CV PRO

Meritus

CV Pro – AI Kit to build your own Self-Driving Car

CV Pro - The AI kit for Autonomous Navigation

CV Pro
AI Kit - Autonomous Navigation

CV Pro AI Kit - Self Driving

- The CV Pro AI kit will collect data while traveling on a physical track, similar to tracking a person.
- The collected data can be utilized to develop a deep learning model and then deploy it.
- This can be achieved by guiding the CV Pro kit to move along a track resembling the one depicted in figure (1). Data collection is essential to enable its autonomous navigation.

Figure 1

CV Pro AI Kit - Autonomous Navigation

- As we progress with the CV Pro kit, we've achieved assembly, software setup, and object detection in a controlled environment, paving the way for our exciting next step: **Autonomous Navigation**.

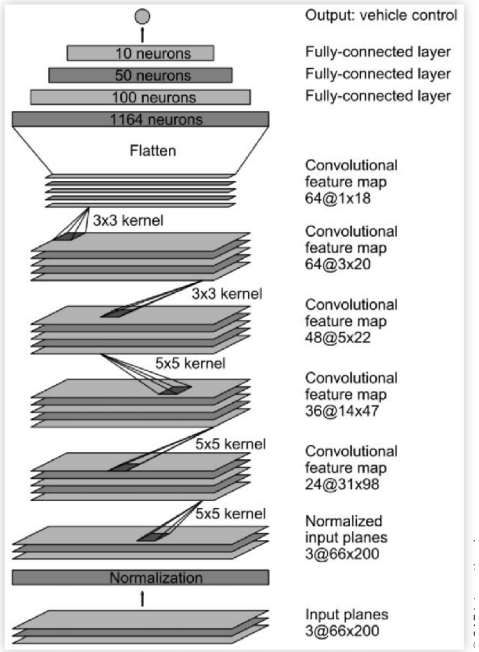
- In the forthcoming phase, we'll focus on the key steps like **Data Collection**, **Training Process,** and **Deploy the Model** using the CV Pro kit. These are vital for making the CV Pro kit drive itself and adapt smartly.

- By mastering these processes, we unlock the kit's potential and pave the way for a more advanced autonomous system. A brief description of the process are provided in the next subsequent slides.

CV Pro - Stages in Autonomous Navigation

- **Data Collection:** In the initial stage of this process, we gather a diverse and inclusive dataset that includes images and videos from various sources and scenarios. This data will serve as the raw material for our AI model, enabling it to acquire knowledge and adapt to a wide array of real-world situations.

- **Training Process:** The heart of our AI's development lies in the training process. Deep learning techniques and neural networks will be employed to teach our AI kit how to autonomously recognize objects. We have generated the model using the PilotNet architecture.



- **Deploying the Model:** Our final objective is to integrate the trained model into the CV Pro kit's software and hardware. This crucial step enables the kit to use its intelligence for autonomous navigation along predefined tracks. It signifies the culmination of our efforts, where our kit transforms into a self-navigating, adaptable system.

Through these processes, we are not only unlocking the full potential of the CV Pro kit but also paving the way for intelligent, autonomous navigation that can adapt to and navigate through diverse real-world scenarios.

CV Pro - Placing Phone Mount
&
Phone

Placing Phone Mount & Phone

- During the data collection process, it's important to note a slight variation in the construction setup. Specifically, concerning the placement of the phone and the sensor. Please adhere to the following instructions provided earlier, in the 'Construction manual' to reconstruct the CV Pro kit for data collection purpose. The completed construction will resemble the depiction provided in figure (2).

Figure 2

Ensure that the CV pro kit has been connected, with the computer and smartphone. If not, follow the steps given below to re-connect:

❖ Turn off / disable the **Firewall Setting** (Both **Public & Private**).

❖ Connect the CV Pro kit to your computer through **'Wifi'.**

❖ Check if the environment is activated. If it is inactive, activate the environment, by following the steps given:

- Enter the command '**my_conda**' in the working terminal.
- From the sub-options displayed enter '**activate**' or '**build'**, based on your requirement.

❖ Initiating the Mosquitto broker instance (starting the server), using the command '**launch_server** ', in the working terminal.

❖ Connect the CV Pro kit to your phone device through **'Wifi'**

❖ Launch the CV Pro application in your phone device.

❖ Access the server connection settings and configure the device with connection details

IP address: 192.168.4.2

Name to connect: cvpro

Once the details have been entered, click on **connect** to establish the connection.

❖ Ensure the order of connection

- CV Pro to Computer
- CV Pro to Mobile

Do not change the order

CV Pro - Data Collection

- After the installation of the required dependencies is complete, we shall now proceed with the ‘Data collection process’.

- Enter the command '**run_cvpro**’, in the working terminal. Upon execution, you'll encounter the following options:

- '**control**' for running the kit to collect data around the track.
- '**videostream**' to enable live video streaming from the smartphone camera (on CV Pro kit) to the laptop.

Step1: Data Collection Process:

- Enter the first option, '**control**'.
- Check if your bot is connected with the application, if connected, enter '**y**'. Refer to figure (3).
- Ensure to enter a valid range within the given speed limit. Otherwise, you will receive error message, as shown below in the figure (4).

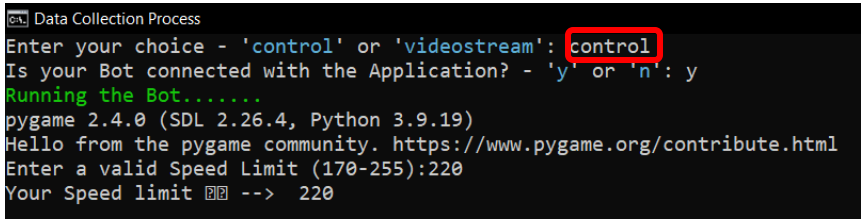


Figure 3

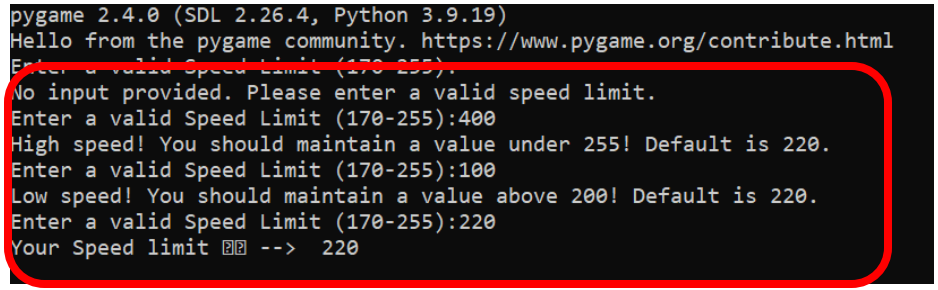


Figure 4

- The following window, (figure 5) will be displayed once you have started the process.

Figure 5

Step 2: Controlling Keys using Pygame Window

- Once data collection commences, the **"CVPro Keyboard Controller"** window will promptly display on your computer screen as shown in figure (6). You will have the capability to manage your AI kit exclusively using your computer keboard keys. Utilize them to guide the kit along the track and gather data.

- To ensure **high-quality data collection**, strive to complete a **minimum of 10 laps** in each direction, both clockwise and counterclockwise.

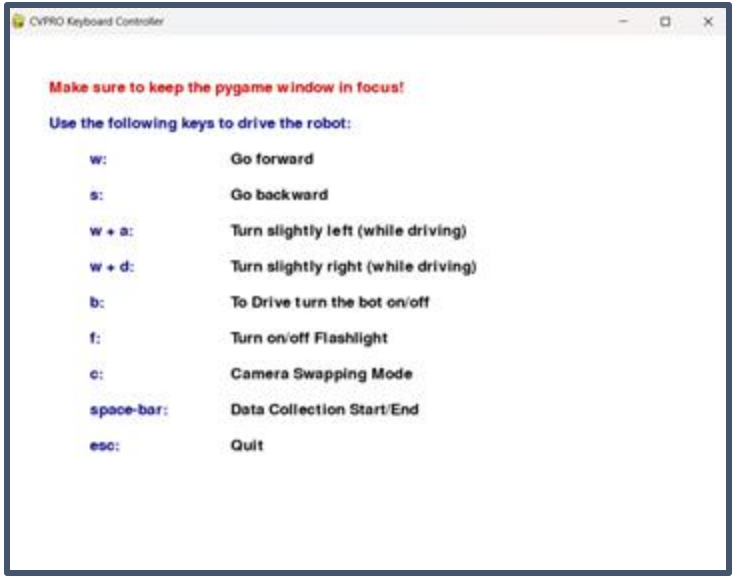


Figure 6

- Enter the option, '**videostream**'. (to visualize video streaming in laptop)
- Check if your bot is connected with the application, if connected, enter '**y**'. Refer to figure (7a).
- Ensure to enter a valid range within the given limit. Otherwise, you will receive error message, as shown below in the figure (7b).

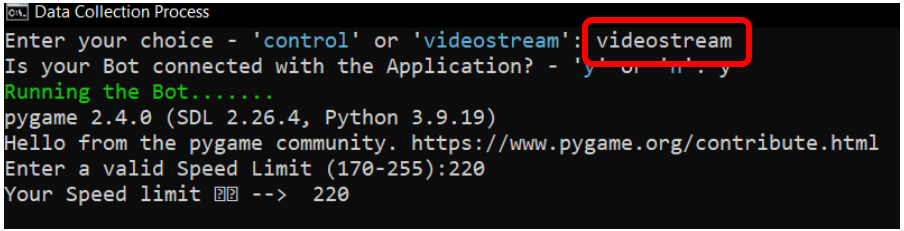


Figure 7a

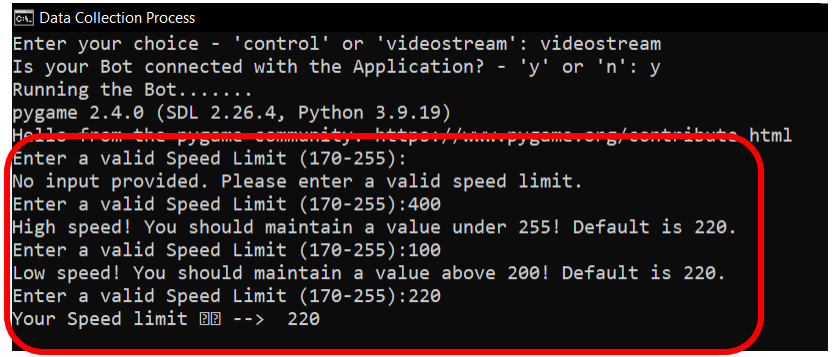


Figure 7b

❖ Upon initiating data collection using the **'videostream'** option, you will see the following window. Pygame window will be visible alongside the video stream being transmitted from the mobile device. You may refer to figure (8) for clarity.

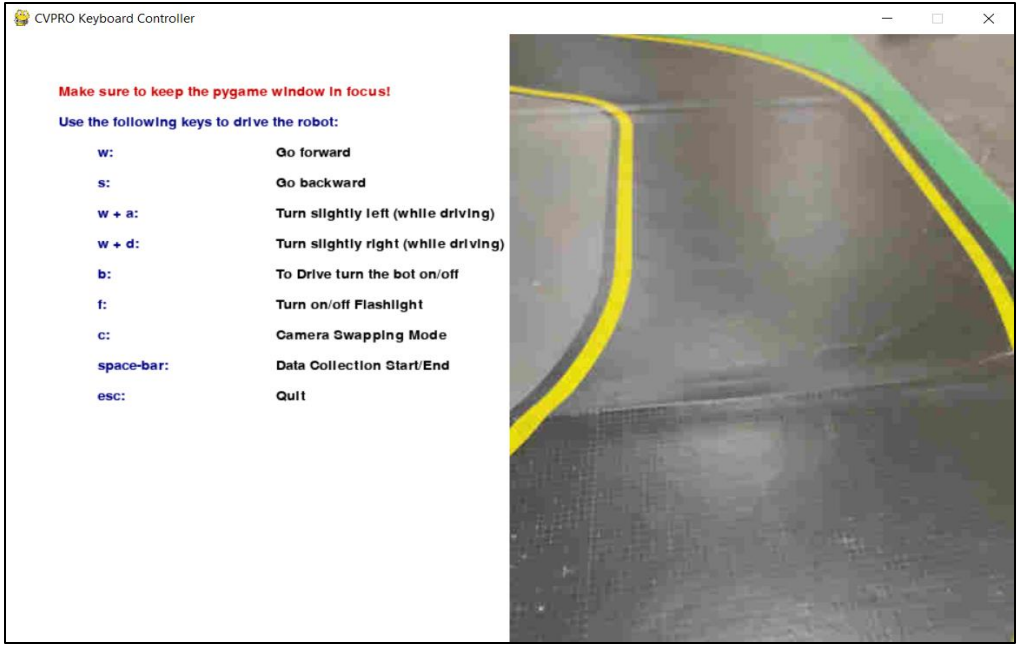


Figure 8

Step 3: Preparing the Smartphone

- Position the bot with the smartphone's rear camera facing the track, as shown in figure (9(a)).
- Ensure the smartphone displays the track image.
- Tap on “Collect Data” (refer figure 9(b)) and click on the 'navigation' arrow (refer to figure (9(c)).

Figure 9(a)

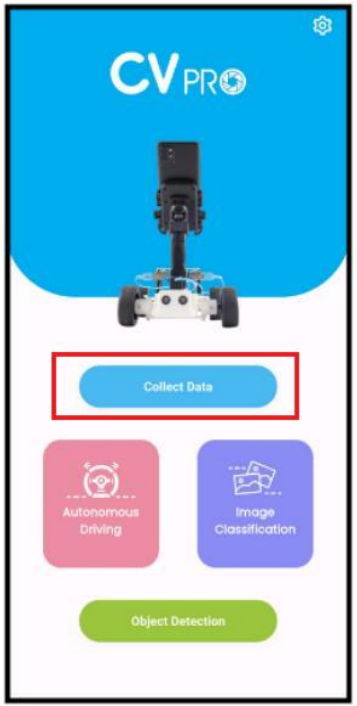


Figure 9(b)

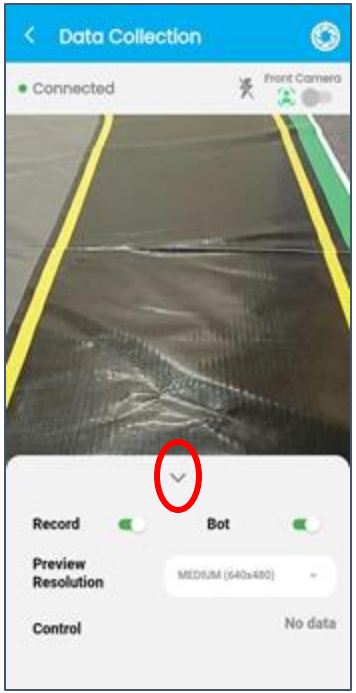
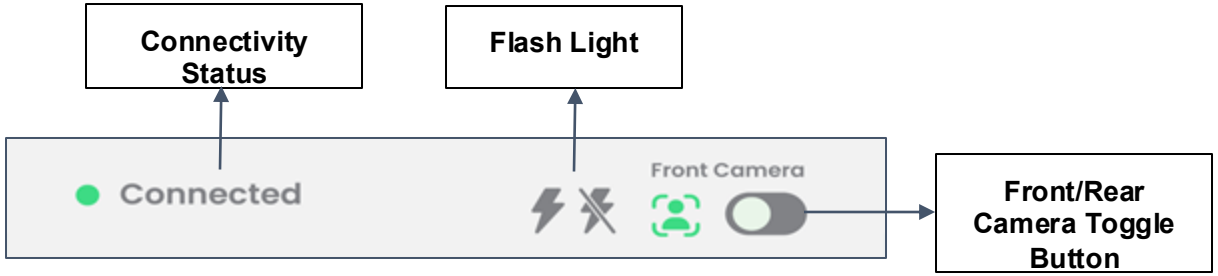


Figure 9(c)

Step 4: Verifying the Connection Status

- Check the connection status on the Data Collection Screen. If not connected, follow the steps given in slides that explain 'Establishing Connection between CV Pro kit and smartphone'.



Step 5: Recording Data:

- Initiate recording by pressing the '**Spacebar**' on your computer **keyboard** or tapping the '**Record**' button on your phone.
- Capture values by tapping '**B**' on the keyboard or activating the '**Bot**' button in the app.
- Select your desired image resolution from the '**preview resolution**' menu. Refer to figure (10).
- Ensure the kit completes a minimum of 10 laps, clockwise and anti-clockwise around the track to gather ample and high-quality data.
- Pause between cycles by toggling the '**Record**' and '**Bot**' options after each lap to save the recorded data. Refer to figure (11).

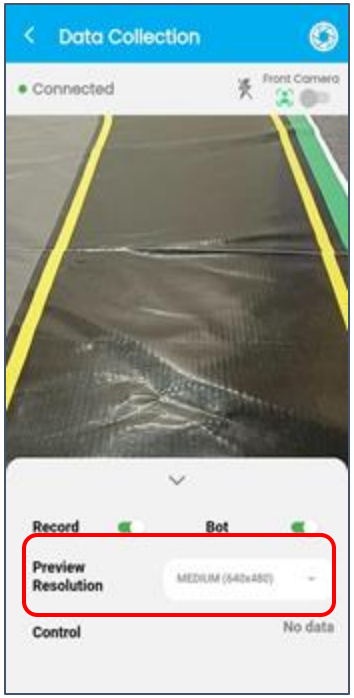


Figure 10

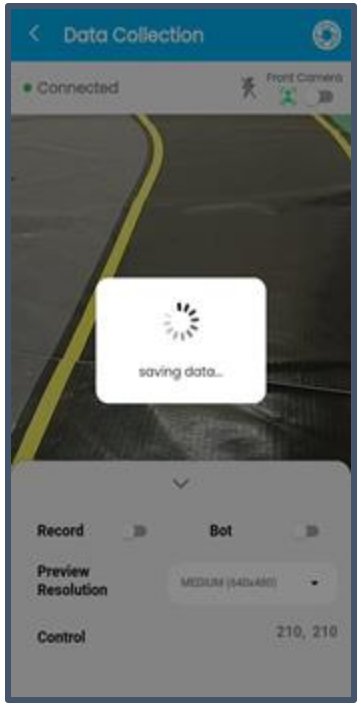


Figure 11

Step 6: Data Storage

- When you have completed collecting data, you can retrieve the data in zip format by clicking the arrow key located in the top left corner. Refer to figure (12).
- Locate the **'cvpro**' folder, saved in '**Documents**' folder on your smartphone for Android phones and in Apple phones, will be stored directly.
- Within **'cvpro**', search for a subfolder resembling a compressed zip file, indicating the date and time of data collection.
- Look within the identified subfolder for **'Videos**' (folder) containing collected video files and **'Files**' (folder) '.csv' files containing timestamp data.
- If no relevant folders are found, repeat the process to collect additional data.

There is no restriction on the number of times you can collect data to improve model creation.

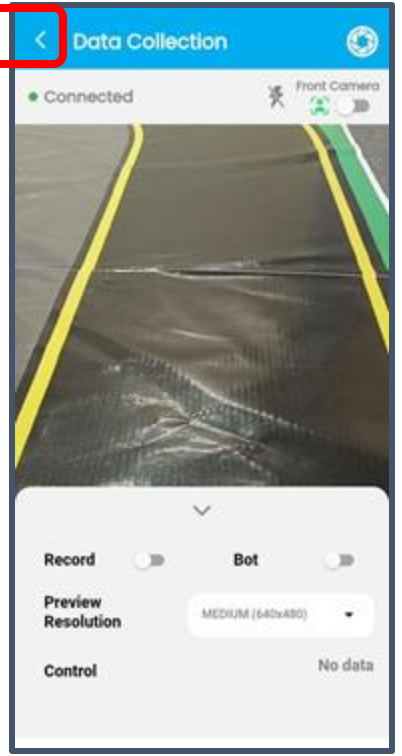


Figure 12

Step 7 : Closing the Connection

- Log off from the connection.
- Close the '***CVPro Application***' on your smartphone.
- Disconnect the devices by closing the server connection on the computer or clicking **'X**' button in the Command Prompt/Terminal or pressing '**Esc**' key in your **keyboard**.
- *Power-off the CV Pro kit to save power.*

Step 8 : Data Transfer

- After successful data collection, Copy & Paste the zip file onto your computer for training purposes which will be dealt in the lesson, '***Training Process***'.
- Extract the copied zip file into your computer and also paste it in the path,

  '\Training_Process\Training_Data\Dataset_CVPro\Autonomous_Driving'

With this, we have successfully collected data and transferred it to the computer, which is required for training purpose and generating a model based on the collected data.

Moving forward, we shall train and generate a model for the autonomous navigation of the CV Pro kit.

If any clarification is required on the process we have done so far, refer to the video given in the ensuing slides.

CV Pro - Training Process

Step 1: Copy & Paste Datasets in Specified Path

- To embark on the model training process, let's get started.
- Begin by copying the extracted files from smartphone to your computer.
- Now, paste all the extracted files into the specified directory path: '**%UserProfile%\Meritus-CVPRO-Windows\Meritus-CVPRO-main\Training_Process\Training_Data\Dataset_CVPro\Autonomous_Driving**'
- As you organize your data, the folder structure will resemble the image given in figure (13).
- Assume that the extracted file is named '20230920_110330.zip.'

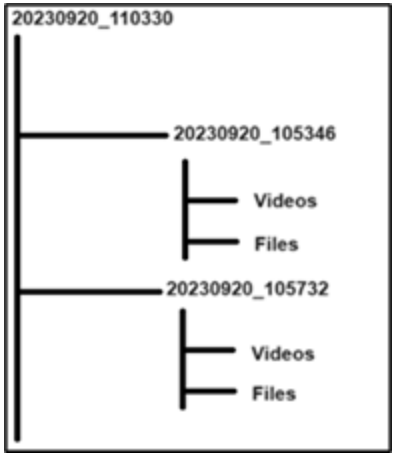


Figure 13

Please remember not to paste the compressed files directly; ensure that you extract them first.

- Begin the training process by entering command, '**train_cvpro**', in the working terminal. Check if your bot is disconnected with the application, if disconnected, enter '**y**'. Refer to figure (14).
- You will be prompted with options to enter the batch size, epoch value and learning rate. You can tap '**Enter**' on your keyboard, to select the default values or manually type the values from the options displayed. Refer to figure (15).

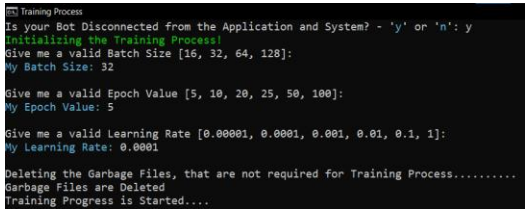


Figure 14

Training process with default values

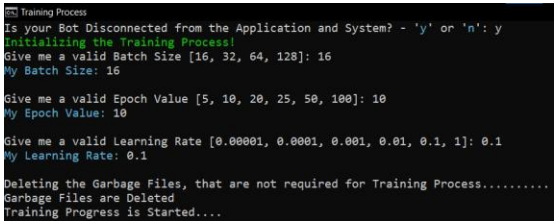


Figure 15

Training process with values entered by user

- The command, **'train_cvpro'** initiates the training process to create the deep learning model. The duration varies depending on the Operating System:

  - Windows CPU – Approximately 30 minutes.
  - MacOS and Linux OS – Takes about 20 to 30 minutes.

- During the training process, few graphs corresponding to 'OpenCV', 'Label encoder', 'Validation graph', and 'Confusion matrix' will be displayed. Close all the graph windows as and when it opens.

- If you feel the quality of the model is not satsifactory, you can modify the batch size, epochs, and learning rate, by selecting any one of the options given in the command menu.

Step 3: Generating TFLITE files:

- Once the model has been successfully created, you'll find the following files: '**best.tflite**,' '**last.tflite**,' and '**label.txt**.'
- These files will be located in the folder: '...**\Training_Process\Training_Data\Save_model**,' as depicted in figure (16).

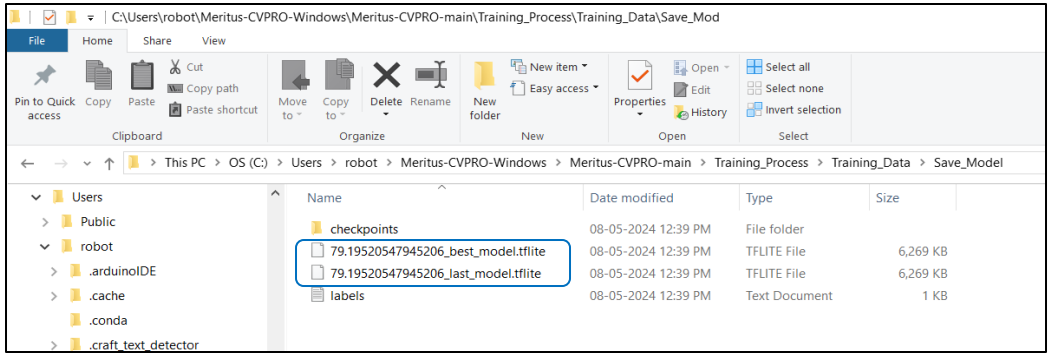


Figure 16

Step 4: Data Transfer (TFLite Files) to Smartphone

- To access these **'best.tflite,' 'last.tflite,'** and **'label.txt** files on your smartphone, copy them from your computer.

- Paste these files into a convenient and easily accessible location on your smartphone for future use. You may create a folder in your smartphone and paste them for easy access.

CV Pro - Deploying the Model

To create a robust deep learning model, it's vital to ensure the collected data meets quality and quantity standards. If the data collected does not meet the quality and quantity, repeat the data collection process. This can be identified if the kit is not navigating properly around the track.

- Launch the CV Pro app and access 'Model Management' via the 'Settings' button. Refer to figure (17).

- Tap 'Upload file' to open your phone's File Manager interface. Locate 'filename.TFLITE' and 'filename.txt' in your device's storage. Refer to figure (18).

- On the 'Model Details' screen, which follows, you'll see fields for 'Model Name,' 'Model Type,' and 'Text File (Labels),' along with an attached clip icon.

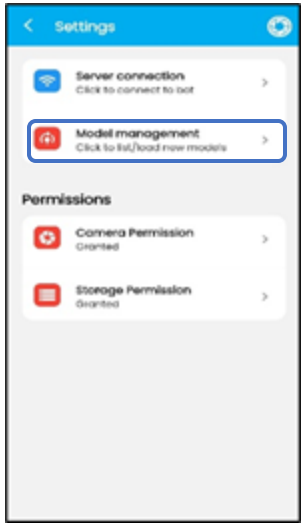


Figure 17

Figure 18

- Select the model's name in the 'Model Name' field. From the 'Model Type' dropdown, select the desired category. To upload the text file, click the clip icon

- Finally, click the 'Submit' to upload the data files. Refer to figure (19).

- After successful upload, you'll find the '.TFLite' model displayed in the 'Model Management' menu of the CV Pro app. Refer to figure (20).

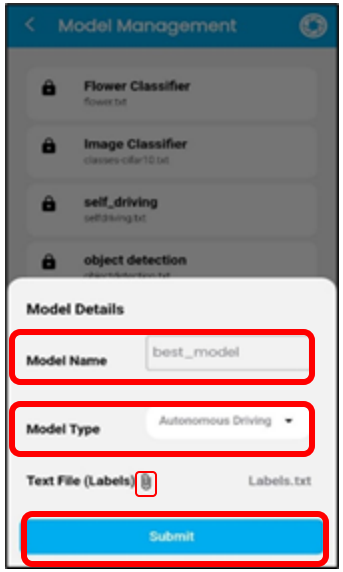


Figure 19

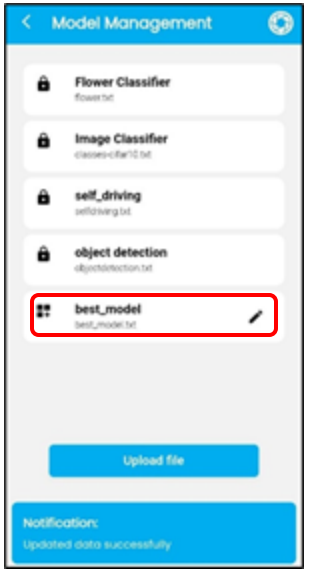


Figure 20

To confirm the successful addition of the file, please check its presence in the 'Model Management' section of the CV Pro app. If you do not see the file, repeat the steps to ensure the model has been added correctly.

Autonomous Navigation

Ensure the connection between the server and CV Pro kit is active. Verify the connection status on your phone. If it's not established, follow the connection setup steps, as follows:

1. Establish connection between CV Pro kit, computer and phone.
2. Start the MQTT broker instance.
3. Upload the model into CV Pro application.
4. Enable autonomous driving mode.

Initiating Autonomous Driving

- Open the CV Pro app and navigate to the **'Home'** screen.
- Tap the **'Autonomous driving'** button, as shown in figure (21).

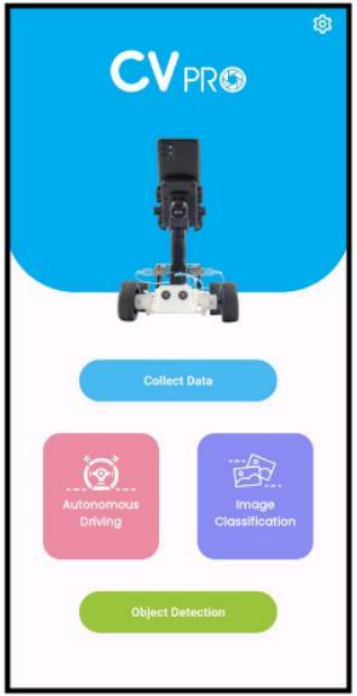


Figure 21

- After establishing the connection, tap the navigation menu at the bottom of the screen to reveal a panel. This panel includes buttons for 'Auto' and 'Self-Driving,' as well as a 'Model' menu item. Choose the model you previously uploaded from the menu. Refer to figure (22).

- Activate the '**Auto**' and '**Self-Driving**' buttons to commence the kit's movement around the track.

Figure 22


Thank you!