GOOD MORNING!
早上好!
안녕하세요!

DAY 2

DAY 1 RECAP

2 PROJECTS

- Mini Project (Individual Team)
  - For learning techniques

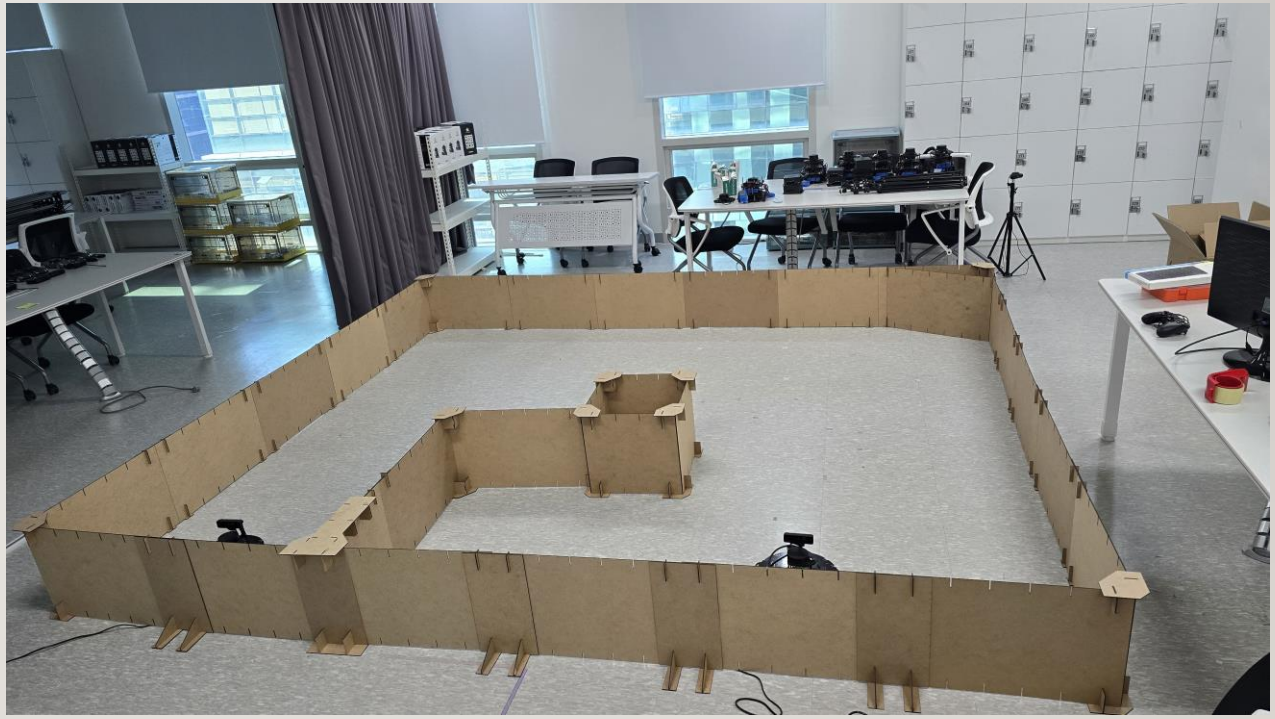
1	로봇 AI 시스템 개발 프로세스 이해	시스템 개발 프로세스의 이해 개발 환경 구축
2	프로젝트에 필요 기술 검증	AI VISION 기술 탐색 및 검증
3	프로젝트에 필요 기술 검증	로봇 AMR 제어 기술 탐색 및 검증
4/5	MINI 프로젝트	통합 시스템 설계 및 개발

2 PROJECTS

- Final Project (2 Teams in One)

6	프로젝트에 필요 기술 검증	윕 시스템 모니터 기술 탐색 및 검증
6-9	파이날 프로젝트	통합 시스템 설계 및 개발
10	최종 프레젠테이션 및 시연	시스템 발표 및 시연

MINI PROJECT DESCRIPTION

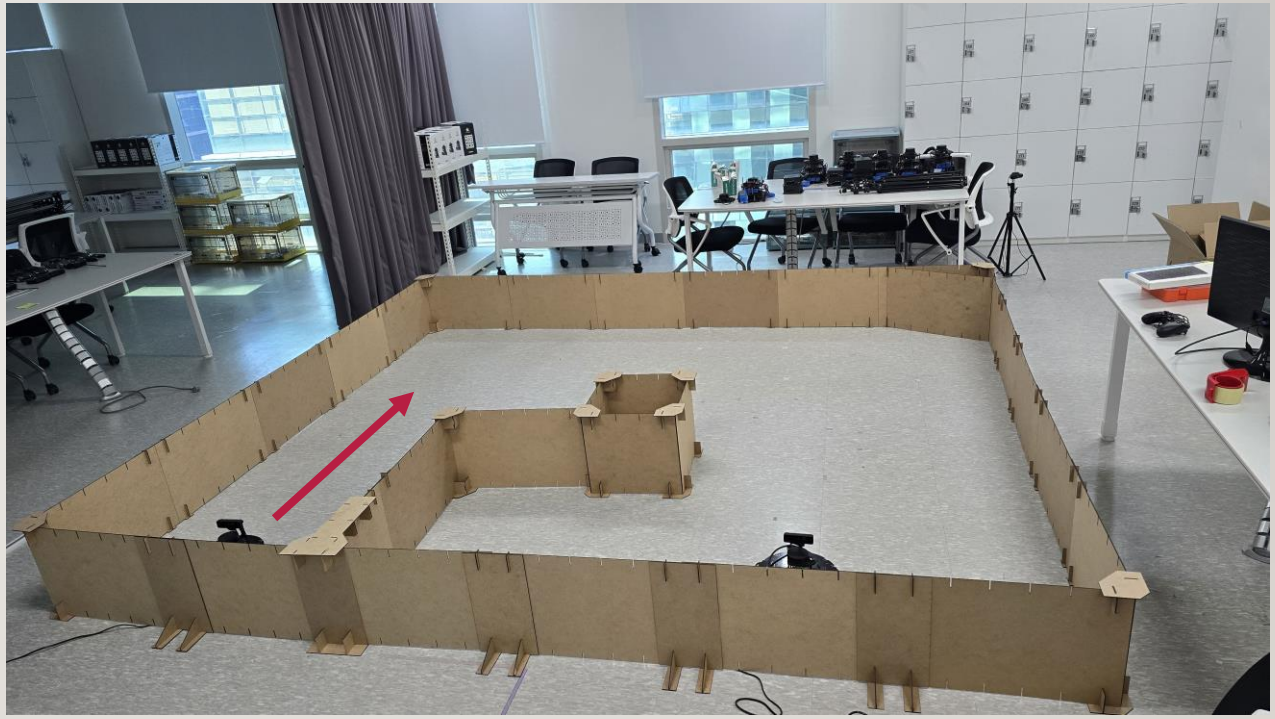


KEY SUBSYSTEM (MODULES) TO DEVELOP

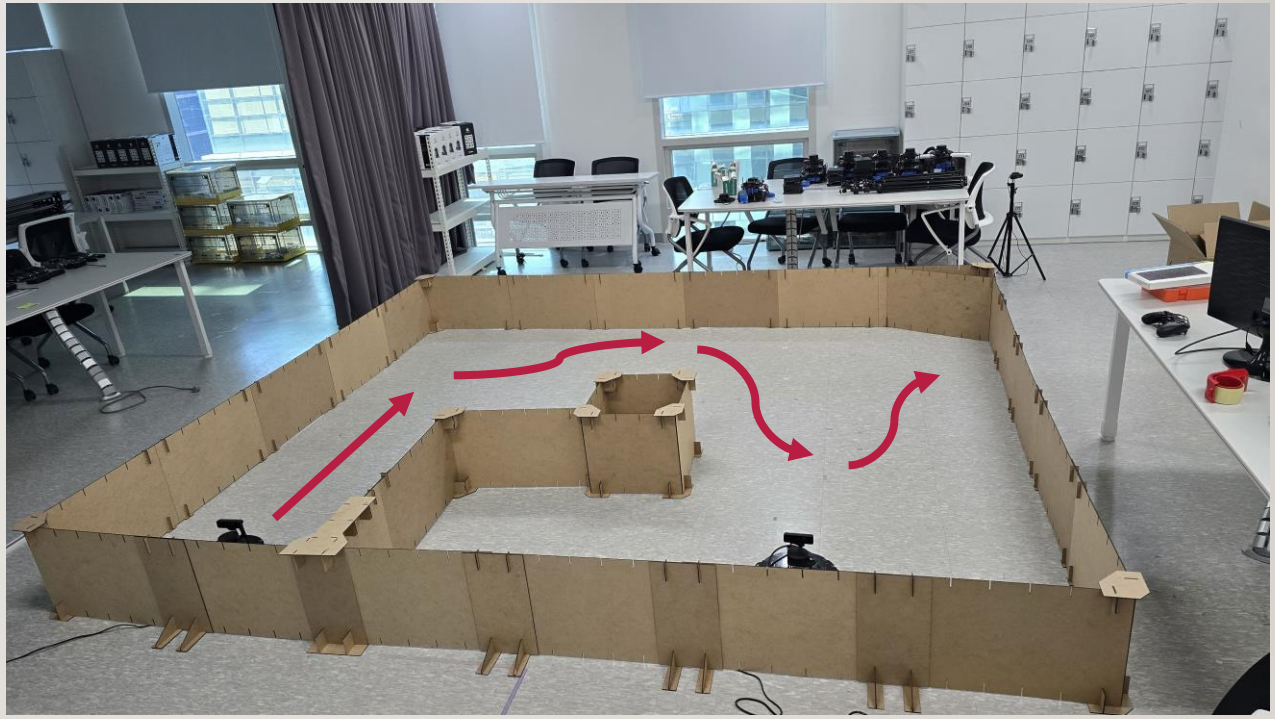
- Detection Alert
  - Camera Capture
  - Object Detection
  - Send messages to other subsystems
- AMR Controller
  - Receive messages and act accordingly
  - Move using (SLAM) with Obstruction avoidance
  - Target Acquisition (Obj. Det.) and Tracking
  - Follow target using camera and motor control

DETECTION ALERT

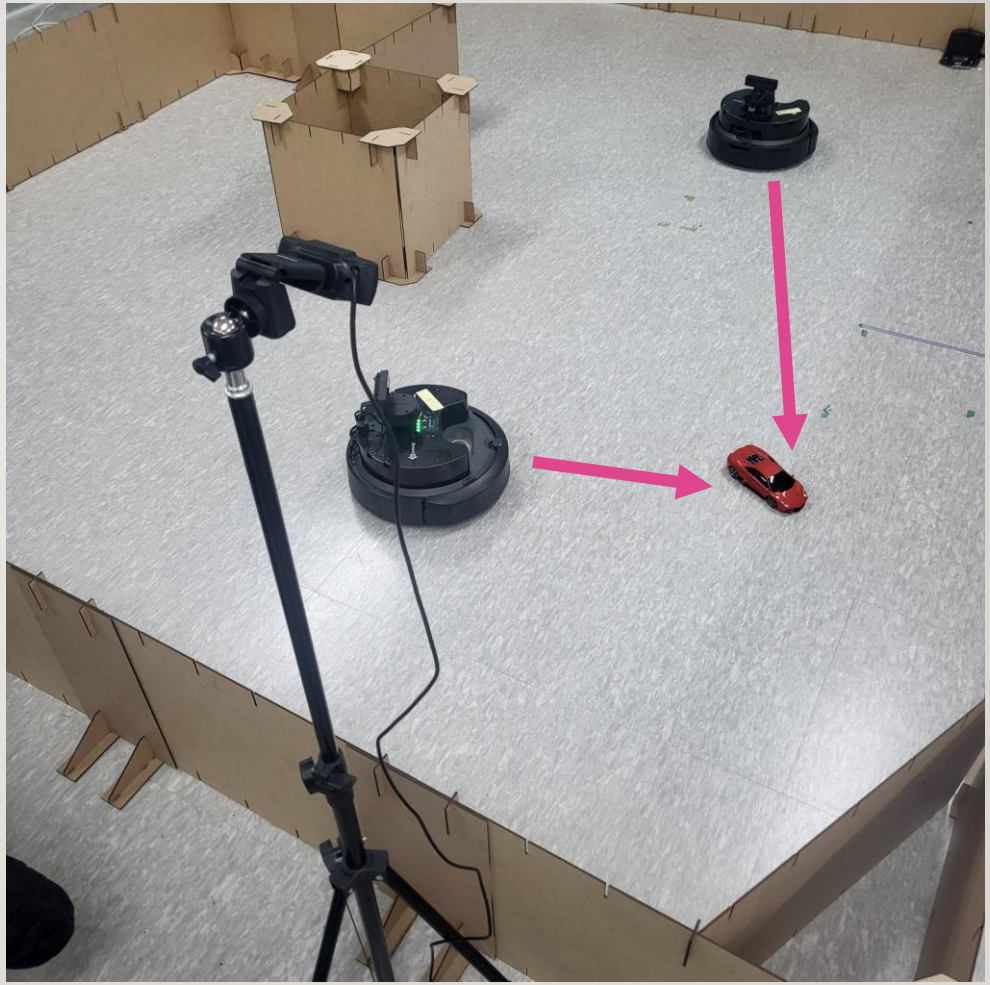
START



NAVIGATE



TRACK & FOLLOW



DAY 1

- Welcome
- Project Introduction
- Introduction to Project Development Process
- Business Requirement Development
- System Requirement Development
- Time Management
- System(High Level) Design (Intro.)

DAY 2 (MINI PROJECT)

- Yolo객체 인식 모델 활용과 성능 평가 방법 이해
  - Custom Dataset과 Fine Tuning으로 자체 객체 인식 모델 구현 및 평가
  - (Optional)경량화 모델 등 개별 요구사항에 적합한 모델 탐색 및 성능 검증

DAY 2 (MINI PROJECT)

WEB-CAM 기반 객체 인식 (IF NEEDED)

- YOLOv8 기반 데이터 수집/학습/deploy (Detection Alert)
  - 감시용 데이터 수집(rc_car, dummy, 등)
  - 감시용 데이터 라벨링
  - YOLOv8 기반 학습
  - YOLOv8 Object Detection

AMR-CAM 기반 객체 인식

- AMR(Autonomous Mobile Robot) Turtlebot4 개발 환경 구축
- 로봇 개발 환경에 완성 모델 서빙 및 테스트 / 로봇 H/W, 제반 환경의 한계점 도출
  - Tracking 데이터 수집((rc_car, dummy, 등)
  - Tracking 데이터 라벨링
  - YOLOv8 기반 학습
  - YOLOv8 Object Tracking

DAY 3 (MINI PROJECT)

- Auto. Driving 시스템 학습
  - Digital Mapping of environment
  - Operate AMR (Sim. & Real)
  - Tutorial 실행
  - Detection, Depth and AMR 주행
  - 로봇 개발 환경에 적용 및 테스트 / 로봇 H/W, 제반 환경의 한계점 도출

TURTLEBOT4 시뮬레이션

- 환경 구축
- SLAM과 AutoSLAM으로 맵 생성
- Sim. Tutorial 실행
- Detection, Depth and AMR 주행 example

DAY 3 (MINI PROJECT)

REAL ROBOT

- Manually operating the AMR (Teleops)
- autonomous driving 시스템 with obstacle avoidance
  - Digital Mapping of environment
  - Launching Localization, Nav2, and using Rviz to operate a robot
  - Goal Setting and Obstacle Avoidance using Navigation

TUTORIAL

- Turtlebot4 API를 활용한 Initial Pose Navigate_to Pose 구현
- Turtlebot4 API를 활용한 Navigate_Through_pose, Follow Waypoints 구현

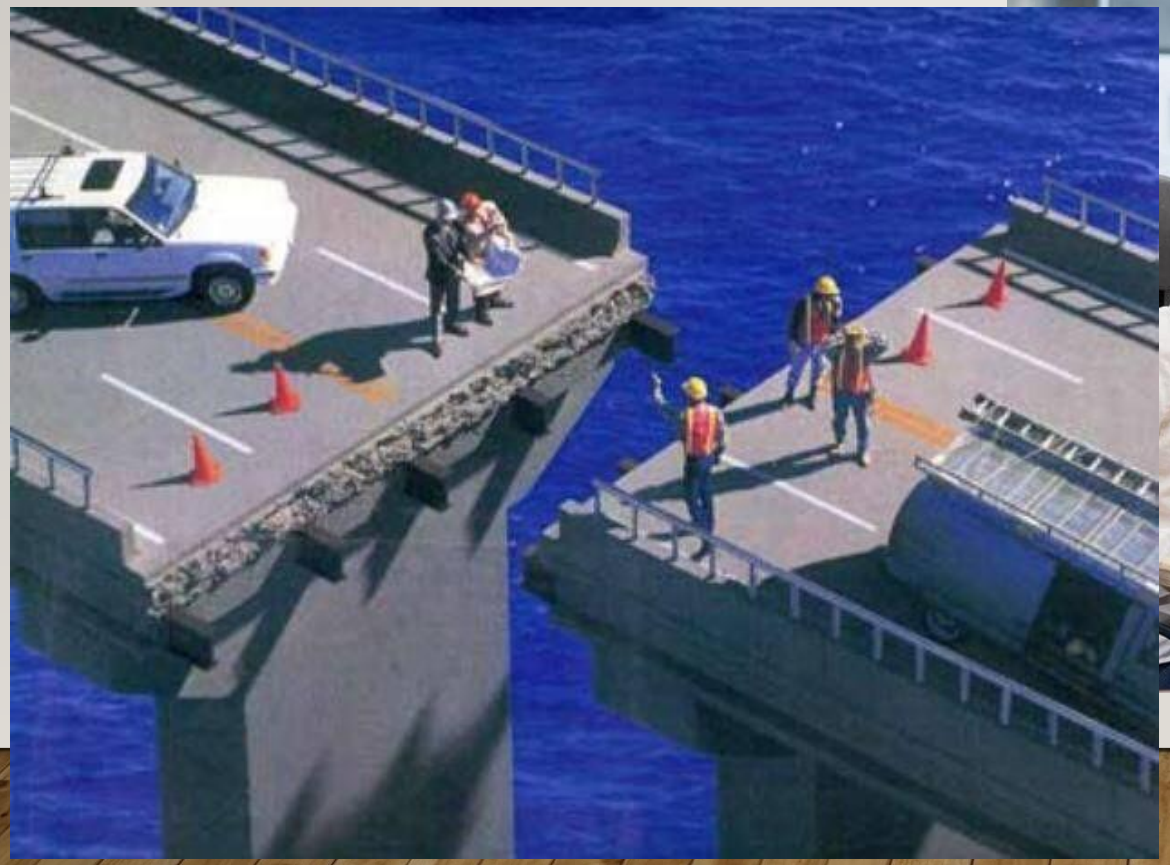
HOW TO WORK TOGETHER

- Participate, Participate, Participate!!!
- No long emails or Kakaotalk, prefer face to face
- Be open to suggestions and idea
- Be proactive (적극적), take initiative (주도적)
- HOW is as important as WHAT

프로젝트 RULE

80/20 → 20/80

TEAMWORK AND PROJECT MANAGEMENT



BRAINSTORMING RULES

- Every input is good input
- Do not critique inputs only seek to understand
- Organize inputs into logical groupings
- Sequence or show relationships as needed
- Use Posted Notes on Flip Chart

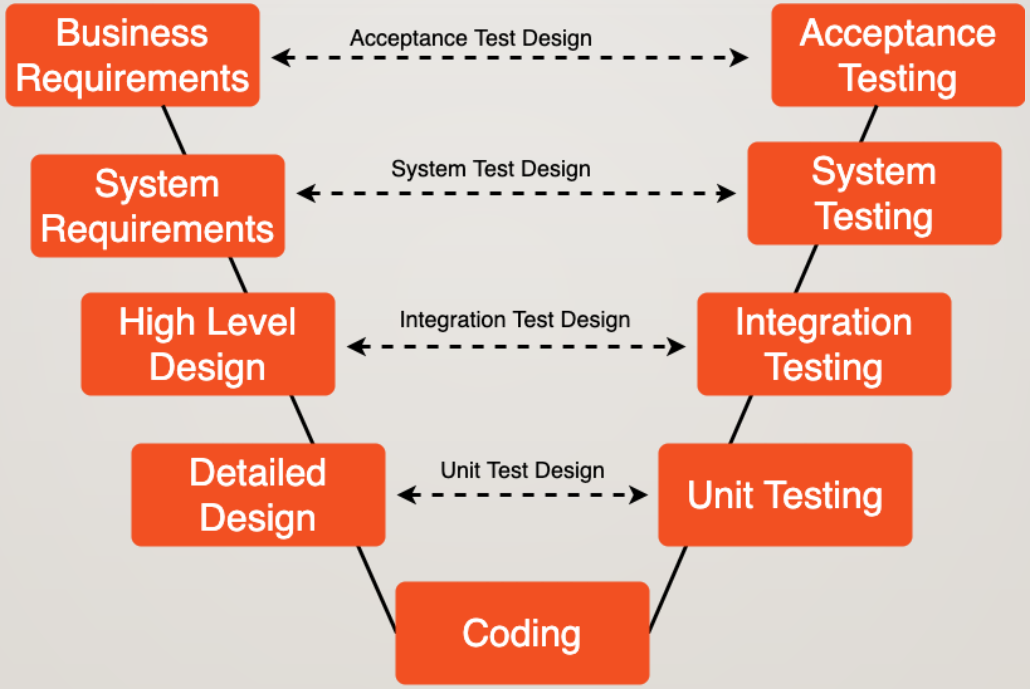
프로젝트 RULE NUMBER ONE!!!

Have Fun Fun Fun!

PROJECT DEVELOPMENT IS A PROCESS

SW DEVELOPMENT PROCESS

Why and What



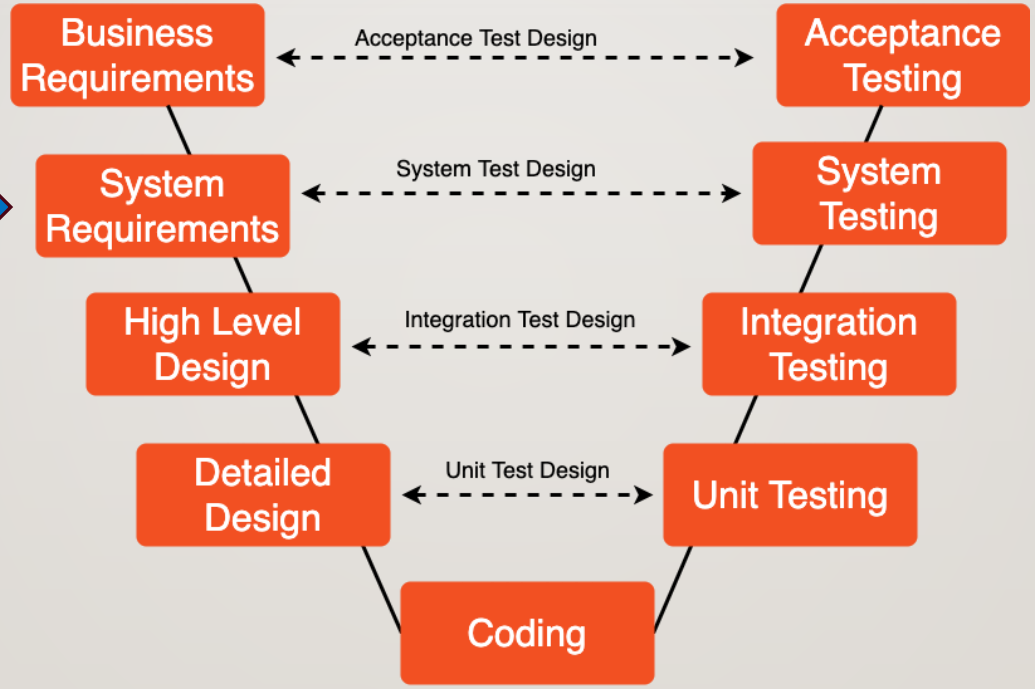
SDLC - V Model - notepub.io

TEAM EXERCISE 1

Brainstorm Business Requirement for the project and write business requirement statement

SW DEVELOPMENT PROCESS

With What
And
How Much



SDLC - V Model - notepub.io

TEAM EXERCISE 2

Brainstorm Updated System Requirement for the project and document

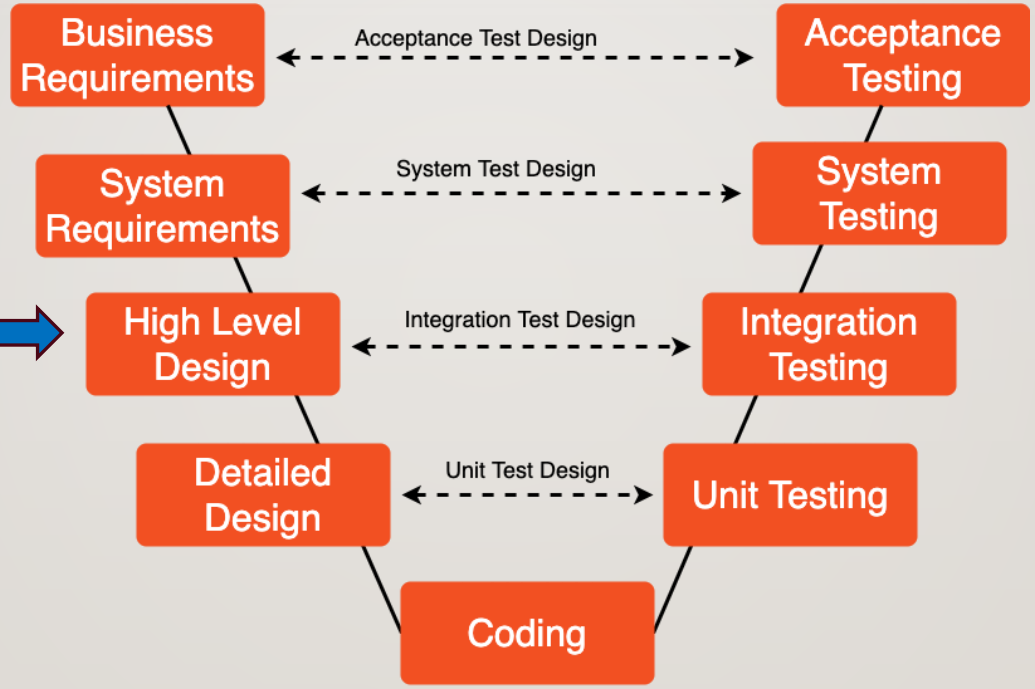
Using the posted notes and flipchart as needed

SYSTEM REQUIREMENT PRESENTATION BY EACH TEAM

Using the posted notes and flipchart as needed

SW DEVELOPMENT PROCESS

HOW:
Where,What,
When,How Much

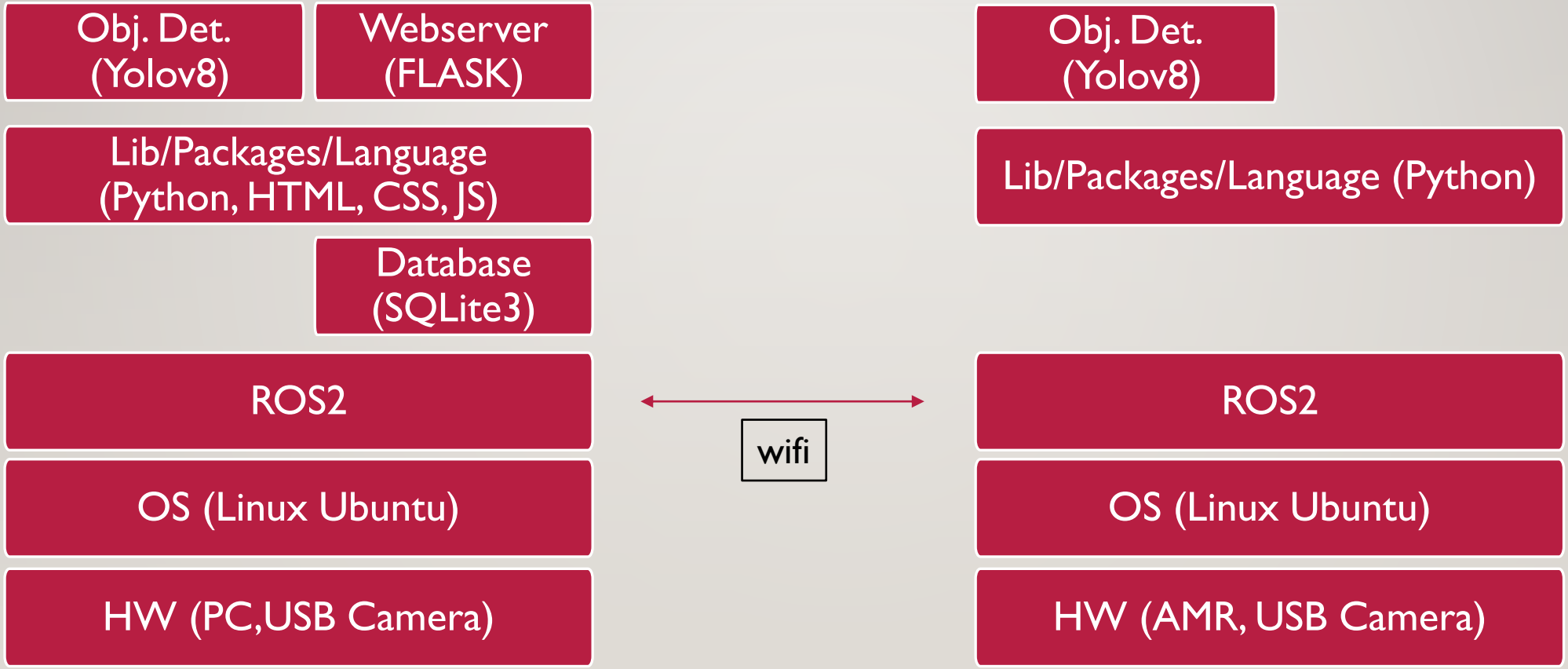


SDLC - V Model - notepub.io

DAY 2

SYSTEM AND DEVELOPMENT ENVIRONMENT SETUP

PROJECT SW STACK



USEFUL COMMANDS

$ lsb_release –a	• Linux distribution info
$ echo $ROS_DISTRO	• ROS: Humble
$ code --version	• Vscode
$ python3 --version	• Python

$ sudo apt update

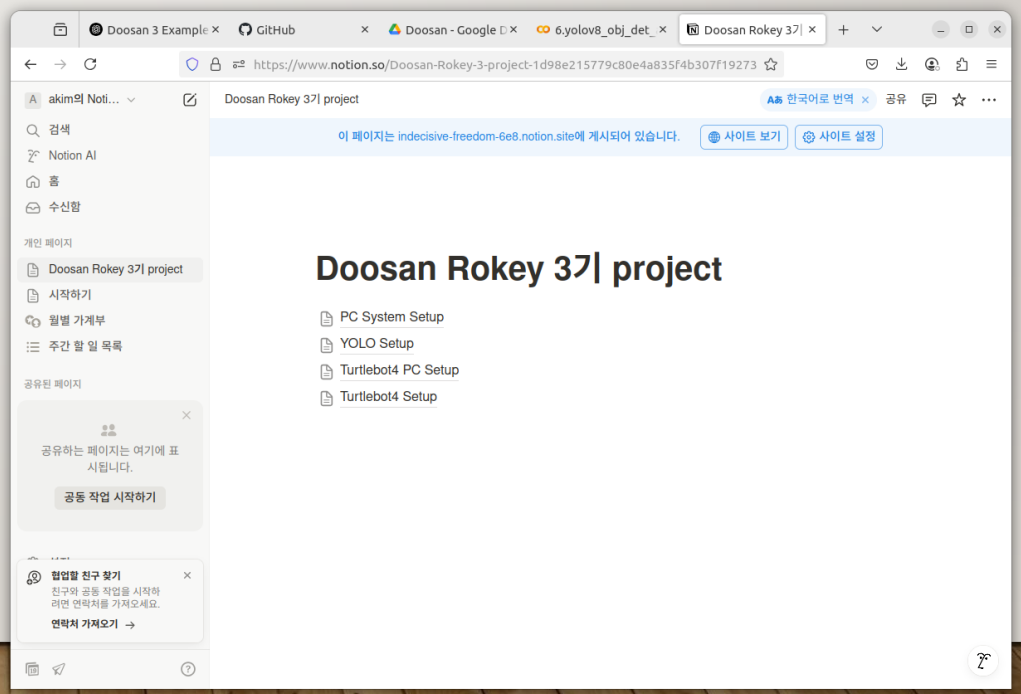
$ sudo apt upgrade

$ python -m ensurepip –upgrade

- Assumes Linux (Ubuntu 22.04), ROS Humble, VScode, and Python are already installed globally

SYSTEM ENVIRONMENT SETUP SHELL SCRIPT

- PC System Setup
- https://indecisive-freedom-6e8.notion.site/PC-System-Setup-1d98e215779c806080bbd1014d63a406



ROS2 DEVELOPMENT WORKSPACE

```
$ cat ~/.bashrc

$ echo "source /opt/ros/humble/setup.bash" >> ~/.bashrc  #check path

$ sudo apt install python3-colcon-common-extensions
$ echo "source /usr/share/colcon_argcomplete/hook/colcon-argcomplete.bash" >> ~/.bashrc
  #check path

$ source ~/.bashrc
```

PREPARING FOR YOLO LABELLING

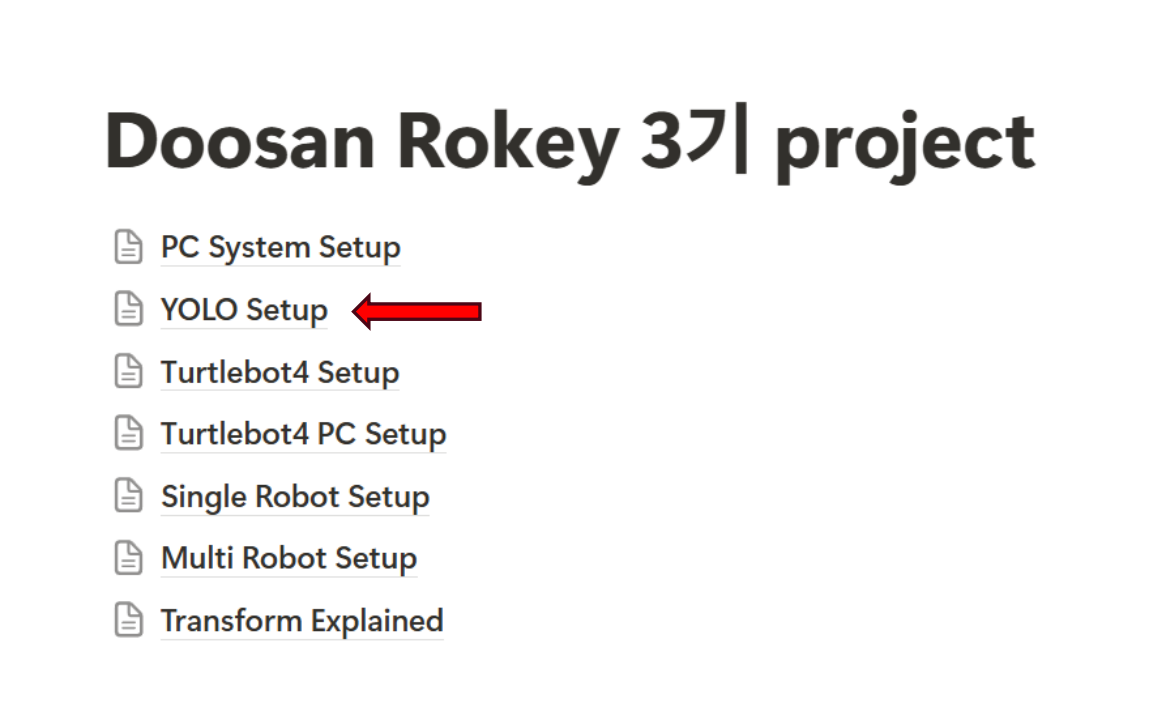
Data Labelling : use previously installed LabelImg

Or

YOLO Setup

https://indecisive-freedom-6e8.notion.site/YOLO-Setup-1d98e215779c80f389eefbe0d86ee0ec

$ labelImg



HOW TO SETUP AMR

Turtlebot4 Setup

https://indecisive-freedom-6e8.notion.site/Turtlebot4-Setup-1d98e215779c801b8e74eff67eb6305e

Doosan Rokey 3기 project

- PC System Setup
- YOLO Setup
- Turtlebot4 Setup
- Turtlebot4 PC Setup
- Single Robot Setup
- Multi Robot Setup
- Transform Explained

SETUP PC FOR AMR

Turtlebot4 PC Setup

https://indecisive-freedom-6e8.notion.site/Turtlebot4-PC-Setup-1d98e215779c80e887b6c1dff4f151be

Doosan Rokey 3기 project

- PC System Setup
- YOLO Setup
- Turtlebot4 Setup
- Turtlebot4 PC Setup
- Single Robot Setup
- Multi Robot Setup
- Transform Explained

SETUP BASH

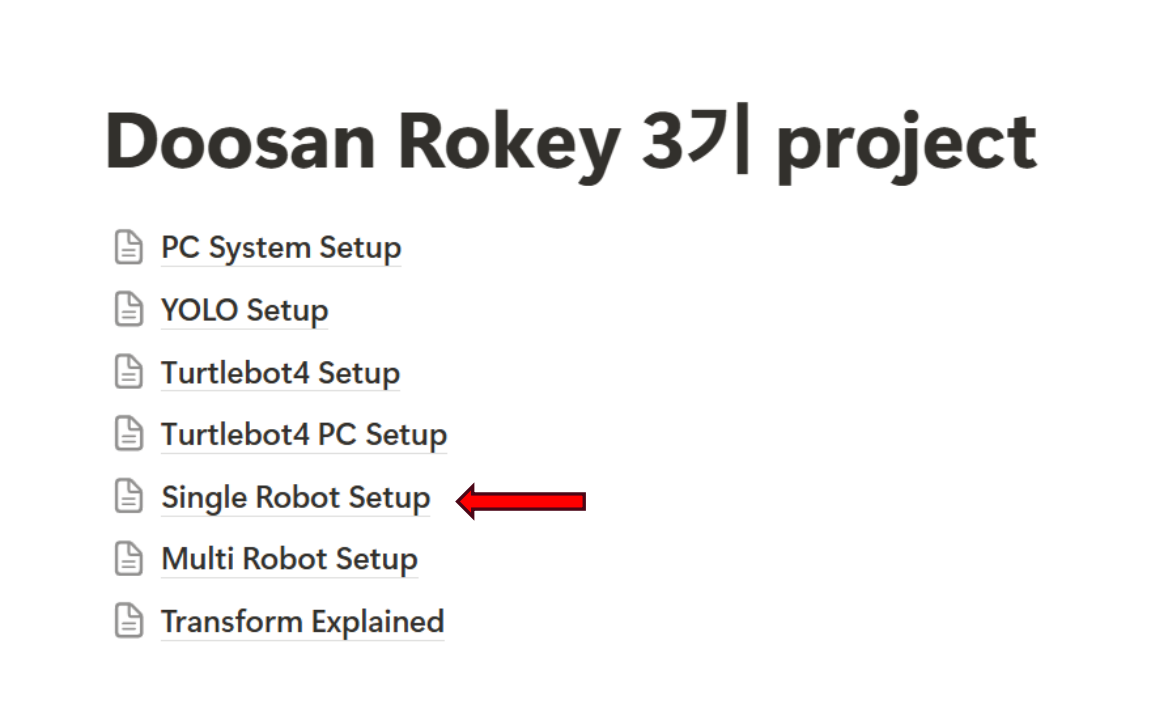
Add in ~/.bashrc:

- source turtlebot4_ws/install/setup.bash
- ROS_DOMAIN_ID = 0

$ source ~/.bashrc

SETUP PC FOR AMR

- Single Robot Setup
- https://indecisive-freedom-6e8.notion.site/Single-Robot-Setup-1f98e215779c805fa521dd07277a2880



AMR (DEMO)

- Power On and Off
- Connecting to Robot
  - Wifi Router
  - SSH
- Docking and Undocking (using pannel/buttons)
- Teleop with keyboard

CONNECTING TO AMR -- SSH

Connect your PC to WiFi router that your AMR is connected

Ex: turtle09

Obtain the ip address shown on the OLED display of the Turtlebot4

EX: 192.168.10.16

Open a terminal window

$ dpkg -l | grep openssh

If not installed…

$ sudo apt install openssh-server –y

Connect to AMR via SSH

$ ssh ubuntu@192.168.10.16

PW: rokey1234

Do **NOT INSTALL** any packages to AMR **WITHOUT** speaking with me first!!!

UNDOCK/DOCK AMR (ON PC OR AMR)

UNDOCK

$ ros2 topic list

Check the list

$ ros2 action send_goal /robot<n>/undock irobot_create_msgs/action/Undock "{}"

DOCK

$ ros2 topic list

Check the list

$ ros2 action send_goal /robot<n>/dock irobot_create_msgs/action/Dock "{}"

HOW TO TEST PC – AMR CONNECTION

PC TERMINAL

$ ros2 topic list (will need to execute it twice)

#Check the list

$ ros2 run teleop_twist_keyboard teleop_twist_keyboard --ros-args -r /cmd_vel:=/robot <n>/cmd_vel

$ ro2 topic echo /robot <n>/rgb/image_raw --once

AMR TERMINAL

$ ros2 topic list (will need to execute it twice)

#Check the list

$ ro2 topic echo /robot <n>/rgb/image_raw --once

USING ROS_WS

ROS2 DEVELOPMENT WORKSPACE

CREATE WORKSPACE

$ mkdir -p ~/rokey3_<grp_letter><grp_num>_ws/src

- (i.e. mkdir –p ~/rokey3_A2_ws/src)

$ cd ~/rokey3_A2_ws

$ rosdep install --from-paths src --ignore-src -r –y

If not installed…

$ sudo rosdep init

$ rosdep update

*NOT CREATED UNTIL COLCON

```
workspace/        # Root of the workspace
  ├── src/        # Source code (ROS packages)
  ├── build/      # Build files (generated by colcon)
  ├── install/    # Installed packages and setup scripts
  └── log/        # Build logs
```

$ colcon build

$ source install/setup.bash

ROS2 DEVELOPMENT WORKSPACE

$ cd ~/rokey3_A2_ws/src

$ ros2 pkg create --build-type ament_python <my_package>

```
my_package/
├── package.xml          # Package metadata and dependencies
├── setup.py             # Build instructions for Python packages
├── setup.cfg            # Optional, configures metadata for setuptools
├── launch/              # Launch files for starting nodes (optional)
├── config/              # Configuration files (optional)
├── resource/            # Empty file matching package name for ament ind
├── my_package/          # Python package directory (contains code)
│   ├── __init__.py      # Makes this directory a Python package
│   └── my_node.py       # Example Python node
└── msg/                 # Message definitions (optional)
```

ROS2 DEVELOPMENT WORKSPACE

Write you code below the my_package/ directory under my_package/ package directory

```
my_package/
├── package.xml          # Package metadata and dependencies
├── setup.py             # Build instructions for Python packages
├── setup.cfg            # Optional, configures metadata for setuptools
├── launch/              # Launch files for starting nodes (optional)
├── config/              # Configuration files (optional)
├── resource/            # Empty file matching package name for ament ind
├── my_package/          # Python package directory (contains code)
│   ├── __init__.py      # Makes this directory a Python package
│   └── my_node.py       # Example Python node
└── msg/                 # Message definitions (optional)
```

ROS2 DEVELOPMENT WORKSPACE

$ cd ~/ rokey3_A2_ws

$ colcon build

```
workspace/        # Root of the workspace
  ├── src/        # Source code (ROS packages)
  ├── build/      # Build files (generated by colcon)
  ├── install/    # Installed packages and setup scripts
  └── log/        # Build logs
```

$ echo "source ~/ rokey3_A2_ws/install/setup.bash" >> ~/.bashrc #check path

$ source ~/.bashrc

ROS HINTS

- 2_0_a_image_publisher.py
- 2_0_b_image_subscriber.py
- 2_0_c_data_publisher.py
- 2_0_d_data_subscriber.py

ROS HINTS

- Edit setup.py under<pakage_name> directory add entry for each node

entry_points={ 'console_scripts': ['<command_name> = <package_name>.<code_filename>:main',},

<command_name> is used when ros2 run is executed i.e. data_publisher

```
tests_require=['pytest'],
entry_points={
    'console_scripts': [
        'pub_image = day2.2_0_a_image_publisher:main',
        'show_image = day2.2_0_b_image_subscriber:main',
        'pub_data = day2.2_0_c_data_publisher:main',
        'show_data = day2.2_0_d_data_subscriber:main',
```

ROS HINTS

$ cd ~/rokey3_A2_ws

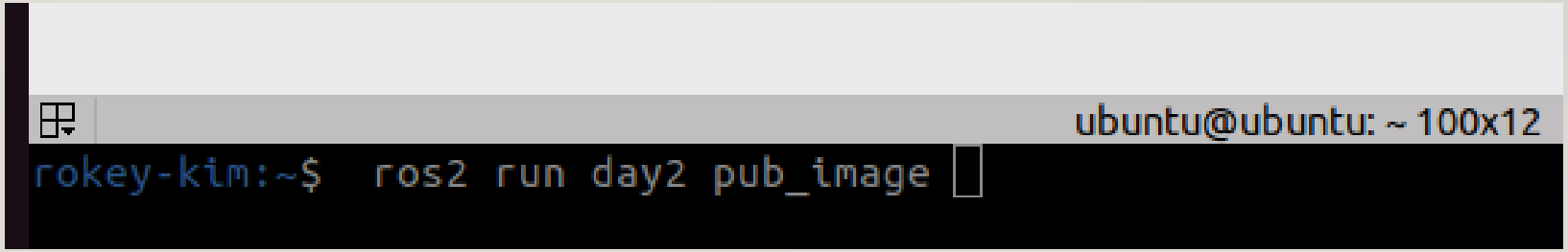
$ colcon build

$ source ~/rokey1_A2_ws/install/setup.bash

$ ros2 run <package_name> <command_name>

$ sudo apt update

$ sudo apt install terminator



ROS HINTS

- 2_0_a_image_publisher.py
- 2_0_b_image_subscriber.py
- 2_0_c_data_publisher.py
- 2_0_d_data_subscriber.py

$ ros2 run rqt_graph rqt_graph

$ ros2 node list

$ ros2 node info <node_name>

$ ros2 topic list

$ ros2 topic info <topic_name>

$ ros2 topic echo /chatter

$ ros2 interface list

$ ros2 interface show <package_name>/msg/<MessageName>

KEY SUBSYSTEM (MODULES) TO DEVELOP

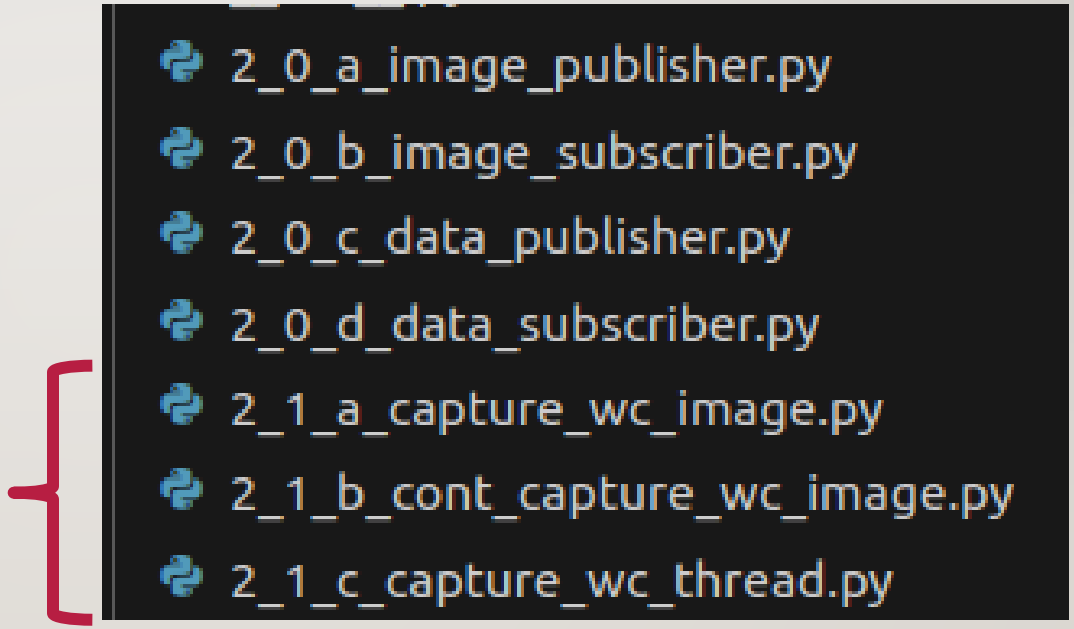
- Detection Alert
  - Camera Capture
  - Object Detection
  - Send messages to other subsystems

- AMR Controller
  - Receive messages and act accordingly
  - Move using (SLAM) with Obstruction avoidance
  - Target Acquisition (Obj. Det.) and Tracking
  - Follow target using camera and motor control

PERFORM DATA COLLECTION FOR DETECTION ALERT

COLLECTION IMAGES FROM WEBCAM

- Image Capture (WEBCAM)



COLLECTION IMAGES FROM AMR CAMERA

AMR INTRODUCTION

- User Manual ·Turtlebot4 User Manual
- https://turtlebot.github.io/turtlebot4-user-manual/


Mounting Plate*
Camera
LiDAR
OLED Display*
Charging Dock
Accessible Power & USB Ports*

UNDOCK/DOCK AMR

UNDOCK

$ ros2 topic list

Check the list

$ ros2 action send_goal /robot<n>/undock irobot_create_msgs/action/Undock "{}"

DOCK

$ ros2 topic list

Check the list

$ ros2 action send_goal /robot<n>/dock irobot_create_msgs/action/Dock "{}"

WHICH IMAGE TOPIC TO USE?

- /oakd/rgb/preview/image_raw
- /oakd/rgb/image_raw
- /oakd/rgb/image_raw/compressed
- /oakd/stereo/image_raw
- …

- *** not all of the topics are visible

- EXERCISE
  - Create a script to display and compare

HOW TO MOVE FILE FROM PC MOVE MAP TO AMR

PC TERMINAL

Connect to turtlebot via ssh first

$ scp <dir_path>/<file_name> ubuntu@<rokey IP>:/home/ubuntu

- $ EX: scp oakd_pro.yaml ubuntu@172.30.1.1:/home/ubuntu/

AMR TERMINAL

$ cd ~ #go to home

$ ls oakd_pro.yaml #check if the file transferred correctly

$ sudo mv oakd_pro.yaml /opt/ros/humble/share/turtlebot4_bringup/config/

$ ls /opt/ros/humble/share/turtlebot4_bringup/config/

UPDATING THE OAKD CONFIG (ROBOT)

ON TURTLEBOT4:

$ cd /opt/ros/humble/share/turtlebot4_bringup/config

$ sudo cp oakd_pro.yaml oakd_pro_orig.yaml

$ sudo cp oakd_pro_new.yaml oakd_pro.yaml

$ sudo reboot

```yaml
/oakd:
  ros__parameters:
    use_sim_time: false

    camera:
      i_enable_imu: false
      i_enable_ir: false
      i_floodlight_brightness: 0
      i_laser_dot_brightness: 100
      i_nn_type: none
      i_pipeline_type: RGBD          # RGB + Depth
      i_usb_speed: SUPER_PLUS

    rgb:
      i_board_socket_id: 0
      i_width: 640
      i_height: 480
      i_fps: 30.0
      i_enable_preview: true
      i_interleaved: false
      i_low_bandwidth: true
      i_publish_topic: true
      i_resolution: 480P          # sets 640x480 internally


    stereo:  # ✅ Required to enable depth
      i_board_socket_id: 1
```

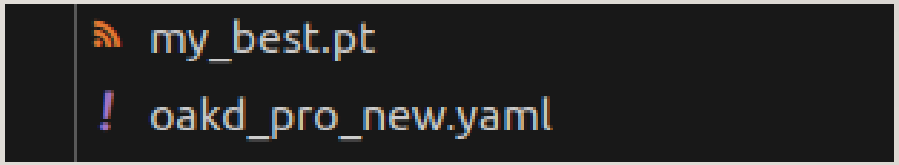
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

UPDATING THE OAKD CONFIG (ROBOT)

ON TURTLEBOT4:

- $ cd /opt/ros/humble/share/turtlebot4_bringup/config
- $ sudo cp oakd_pro.yaml oakd_pro_orig.yaml
- $ sudo cp oakd_pro_new.yaml oakd_pro.yaml
- $ sudo reboot

- $ sudo systemctl status turtlebot4.service
- $ sudo systemctl restart turtlebot4.service
- $ ros2 topic list



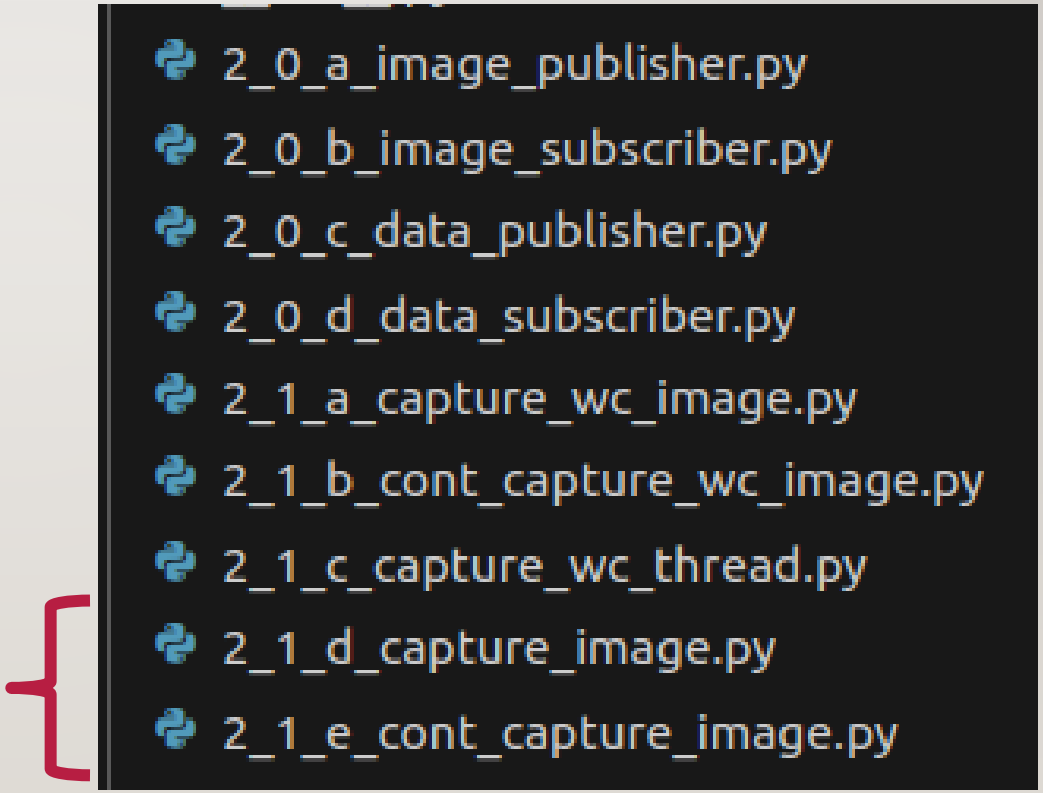
DIMENSIONS AND RESOLUTION

Supported `i_resolution` values (RGB):

Resolution Keyword	Width × Height	Notes
`1080P`	1920 × 1080	Default, high-res
`720P`	1280 × 720	Medium-res
`800P`	1280 × 800	Slightly taller
`480P`	640 × 480	✅ Ideal for alignment with stereo
`400P`	640 × 400	Wide, cropped top/bottom
`320P`	640 × 360	Lower-res
`240P`	320 × 240	Very low-res, fast

CODING HINTS

- Image Capture (AMR)



CODING HINTS

- Image Capture

```
2_1_a_capture_wc_image.py
2_1_b_cont_capture_wc_image.py
2_1_c_capture_wc_thread.py
2_1_d_capture_image.py
2_1_e_cont_capture_image.py
```

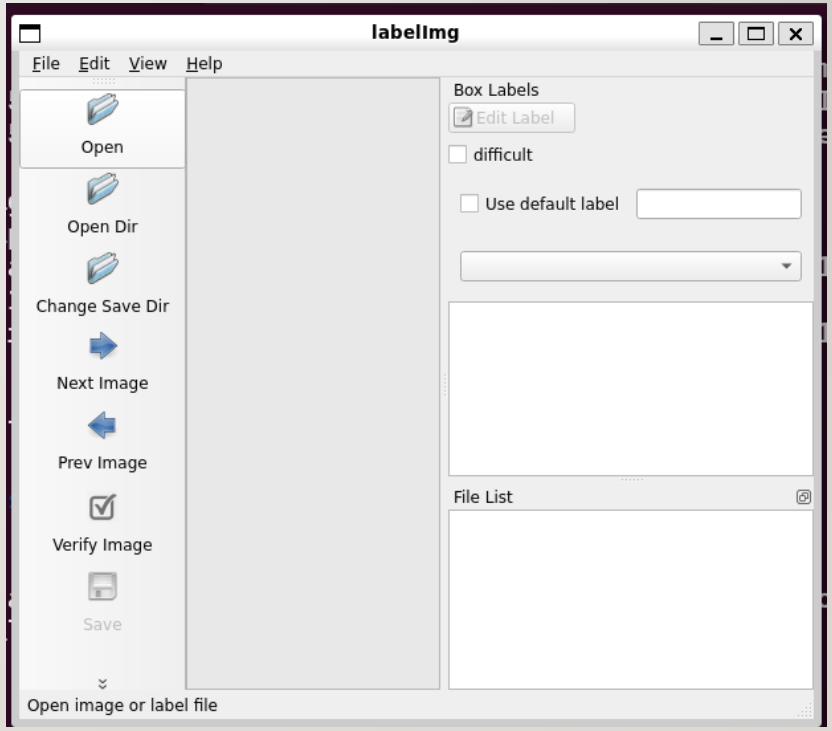
- Data Labelling
  - labellmg

CODING HINTS

- Data Labelling : use previously installed LabelImg

- Or

- pip3 install labelImg
  - May also need "pip3 install PyQt5 lxml"
- labelImg



CODING HINTS

- Data Labelling : LabelImg

라벨링 순서

1. 이미지파일 불러오기 (Open Dir)
2. 저장형식 변경 (PascalVOC, YOLO)
3. 이미지 선택
4. 바운딩 박스 그리기(create rectbox)
5. Class 지정
6. 저장경로 생성 및 변경(Change Save Dir)
7. 저장(Save)

단축키

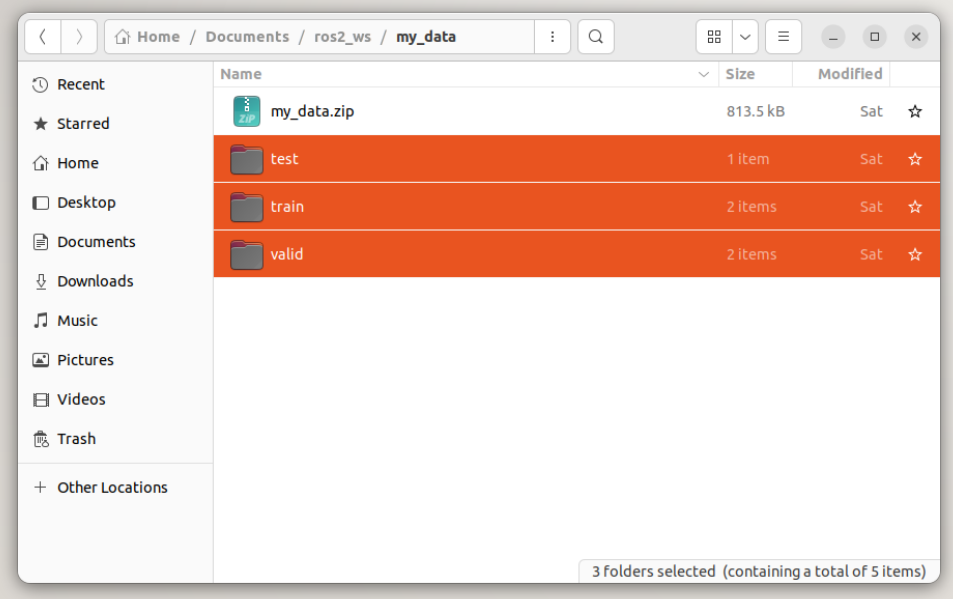
Ctrl + u	Load all of the images from a directory
Ctrl + r	Change the default annotation target dir
Ctrl + s	Save
Ctrl + d	Copy the current label and rect box
Ctrl + Shift + d	Delete the current image
Space	Flag the current image as verified
w	Create a rect box
d	Next image
a	Previous image
del	Delete the selected rect box
Ctrl++	Zoom in
Ctrl--	Zoom out
↑→↓←	Keyboard arrows to move selected rect box

CODING HINTS

- Image Capture
- Data Labelling
- Data Preprocessing

2_1_a_capture_wc_image.py
2_1_b_cont_capture_wc_image.py
2_1_c_capture_wc_thread.py
2_1_d_capture_image.py
2_1_e_cont_capture_image.py
2_3_a_create_data_dirs.py
2_3_b_move_image.py
2_3_c_move_labels.py

ZIP TRAIN DATA SET

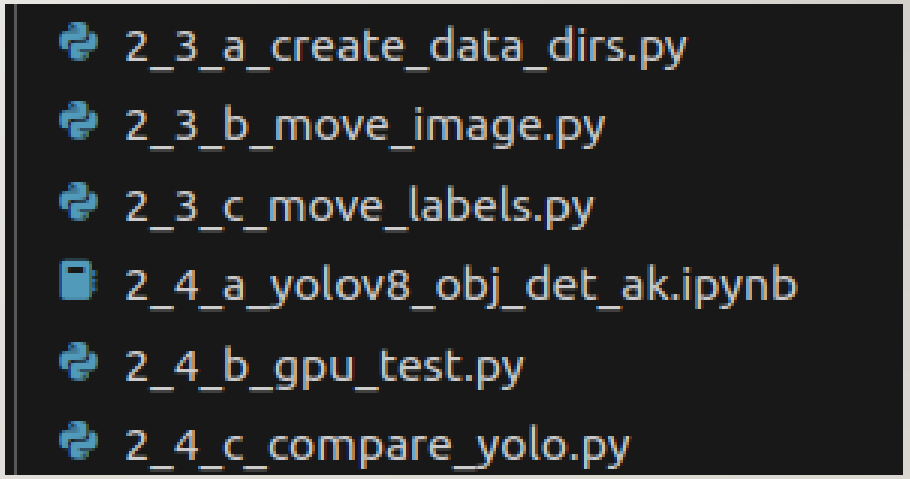


PERFORM YOLO TRAINING & INFERENCE

CODING HINTS

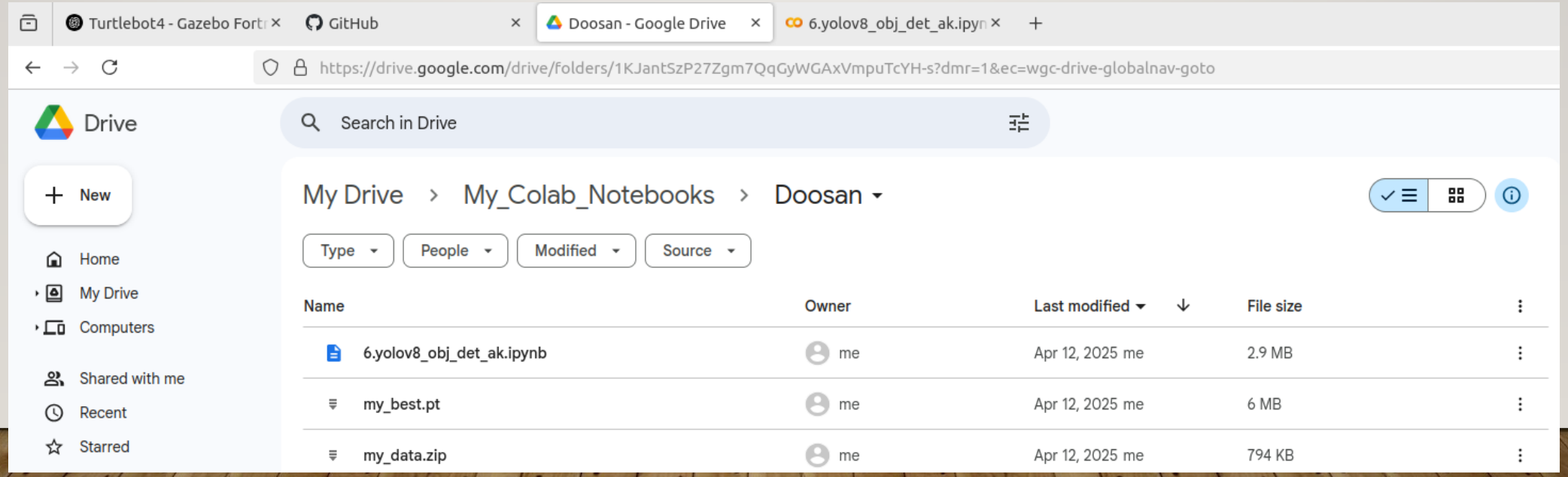
- Image Capture
- Data Labelling
- Preprocessing

- Yolo8 Object Det (Training)



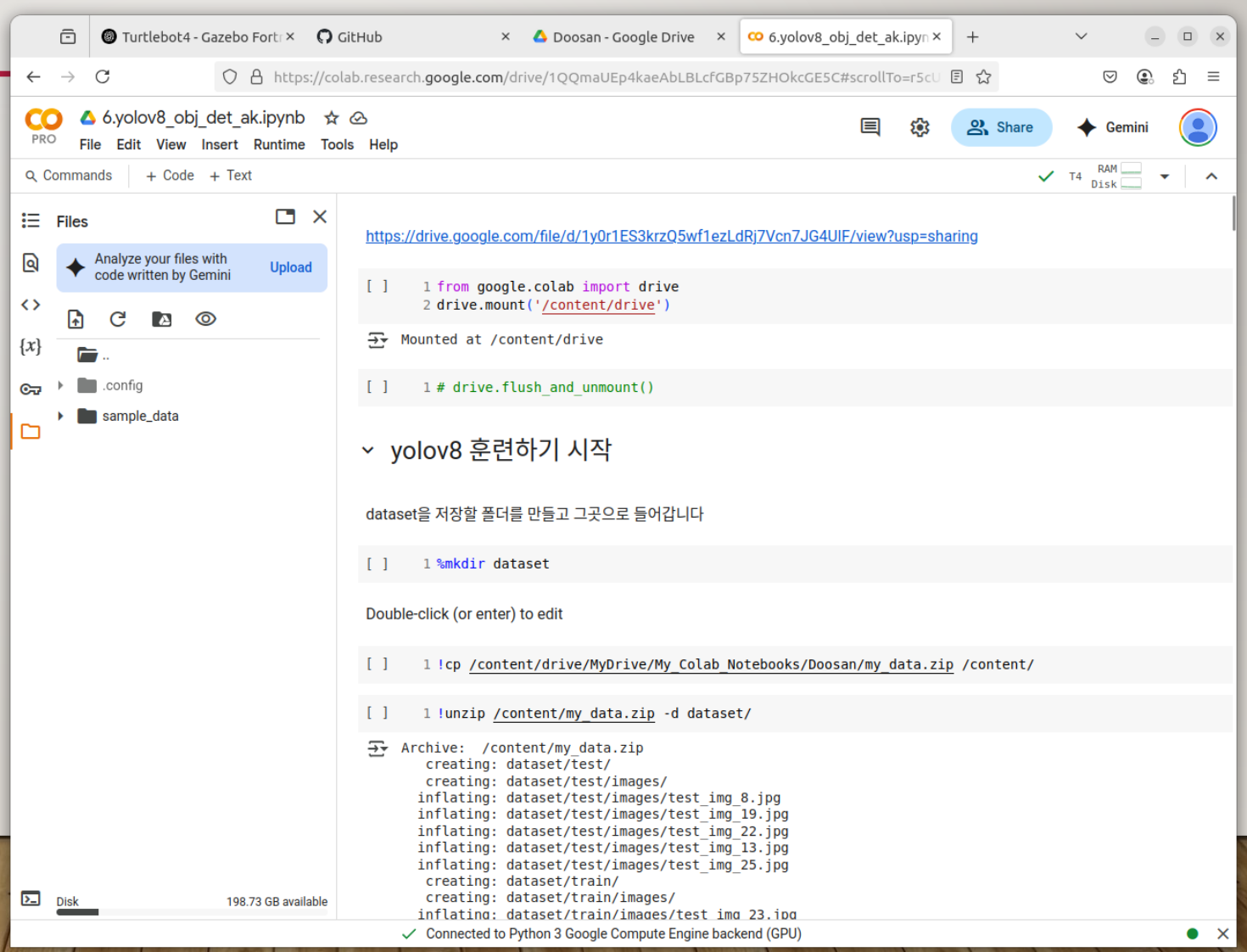
USING GOOGLE COLLAB. TO CREATE CUSTOM MODEL

- Move the files to google drive
  - my_data.zip
  - yolov8.obj.det.ak.ipynb



USING GOOGLE COLLAB. TO CREATE CUSTOM MODEL

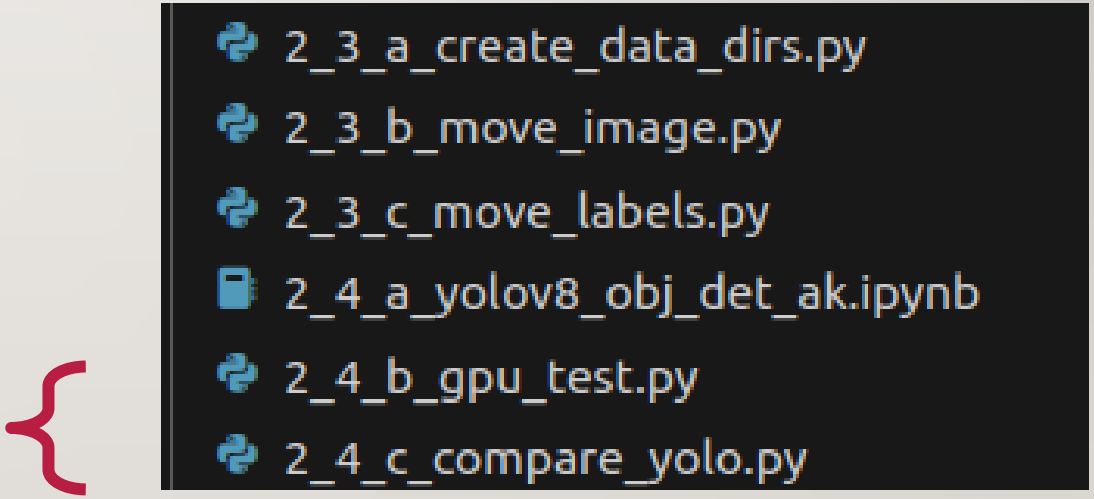
- Move the training script to google collab. and execute line by line



CODING HINTS

- Image Capture
- Data Labelling
- Preprocessing

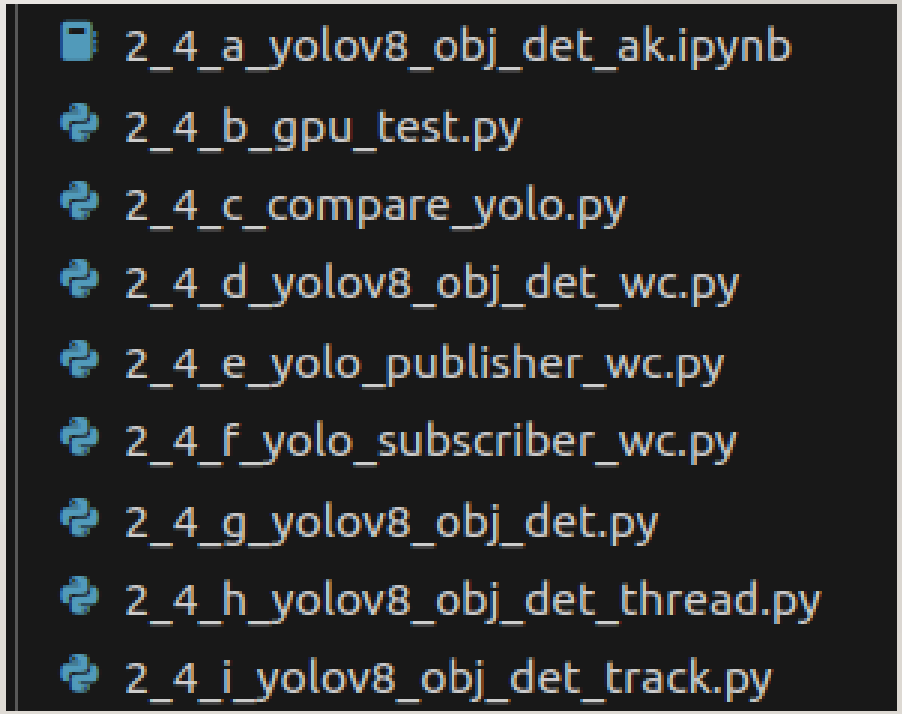
- Yolo8 Object Det (Model)



CODING HINTS

- Image Capture
- Data Labelling
- Preprocessing

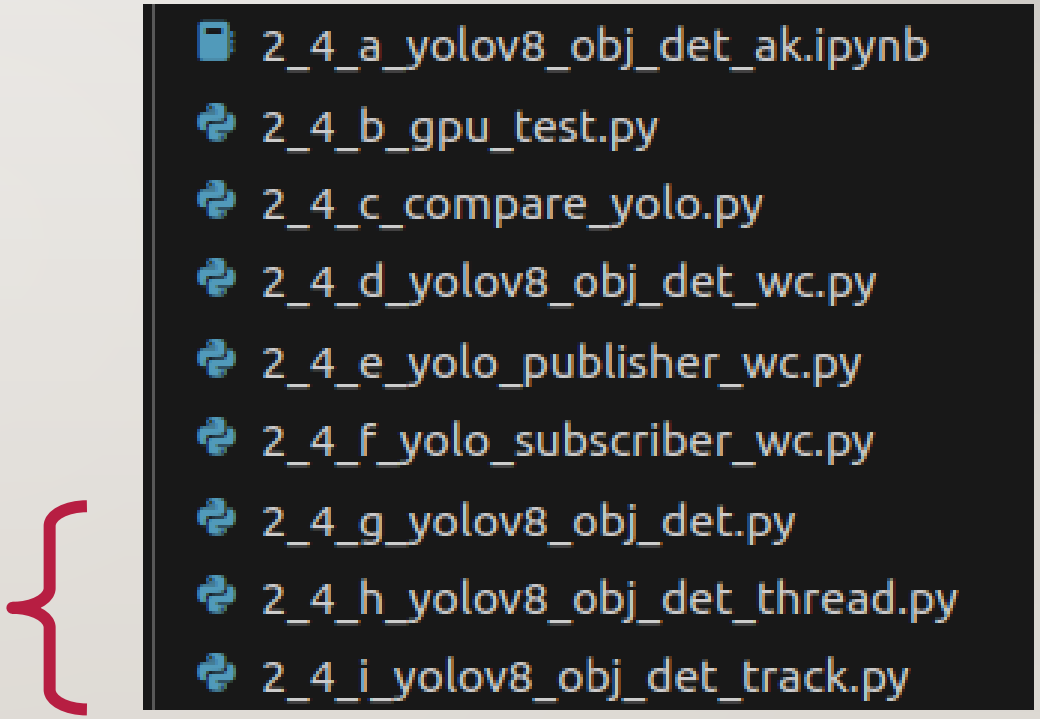
- Yolo8 Object Det (WEBCAM)



CODING HINTS

- Image Capture
- Data Labelling
- Preprocessing

- Yolo8 Object Det (AMR)



프로젝트 RULE NUMBER ONE!!!

Are we still having FUN!