2024/2025 SEMESTER ONE (MINI-PROJECT)
Diploma in Computer Engineering
3rd Year FT (DCPE)
5G&AIOT

Group Number:

Group Members and Adm.No: Example (PXXXXXX)

SAS code:
LAB3 35%

Duration: 4 weeks

Objectives

- Create a 5G Facial Recognition Door Access System based on requirements.
- Capture a live stream from a pi-camera over the 5G network in real-time.
- Implement AI at the MEC(Laptop) to do face recognition on the live stream over 5G.
- Light up LED at the transmitting side when a face is successfully recognized at MEC.
- Recommend features/improvements to the system and present everything in presentation slides using the CDIO framework.
- Present a 3-minutes long presentation on more 5G & AIoT applications.

Project Schedule

Week 13	–	Set up a 5G cellular network connection between 2 5G RPI CPEs.
Week 14	–	Stream a pi camera and capture its RTSP/HTTP stream over 5G.
Week 15	–	Use CodeProject.AI server to do face recognition on the livestream and light up an LED when a face is recognized.
Week 16	–	Continue with Mini-Project if not done.
Week 17 & 18	–	Project Assessment (35%)
Week 13-16	–	Documentation and presentation slides

Sheep Facial Recognition Example

In Australia, NeXtgen Agri, an innovative agricultural technology company from New Zealand, is testing their cutting-edge sheep facial recognition technology on sheep for lamb matching. The reason is because farmers have a hard time identifying which ewes (female sheep) are producing the best and most lambs among the tens of thousands of sheep. The company uses a combination of a camera, a computer, and neural networks to make the lamb matching process easier for farmers. Their face recognition technology involves a camera using proximity data, which will then autonomously figure out which sheep are related to each other [1]. This example shows how AI can enhance the sustainability of sheep farming operations. However, our mini project is not going to just use AI only but 5G and AIoT to create applications.

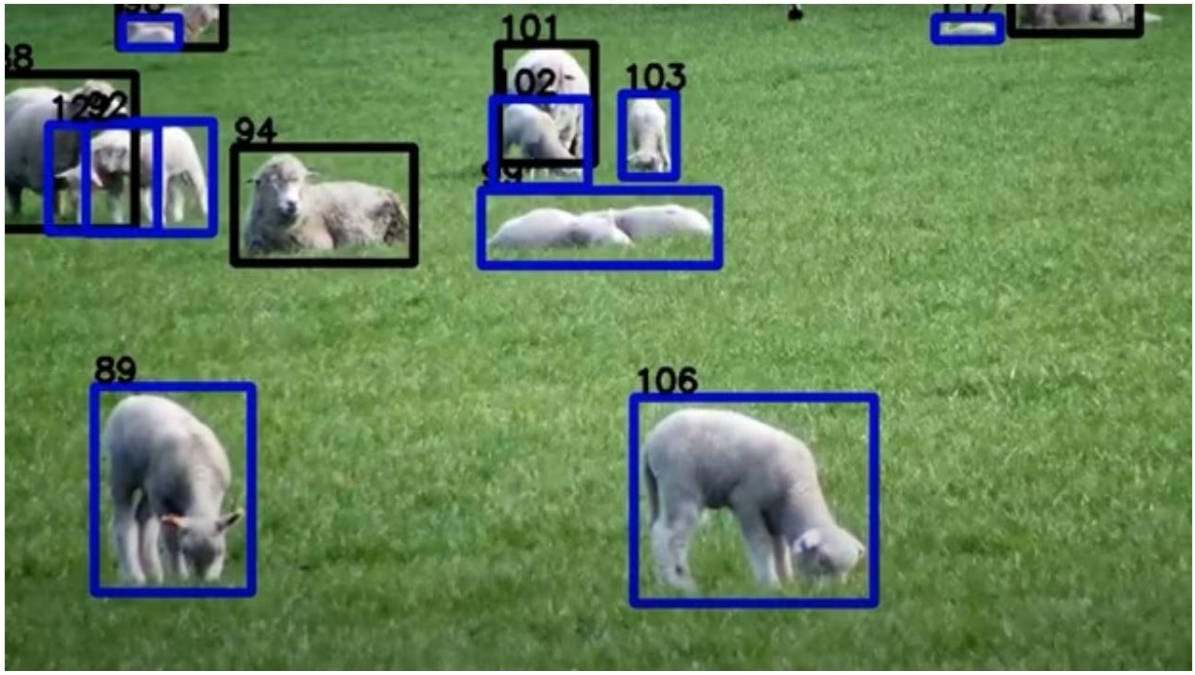


Figure 1:The camera identifies individual sheep based on data it has captured [2]

Mini Project Requirements

The mini project's focus is on **Sustainable Development Goal 9** which is "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" [3]. One example is Smart Buildings. Smart buildings help to improve the quality of life for people in the building and surrounding community. They also reduce waste through better energy management and improved occupant comfort, which can lead to increased productivity at work or school [4]. Facial Recognition can be used in a smart building to enhance security, making residents feel much safer in their homes. By leveraging 5G's high-speed data transfer, low latency, edge computing capabilities, reliability, and scalability, facial recognition door access system can provide seamless access control and enhanced security for residents in a smart building.

The diagram below shows a 5G Facial Recognition Door Access System high-level diagram. 24-hours livestreams captured by all the cameras in the smart buildings are sent over the 5G cellular network to the MEC to perform AI face recognition on those livestreams and unlock the door if owner's faces are recognized. The concept is that by sending frames to the Muti-Edge Computing (MEC) server to process is faster than cloud server and thus reduces the overall latency.

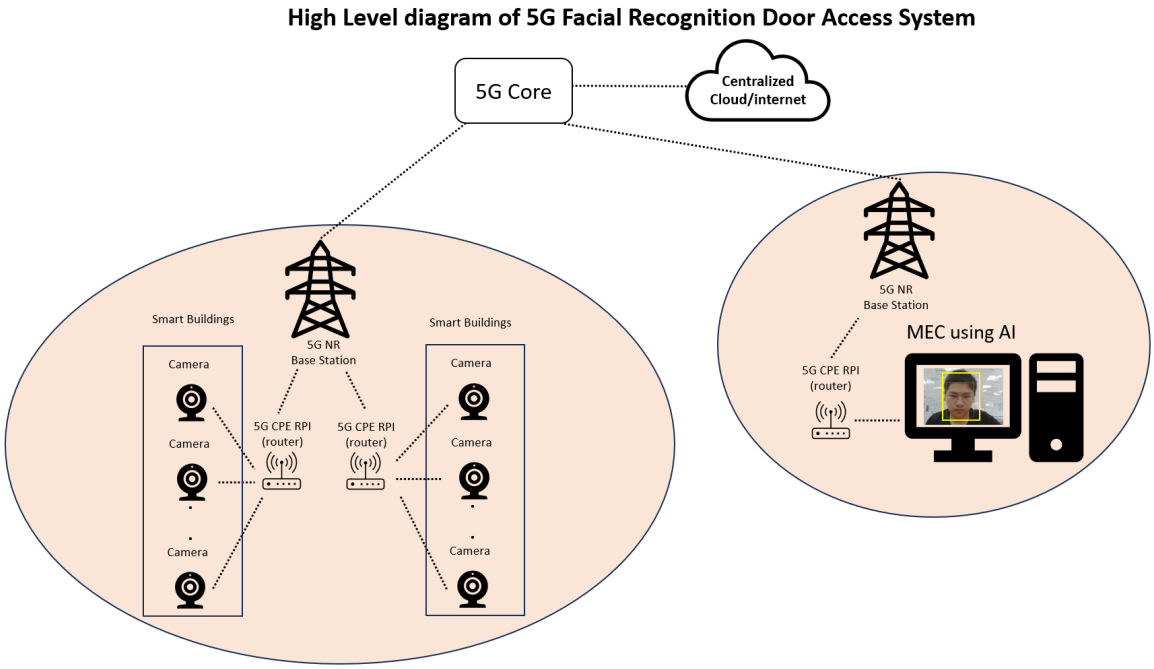


Figure 2: 5G Facial Recognition Door Access System High-Level Diagram

However, you are not required to create a 5G Facial Recognition Door Access System according to the high-level diagram. For the mini project, you are only required to create a simplified 5G Facial Recognition Door Access System according to figure 3.

Instructions

- Each group should have 4-5 members, split the workload among yourselves equally.
- Each group will receive 2 5G RPI CPEs, 1 SD card, 2 Sim cards, a pi camera, breadboard, an LED, a resistor, 2 wires, a monitor, a keyboard, and mouse.
- Groups 1-18 will each be assigned an SD card labelled 1-18 respectively. **!!DO NOT MIX UP THE SD CARD'S NUMBER**
- When using the SD card, students can choose to keep the existing content inside or start afresh by flashing a new Raspberry Pi OS.
- You are not allowed to bring the 5G RPI CPEs or its components home. So, ensure you can complete Section A task 1 within the duration of the mni-project.
- Refer to the slides in Extra_resources folder on how to back up an SD card on your laptop using win32 Disk Imager and load the SD card image file into an SD card. The reason for backing up and loading an SD card is so that you can continue where you left and won't lose any progress. If you don't, you will risk losing the SD card, losing all its content. Currently, we have exactly 18 SD cards for all 18 groups. If any of them are broken, all of you must share the SD cards which is why it is important to back up your group's SD card. If you don't want to back up, you can choose to use or buy your own SD card for the mini project.

Section A

1) Your first task is to create a simplified 5G Facial Recognition Door Access System.

Figure 3 shows the simplified block diagram of 5G Facial Recognition Door Access System which your group is going to implement. One 5G CPE RPI inserted with an SD card is placed at the transmitting side, a Pi Camera and LED is connected to it. At the receiver side, only the 5G Hat component of the 5G CPE RPI is connected to the MEC to provide 5G connection via USB communication. The Raspberry Pi at the receiver side is currently not used, therefore your group will only need 1 SD card for the whole project.

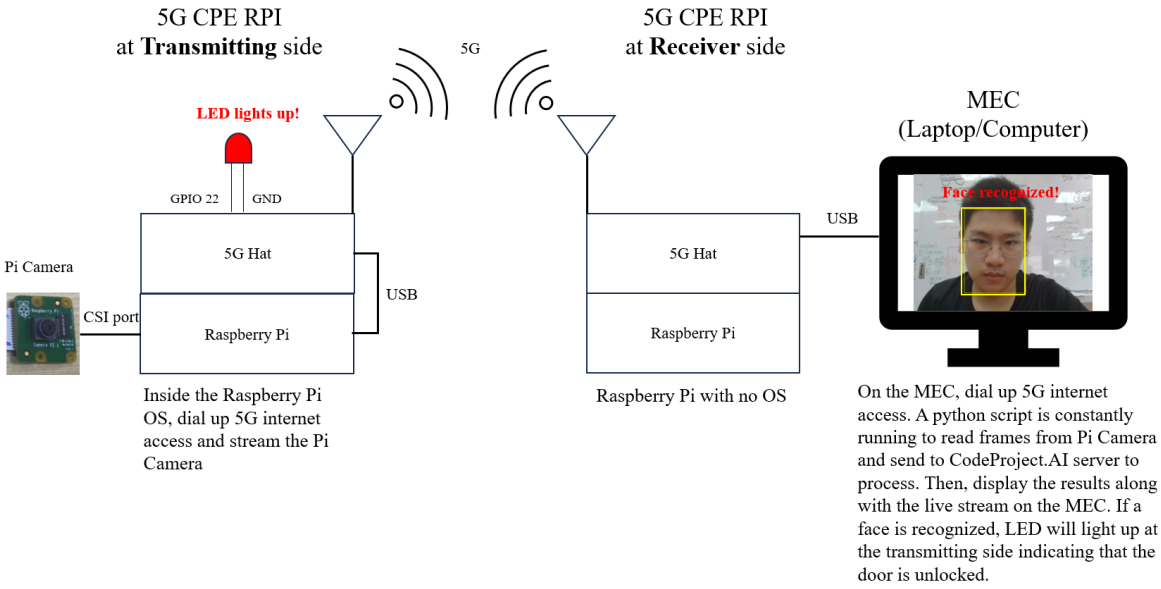


Figure 3: Simplified block diagram of 5G Facial Recognition Door Access System

Explaining in depth on this 5G Facial Recognition Door Access System should work.

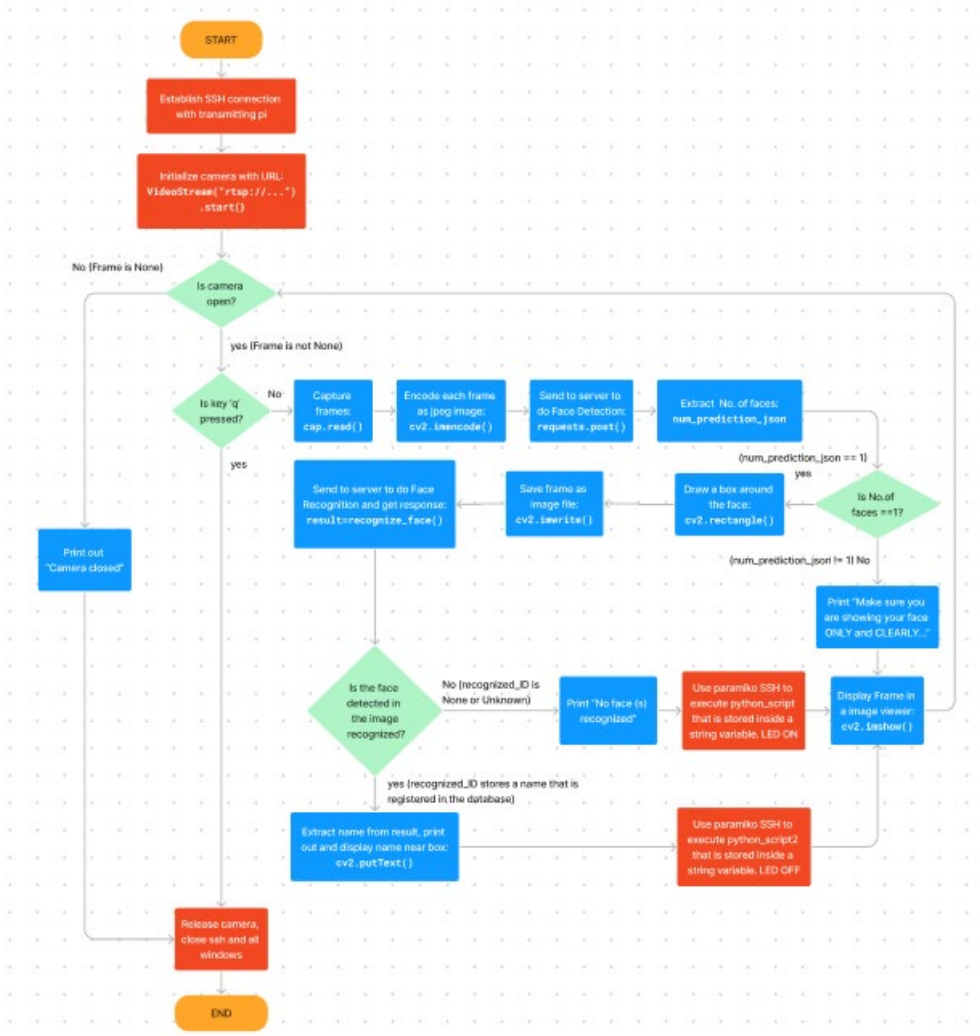
Transmitting side:

Firstly, a pyserial python script inside the Raspberry Pi is executed to dial up 5G internet access and another linux command is used to obtain a public IP address. Secondly, you will stream the Pi Camera and obtain a RTSP/HTTP URL.

Receiver side:

Firstly, a pyserial python script is executed on the MEC (Laptop) to dial up 5G internet access. Secondly, a modified recognition.py python script will run to capture the live stream from the Pi Camera using the RTSP/HTTP URL. Then, it sends the frames as an image to the locally installed CodeProject.AI server to detect and recognize faces. Then, the results along with the live stream will be displayed on the MEC. Finally, whenever a face is successfully recognized, the LED will light up at the transmitting side which will indicate that the door has unlocked.

Flowchart of Modified Recognition.py



During the whole process from the moment the python script starts capturing the stream, the live stream displayed on the MEC must be as close to real-time as possible.

2) Your second task is to create presentation slides on everything you have done for Section A task 1 using the CDIO framework.

Section B

3) Your third task is to recommend improvements/features to the 5G facial recognition door access system. Write down the improvements and features in the same presentation slides created in Section A task 2.

4) Your fourth and final task is to create another 3-minutes long presentation slides on 1 or more 5G & AIoT applications related to Sustainable Development Goal 9. (Groups with 5 members need to present at least 2 5G & AIoT applications, they will also be given more time to present).

Reference

Sustainability of Sheep Farming Operations with facial recognition articles

- [1] Rajkovic, M. (2023) Farming gets a futuristic makeover: Unleashing AI and Facial Recognition in agriculture, Otto. Available at: https://www.ottoit.com.au/farming-gets-a-makeover/ (Accessed: 08 May 2024).
- [2] Williams, L. (2023) All eyes turn to sheep as facial recognition trial arrives in Australia, ABC News. Available at: https://www.abc.net.au/news/2023-06-06/sheep-face-recognition-trial-arrives-in-australia-genesmith/102414936 (Accessed: 08 May 2024).

Sustainable Development Goals

- [3] United Nations (no date) Goal 9 | Department of Economic and Social Affairs, United Nations. Available at: https://sdgs.un.org/goals/goal9#targets_and_indicators (Accessed: 08 May 2024).
- [4] PlanRadar (2022) How smart buildings are shaping resilient infrastructure for the future, PlanRadar. Available at: https://www.planradar.com/sg/smart-buildings-shaping-resilient-infrastructure/ (Accessed: 08 May 2024).

Pi Camera Livestreaming

- Santos, S. (2019) Video streaming raspberry pi camera, Random Nerd Tutorials. Available at: https://randomnerdtutorials.com/video-streaming-with-raspberry-pi-camera/ (Accessed: 27 May 2024).
- Bluenviron (no date) Bluenviron/mediamtx: Ready-to-use SRT / webrtc / RTSP / RTMP / LL-HLS media server and media proxy that allows to read, publish, proxy, record and playback video and audio streams., GitHub. Available at: https://github.com/bluenviron/mediamtx (Accessed: 27 May 2024).
- Raspberry Pi Foundation (no date) Streaming with FFmpeg, Projects.raspberrypi.org. Available at: https://projects.raspberrypi.org/en/projects/infrared-bird-box/10 (Accessed: 27 May 2024).

MQTT broker Installation

- https://www.youtube.com/watch?v=hyJhKWhxAxA
- Orlivskyi, S. (2024) Mosquitto MQTT broker on Windows Installation - Ultimate Guide, Cedalo. Available at: https://cedalo.com/blog/how-to-install-mosquitto-mqtt-broker-on-windows/ (Accessed: 27 May 2024).

OpenWRT OS

- Hazarjast (2023) Hazarjast/5g_rpi4_build: Info repository related to raspberry pi4 5g modem build, GitHub. [online] Available at: https://github.com/hazarjast/5g_rpi4_build#operating-system-selection (Accessed: 27 May 2024).

Extra Resources

- Inside mini project folder, there should be an additional folder called Extra_resources.