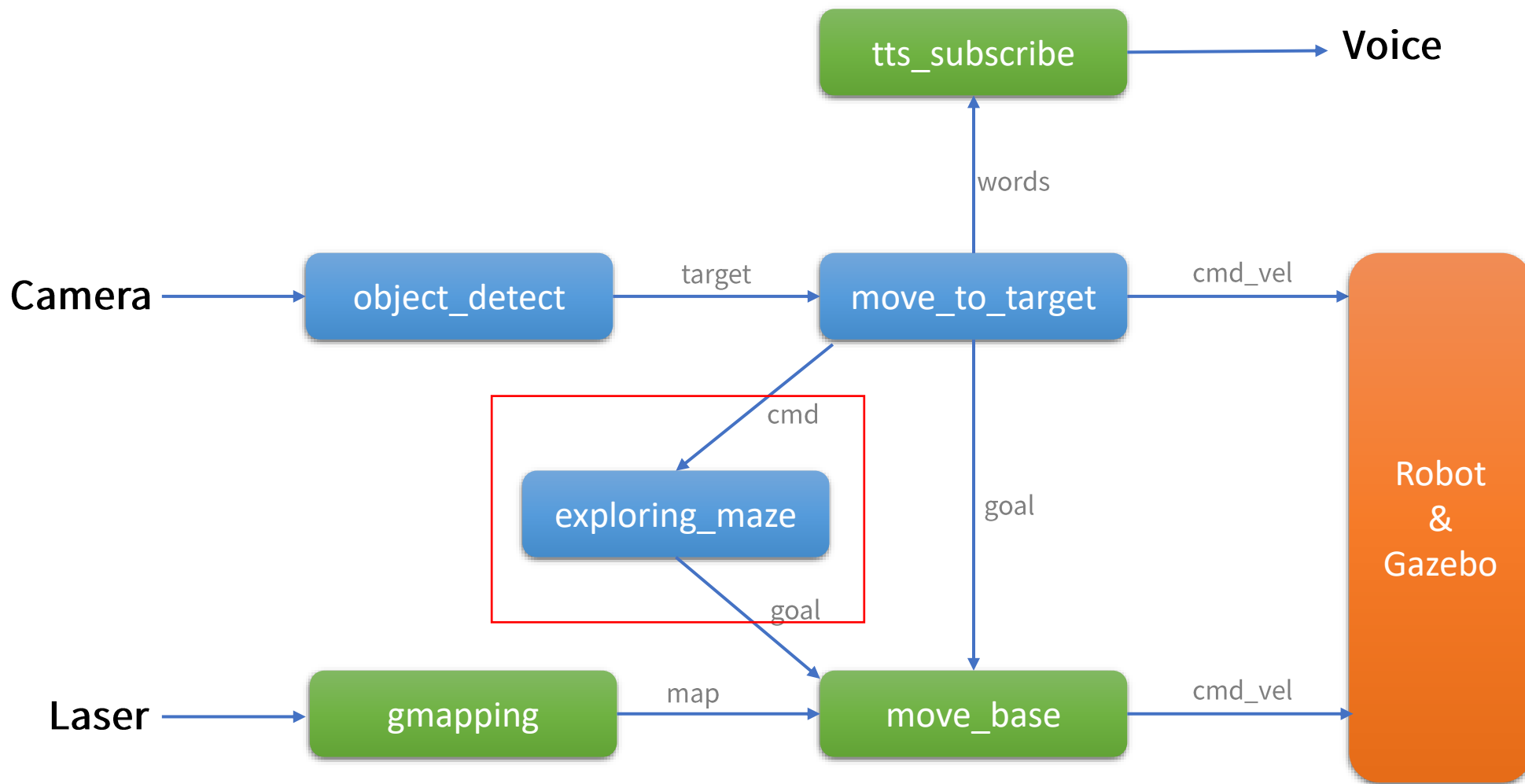
订阅图像识别的结果

move_to_target.cpp



根据目标像素位置调整速度指令

3. “迷宫寻宝”之任务实现 —— 导航&SLAM



“迷宫寻宝”实现框架



3. “迷宫寻宝”之任务实现 —— 导航&SLAM

开始主循环, 随机导航

```
while not rospy.is_shutdown():
```

设定下一个随机目标点

```
self.goal = MoveBaseGoal()
```

```
self.goal.target_pose.pose = start_location
```

```
self.goal.target_pose.header.frame_id = 'map'
```

```
self.goal.target_pose.header.stamp = rospy.Time.now()
```

```
if self.exploring_cmd is STATUS_EXPLORING:
```

```
    self.goal.target_pose.pose.position.x = random.randint(0, 8)
```

```
    self.goal.target_pose.pose.position.y = random.randint(0, 9)
```

```
elif self.exploring_cmd is STATUS_CLOSE_TARGET:
```

```
    rospy.sleep(0.1)
```

```
    continue
```

```
elif self.exploring_cmd is STATUS_GO_HOME:
```

```
    self.goal.target_pose.pose.position.x = 0
```

```
    self.goal.target_pose.pose.position.y = 0
```

让用户知道下一个位置

```
rospy.loginfo("Going to: " + str(self.goal.target_pose.pose))
```

向下一个位置进发

```
self.move_base.send_goal(self.goal)
```

五分钟时间限制

```
finished_within_time = self.move_base.wait_for_result(rospy.Duration(300))
```

查看是否成功到达

```
if not finished_within_time:
```

```
    self.move_base.cancel_goal()
```

```
    rospy.loginfo("Timed out achieving goal")
```

```
else:
```

```
    state = self.move_base.get_state()
```

```
    if state == GoalStatus.SUCCEEDED:
```

```
        rospy.loginfo("Goal succeeded!")
```

```
    else:
```

```
        rospy.loginfo("Goal failed!")
```

运行所用时间

```
running_time = rospy.Time.now() - start_time
```

```
running_time = running_time.secs / 60.0
```

输出本次导航的所有信息

```
rospy.loginfo("Current time: " + str(trunc(running_time, 1)) + " min")
```

➡ 随机产生一个导航目标点进行寻宝

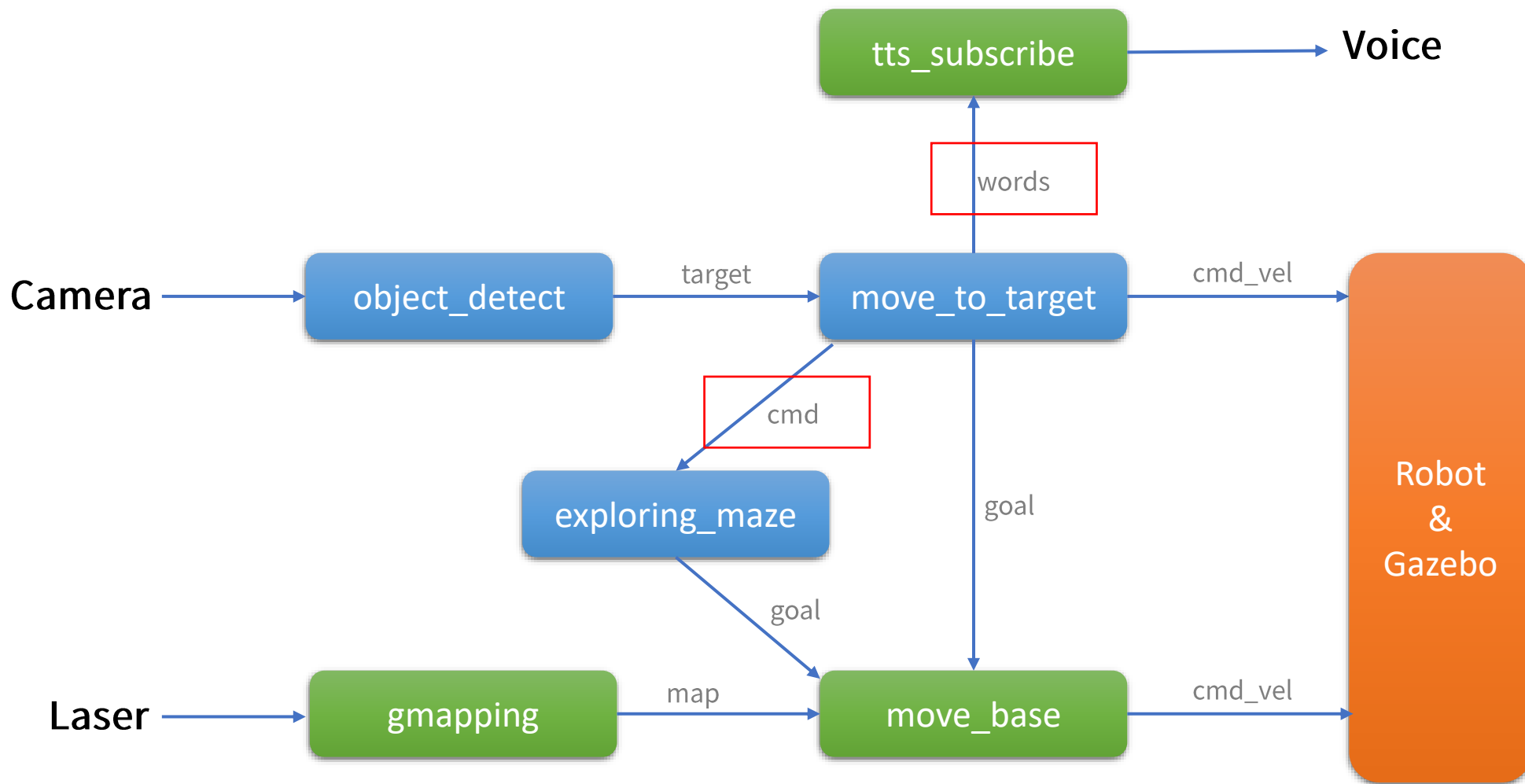
➡ 自主导航并视觉寻宝

exploring_maze.py

➡ 输出寻宝导航过程的时间



3. “迷宫寻宝”之任务实现 —— 系统集成

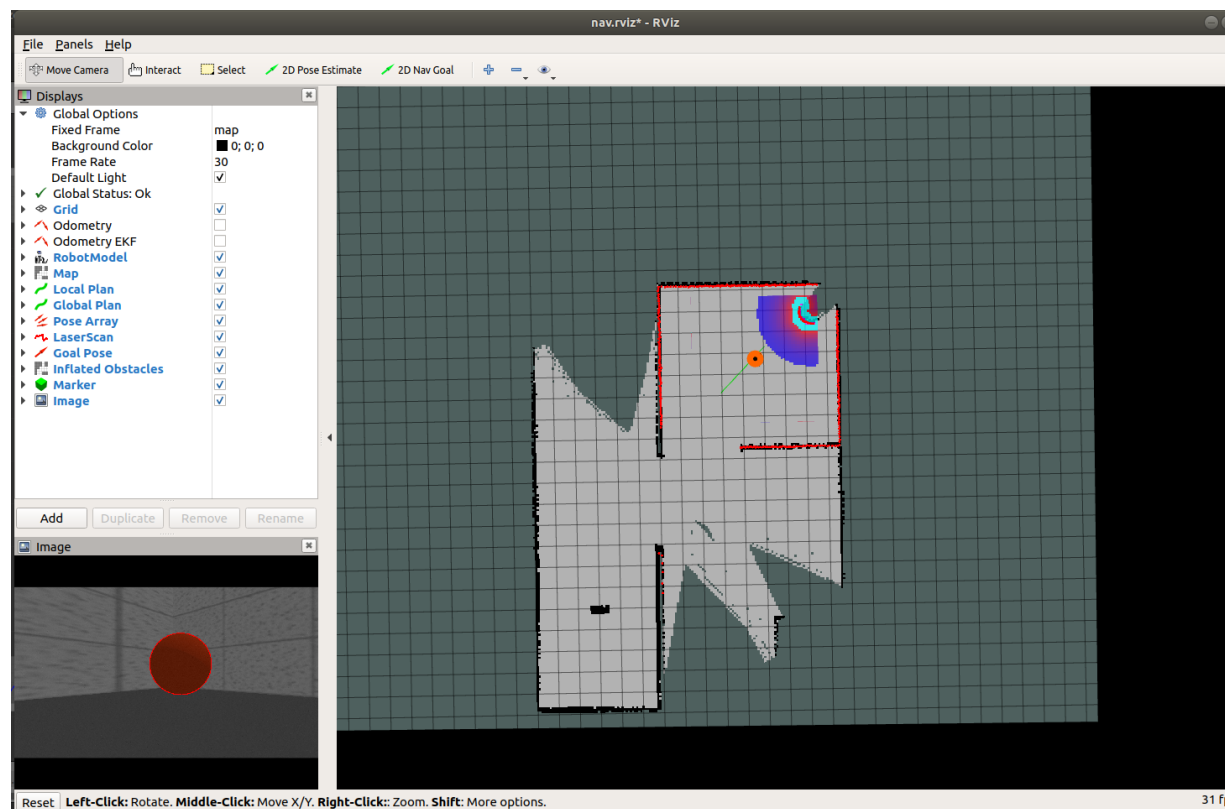
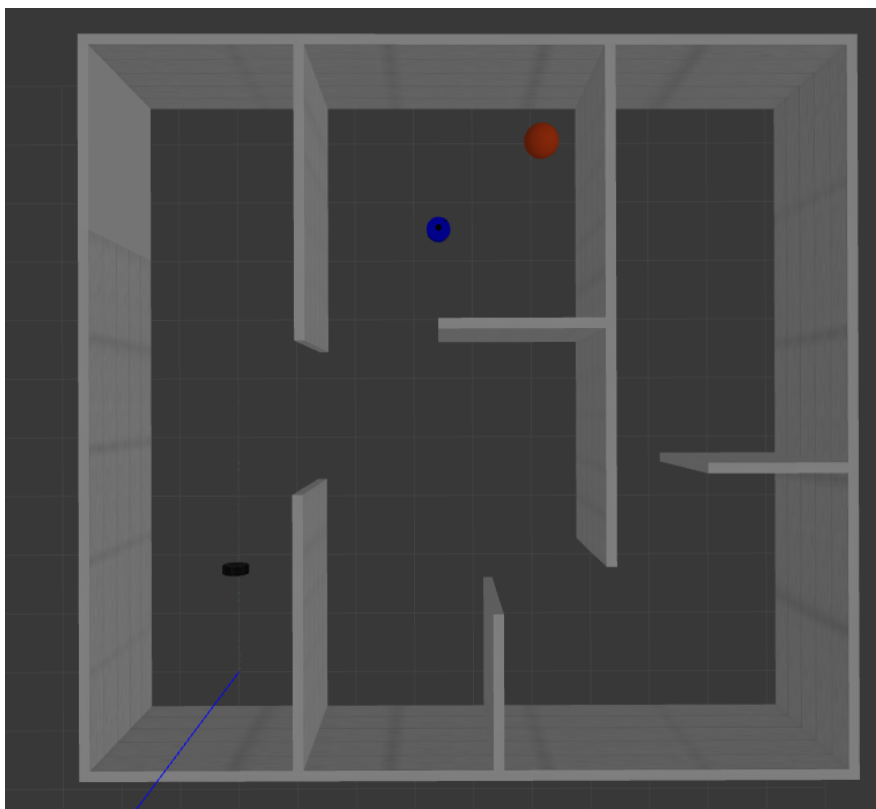


“迷宫寻宝”实现框架



3. “迷宫寻宝”之任务实现 —— 系统运行

```
$ roslaunch mbot_gazebo mbot_maze_gazebo.launch  
$ roslaunch mbot_navigation exploring_slam_demo.launch  
$ roslaunch mbot_vision find_target.launch
```



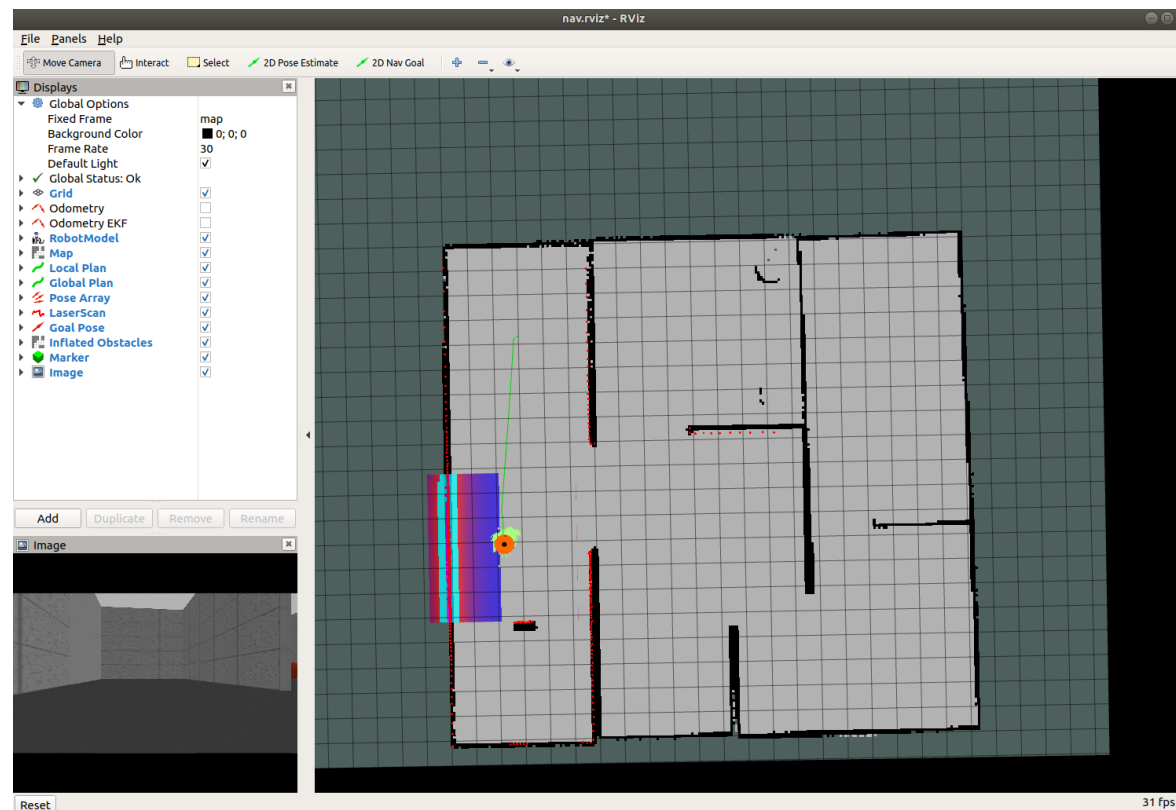
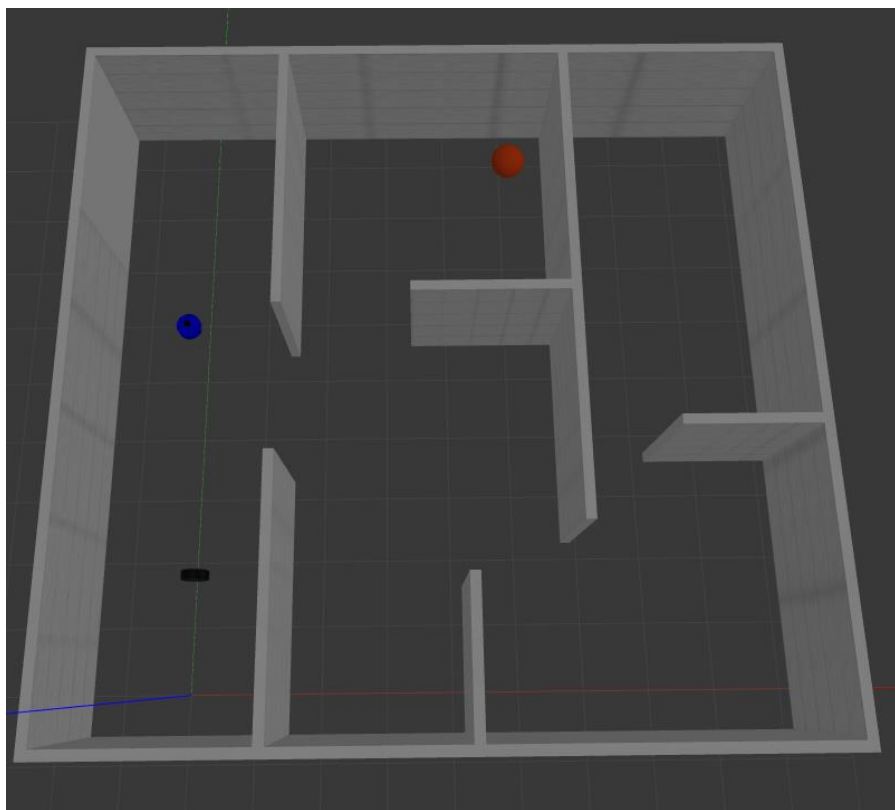


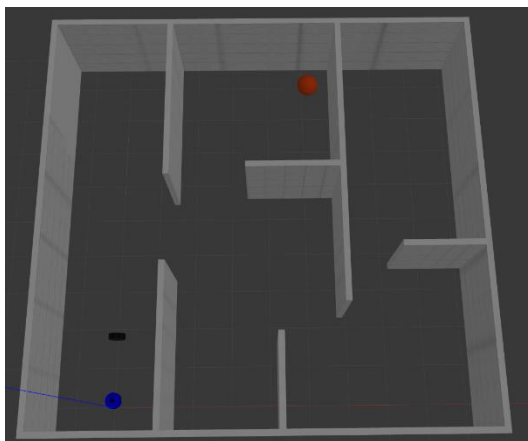
3. “迷宫寻宝”之任务实现 —— 系统运行

```
$ roslaunch mbot_gazebo mbot_maze_gazebo.launch
```

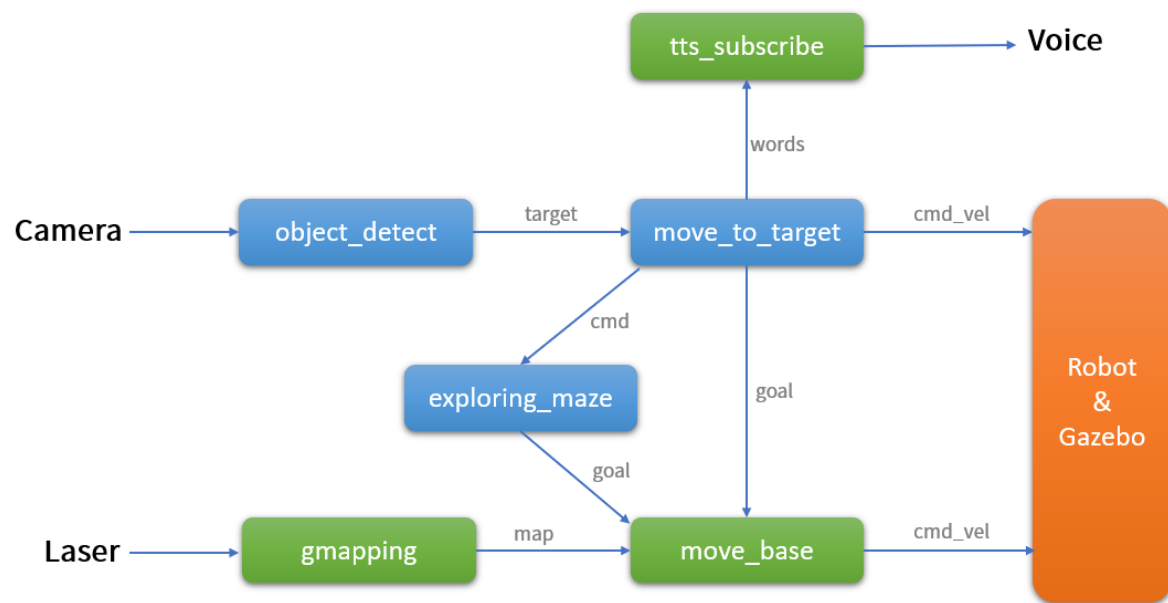
```
$ roslaunch mbot_navigation nav_maze_demo.launch
```

```
$ roslaunch mbot_vision find_target_pro.launch
```





- 机器人建模仿真
- 图像识别
- 语音交互
- 自主导航
- SLAM
- ROS通信机制
- 系统设计与集成





1、下载本讲作业代码，按照课程内容及代码提示，填充代码中缺少的部分，并复现课程中的“迷宫寻宝”效果；

(需要修改的文件：exploring_maze.py、exploring_maze_pro.py、object_detect.py、move_to_target.cpp、find_target.launch、find_target_pro.launch)

2、接受“迷宫寻宝”挑战，仿照本讲例程源码，使用自己的机器人模型及仿真环境，完成“迷宫寻宝”任务，挑战自己的时间极限。

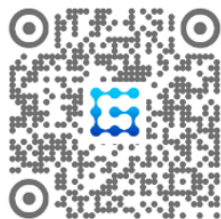




Thank You

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