LAB: Pet Feeder Robot

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[Demo Video]

Introduction

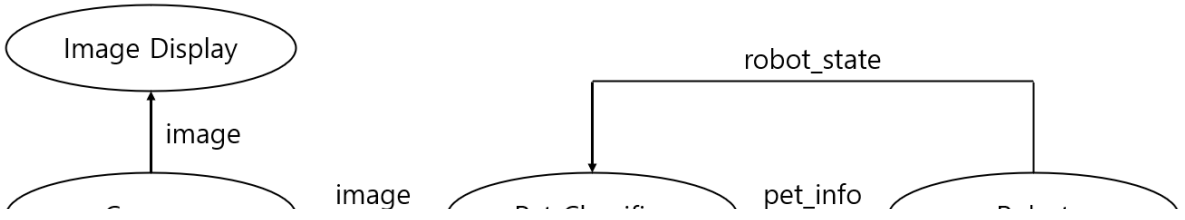
This lab aims to implement an automated Pet Feeder Robot using ROS, with a pet classifier via camera.

Figure 1. Pet Feeder

System Requirements

- Hardware
  - Robot: Indy 10(Robot IP: 192.168.0.8)
  - Camera: PC built-in camera (or USB camera)
- Software
  - Ubuntu 20.04
  - ROS Noetic
  - Pytorch (to use an Image-Net)

Pet Feeder Robot System



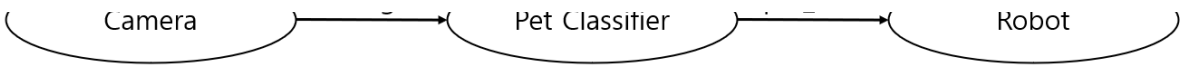


Figure 2. Flow Chart

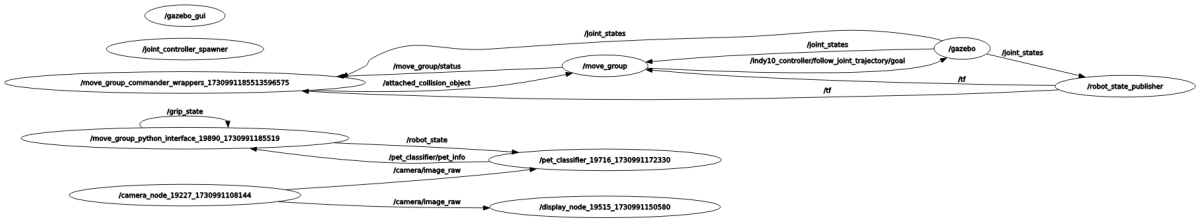


Figure 3. RQT Graph

Procedure

Nodes Design

The main nodes for this robotic system are listed below.

- Camera
  - This node generate image data from camera sensor
  - publish `camera/image_raw`
- Image display
  - This node shows image view to the user
  - Subscribe
- Pet Classifier
  - This node classifies objects(in the project, there are Golden Retriever and Tabby Cats)
  - Subscribe
  - Publish
- Pet feeder robot (=move_group_python_interface)
  - This node manipulates Indy10 Robot
  - Subscribe

ROS Programming

- Write source code for nodes in `catkin_ws/src/indy_driver/src`
  - `camera.py`

```
import rospy
import cv2
from sensor_msgs.msg import Image
from cv_bridge import CvBridge, CvBridgeError

class CameraNode:
    def __init__(self):
        self.bridge = CvBridge()                # cv_bridge 객체 생성
```

```
        self.image_pub =
rospy.Publisher("camera/image_raw",Image,queue_size=1)    #
"camera/image_raw"라는 토픽으로 메시지를 publish할 publisher 객체 생성
        self.cap = cv2.VideoCapture(0)          # 카메라 연결을 위한
VideoCapture 객체 생성

    def run(self):
        rospy.init_node('camera_node', anonymous=True)  # 노드 이름
"camera_node"로 초기화
        rate = rospy.Rate(30)                           # 루프 실행 주기 :
30hz
        while not rospy.is_shutdown():                  # ROS가 종료되지
않은 동안
            ret, frame = self.cap.read()                # 카메라로부터 이미
지를 읽음
            if ret:                                     # 이미지가 정상적으
로 읽혀진 경우
                try:
                    # 읽어들인 이미지를 ROS Image 메시지로 변환하여 토픽으로
publish

 self.image_pub.publish(self.bridge.cv2_to_imgmsg(frame, "bgr8"))

                except CvBridgeError as e:
                    print(e)                            # CvBridge 변환
예외 처리
            rate.sleep()                                # 지정된 루프 실행
주기에 따라 대기
if __name__ == '__main__':
    try:
        camera = CameraNode()       # CameraNode 객체 생성
        camera.run()                # run 메서드 실행
    except rospy.ROSInterruptException:
        pass
```

- `image_display.py`

```
import rospy
from sensor_msgs.msg import Image   # sensor_msgs 패키지로부터 Image 메시지
타입을 import
from cv_bridge import CvBridge      # cv_bridge 라이브러리 : OpenCV 이미지
와 ROS 메시지 간의 변환 가능
import cv2                          # OpenCV 라이브러리
class DisplayNode:
    def __init__(self):
        self.bridge = CvBridge()
        self.image_sub =
rospy.Subscriber("camera/image_raw",Image,self.callback)  #
camera/image_raw 토픽에서 Image 메시지 수신
    def callback(self,data):
        try:
            # 수신된 Image 메시지를 OpenCV 이미지로 변환
            cv_image = self.bridge.imgmsg_to_cv2(data, "bgr8")
        except CvBridgeError as e:
            print(e)
```

```
        cv2.imshow("Camera", cv_image)  # 변환된 이미지를 "Camera"라는 이름
의 윈도우에 표시
        cv2.waitKey(1)                  # 1ms 동안 키보드 입력 대기
    def run(self):
        rospy.init_node('display_node', anonymous=True) # 노드 초기화 및 이
름 설정
        rospy.spin()                                    # 노드가 종료될 때
까지 계속 실행
if __name__ == '__main__':
    try:
        display = DisplayNode()     # DisplayNode 클래스의 인스턴스 생성
        display.run()               # 노드 실행
    except rospy.ROSInterruptException:
        pass
```

- `pet_classifier.py`

```
import rospy
from sensor_msgs.msg import Image   # sensor_msgs 패키지로부터 Image 메시지
타입을 import
from cv_bridge import CvBridge, CvBridgeError      # cv_bridge 라이브러리
: OpenCV 이미지와 ROS 메시지 간의 변환 가능
import cv2                          # OpenCV 라이브러리
import numpy as np
import torch
from torchvision import models
from torchvision.models import AlexNet_Weights
from PIL import Image as PILImage
from torchvision import transforms
import torch.nn.functional as F
import json
import urllib
from indy_driver.msg import robot_state, pet_info
transforms = transforms.Compose([
                transforms.Resize(256),
                transforms.CenterCrop(224),
                transforms.ToTensor(),
                transforms.Normalize(
                    mean=[0.485, 0.456, 0.406],
                    std=[0.229, 0.224, 0.225]
            )])
# ImageNet 클래스 레이블을 로드하는 함수
def load_imagenet_labels():
    url = "https://raw.githubusercontent.com/anishathalye/imagenet-
simple-labels/master/imagenet-simple-labels.json"
    filename = "imagenet_classes.json"
    urllib.request.urlretrieve(url, filename)
    with open(filename, 'r') as f:
        return json.load(f)
class PetClassifierNode():
    def __init__(self, labels):
        rospy.init_node('pet_classifier', anonymous=True) # 노드 초기화 및
이름 설정
        self.bridge = CvBridge()
        self.bAction = False
        # Subscriber
```

```
        self.sub_image = rospy.Subscriber("camera/image_raw", Image,
self.action)  # camera/image_raw 토픽에서 Image 메시지 수신
        self.sub_robot = rospy.Subscriber("robot_state", robot_state,
self.chk_robot)  # camera/image_raw 토픽에서 Image 메시지 수신
        # Publisher
        self.pub_pet_info = rospy.Publisher('pet_classifier/pet_info',
pet_info, queue_size=10)
        # Model init
        self.model = models.alexnet(weights=AlexNet_Weights.DEFAULT)
        self.model.eval()
        self.labels = labels
        # Message Control Variables
        self.bSend = False
        self.bAction = False
        self.pet_info = pet_info()
        self.thresh_cnt = 5
        self.chk_cnt = 0
        self.pet_id_prev = 0
        self.pet_id_curr = 0
    def chk_robot(self,robot_state):
        if robot_state.move == 1:
            self.bAction = False
        else:
            self.bAction = True
    def action(self,data):
        if self.bAction:
            try:
                # 수신된 Image 메시지를 OpenCV 이미지로 변환
                cv_image = self.bridge.imgmsg_to_cv2(data, "bgr8")
                # OpenCV 이미지를 PIL 이미지로 변환
                pil_image = PILImage.fromarray(cv2.cvtColor(cv_image,
cv2.COLOR_BGR2RGB))
                # 이미지 전처리
                input_tensor = transforms(pil_image)
                input_batch = input_tensor.unsqueeze(0)  # 배치 차원 추가
                # model 예측
                with torch.no_grad():
                    output = self.model(input_batch)
                    percentages = F.softmax(output, dim=1)[0] * 100
                    _, indices = torch.sort(output, descending=True)
                    label = self.labels[indices[0][0]]
                    if label == "tabby cat":
                        self.pet_id_curr = 1
                    elif label == "Golden Retriever":
                        self.pet_id_curr = 2
                        print("Detecting Retriever")
                    else:
                        self.pet_id_curr = 0
                    if (self.pet_id_curr == self.pet_id_prev) and
self.pet_id_curr != 0:
                        self.chk_cnt += 1
                    else:
                        self.chk_cnt = 0
                    if self.chk_cnt >= self.thresh_cnt:
                        self.chk_cnt = 0
                        self.bSend = True
```

```
                    if self.bSend:
                        self.pet_info.name = label
                        self.pub_pet_info.publish(self.pet_info)
                        self.bSend = False
                    self.pet_id_prev = self.pet_id_curr
                    rospy.loginfo("%s, %d, %d",label, self.pet_id_curr,
self.chk_cnt)
            except Exception as e:
                print(e)

    def run(self):
        rospy.spin()                                    # 노드가 종료될 때
까지 계속 실행


if __name__ == '__main__':
    try:
        # ImageNet 레이블 로드
        imagenet_labels = load_imagenet_labels()
        pet_classifier = PetClassifierNode(imagenet_labels)       #
CameraNode 객체 생성
        pet_classifier.run()                # run 메서드 실행
    except rospy.ROSInterruptException:
        pass
```

- `pet_feeder.py`

  In the lab, quantity of pet food is 1, 3 respectively for

```
import sys
import rospy
import moveit_commander
import moveit_msgs
import geometry_msgs

import tf
import numpy as np

from math import pi

from move_group_python_interface import MoveGroupPythonInterface
from indy_driver.msg import pet_info

DEG2RAD = pi/180
RAD2DEG = 180/pi

tau = 2*pi

feed_info = { "pt_A_top" :  { "tabby cat" : np.array([- 1/6, 0, 1/4, 0,
1/4, 0])*tau ,
                              "Golden Retriever" : np.array([- 1/6, 0,
1/4, 0, 1/4, 0])*tau },
              "pt_A_bottom":{ "tabby cat" : np.array([0, 0, 1/10, 0, -
1/10, 0])*tau ,
                              "Golden Retriever" : np.array([0, 0, 1/10,
0, - 1/10, 0])*tau },
```

```
                "pt_B_top" :  { "tabby cat" : np.array([1/16, 0, 1/4, 0,
1/4, 0])*tau ,
                                "Golden Retriever" : np.array([1/16, 0, 1/4,
0, 1/4, 0])*tau },
                "pt_B_bottom":{ "tabby cat" : np.array([1/8, 0, 1/12, 0, -
1/12, 0])*tau ,
                                "Golden Retriever" : np.array([1/8, 0, 1/12,
0, - 1/12, 0])*tau },
                                "quantity" : {"tabby cat": 1,
                                              "Golden Retriever": 3},
                "up_A" :      { "rel_xyz" : [0.0, 0.0, 0.200] ,
                                "rel_rpy"  : [0.0, 0.0, 0.0] },
                "down_A" :    { "rel_xyz" : [0.0, 0.0, -0.200] ,
                                "rel_rpy"  : [0.0, 0.0, 0.0] },
                "up_B" :      { "rel_xyz" : [0.0, 0.0, 0.150] ,
                                "rel_rpy"  : [0.0, 0.0, 0.0] },
                "down_B" :    { "rel_xyz" : [0.0, 0.0, -0.150] ,
                                "rel_rpy"  : [0.0, 0.0, 0.0] }
}

class PetFeederNode():
    def __init__(self):
        # rospy.init_node('pet_feeder', anonymous=True) # 노드 초기화 및 이
름 설정

        # Subscriber
        self.sub_pet_class = rospy.Subscriber("pet_classifier/pet_info",
pet_info, self.feed)  # camera/image_raw 토픽에서 Image 메시지 수신

        # Robot initialization
        self.robot = MoveGroupPythonInterface(real=True,
gripper="Vaccum")
        self.robot.move_to_standby()

        self.robot.grip_off()

    def feed(self, pet_info):

        for i in range(feed_info["quantity"][pet_info.name]):

            # point A
            # go_to_pose_abs(self, absolute_xyz, absolute_rpy)
            self.robot.go_to_joint_abs(feed_info["pt_A_top"]
[pet_info.name])
            self.robot.go_to_pose_rel(feed_info["down_A"]['rel_xyz'],
feed_info["down_A"]['rel_rpy'])
            self.robot.grip_on()
            self.robot.go_to_pose_rel(feed_info["up_A"]['rel_xyz'],
feed_info["up_A"]['rel_rpy'])

            # point B
            self.robot.go_to_joint_abs(feed_info["pt_B_top"]
[pet_info.name])
            self.robot.go_to_pose_rel(feed_info["down_B"]['rel_xyz'],
feed_info["down_B"]['rel_rpy'])
            self.robot.grip_off()
```

```
            self.robot.go_to_pose_rel(feed_info["up_B"]['rel_xyz'],
feed_info["up_B"]['rel_rpy'])

        self.robot.move_to_standby()

    def run(self):
        rospy.spin()                                    # 노드가 종료될 때
까지 계속 실행

if __name__ == '__main__':
    try:
        pet_feeder = PetFeederNode()
        pet_feeder.run()                # run 메서드 실행
    except rospy.ROSInterruptException:
        pass
```

    - The source codes were provided in UR5e-Execution, and needs to be appropriately modified.
- add message in `catkin_ws/src/indy_driver/msg`
    - `pet_info.msg`
- modify the file `CMakeList.txt` in `catkin_ws/src/indy_driver`
- Make `.launch` file

Simulation

Write the code here to run the simulation in the terminal

- terminal 1

```
roslaunch indy10_gazebo indy10_moveit_gazebo.launch
```

- terminal 2

```
rosrun indy_driver camera.py
```

```
rosrun indy_driver image_display.py
```

```
rosrun indy_driver pet_classifier.py
```

```
rosrun indy_driver pet_feeder.py
```

Robot Execution

The bash command for robot execution are the following:

- terminal 1

```
roslaunch indy10_moveit_config moveit_planning_execution.launch
robot_ip:=192.168.0.8
```

- terminal 2

```
rosrun indy_driver camera.py
```

```
rosrun indy_driver pet_classifier.py
```

```
rosrun indy_driver image_display.py
```

```
rosrun indy_driver pet_feeder.py
```

Some of the python files may need pytorch from Anaconda environment.

Discussion

1. The DL model used in the lab is not accurate enough, threshold of count consecutive frame is 5 as the model cannot classify 'Golden Retriever' and 'Tabby Cat' well.
2. For golden retriever, the feeder acts 3 times where tabby cat acts one time.