THE UNIVERSITY OF DANANG
UNIVERSITY OF SCIENCE AND TECHNOLOGY
DANANG INTERNATIONAL INSTITUTE OF TECHNOLOGY

INTERNSHIP PROJECT REPORT
M1-FIRST REPORT

Water Meter Reading with Camera-based Index Recognition

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Danang, May 2024

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1.1. Overview

a. The motivation of project

Today, beach tourism is an important segment of the tourism industry, bringing many economic and cultural benefits to coastal areas around the world. Currently, Vietnam's tourism development strategy until 2030 has identified marine tourism as one of the main strengths that needs to be prioritized and developed. In fact, this is also the "magnet" that attracts up to 70%[1] of the total number of Vietnamese tourists.

Access to clean water is crucial for all individuals, underscoring the need for careful monitoring of water usage. Traditional methods of water meter reading are time-consuming and susceptible to human error. Implementing camera-based recognition for meter readings presents an ideal solution. Leveraging recognition algorithms ensures precise tracking, facilitating more effective management of water consumption.

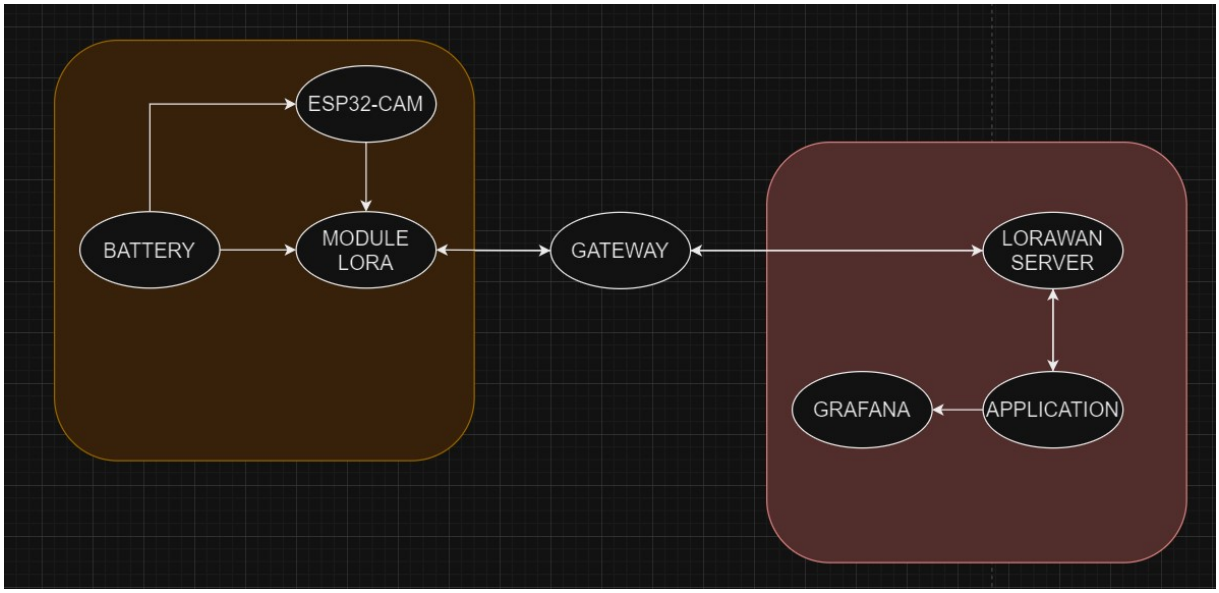
b. Existing techniques solutions

https://github.com/jomjol/AI-on-the-edge-device/?tab=readme-ov-file

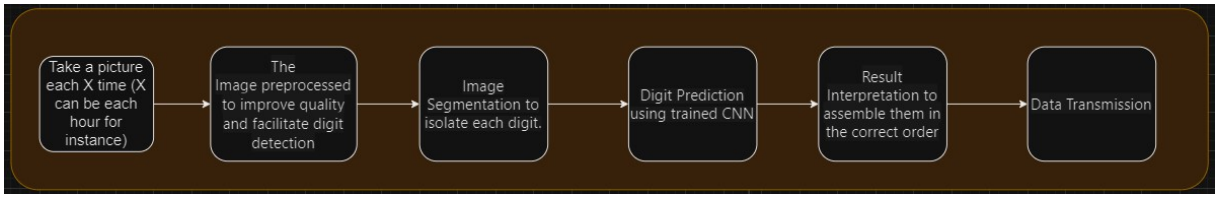
1.2. Preliminary solution

a. Technical solution with block diagram

- Use https://app.diagrams.net/ to draw the system block diagram
- Describe the operating principle of system diagram



ESP32-CAM process:



System will mainly be composed of the ESP32-CAM which, with a battery, will be able to transfer data it collected via LoRaWAN and then display it on a Grafana interface.

Figure 1-3 System block diagram

b. Design process

- **Stage 1: Determine goals and requirements**
  - The goal is to have a portable system, tha's why we use a micro controller as the ESP32-CAM
  - Set specific requirements such as:
    - Research object of the project is to read digits and make them redable
    - We will start from understanding system, connecting it, train a model to sending result using LoRaWAN
- **Stage 2: Research the technologies used in the system**
  - Usage of ESP32-CAM and way to implement code inside it.
  - Overview of LoRa technology.
  - Learn about communication protocols in the system.
- **Stage 3: Research on microcontroller programming and types of sensors used in the system**
  - Learn about ESP32-CAM programming.
- **Stage 4: System design**
  - - Design a support for mounting and connecting the camera
  - Set up a warning system: when water consumption rises sharply in a short space of time, this may indicate a leak
- **Stage 5: Test and check**
  - Conduct performance testing of the wearable device and the associated application.

- Ensure that the system operates stably and responds properly to the requirements.

c. Requirements for the system

❖ **Requirement 1:** For wearable devices

- **Connect to LoRa gateway:**
  - Requirements: The device needs to be able to connect to the LoRa gateway over long distances.
  - Farthest distance: Depending on environmental conditions and areas such as urban or suburban, the farthest distance can be 15km under ideal conditions. This will depend on the locatin where the water meter is placed.
- **Battery and usage time:**
  - Requirements: The battery needs to have enough capacity to maintain device operation for the expected time.
  - Usage time: Depending on the device's power consumption, the 600mAh, 3.7V Lithium Polymer Battery can provide power for a few hours to a few days, depending on usage.
  - Size and power consumption: The device needs to be compact in size, save space, and have the lowest possible energy consumption to ensure long-term operation of the device.

❖ **Requirement 2:** For LoRa

To configure LoRa devices, three important parameters are required:

- **Spreading Factor** (SF) is a factor that affects the speed and energy consumption of devices, usually ranging from 7-12.
- **BW** (Bandwidth): there are three main types of bandwidth: 125kHz, 250kHz, and 500kHz - the deciding factor in the data rate and transmission distance of the devices. The larger the bandwidth, the shorter the transmission distance, so to achieve the longest transmission distance, choose the smallest bandwidth - 125kHz.
- **CR** (Coding Rate): the factor that affects the time delay when the device transmits data to the LoRa gateway and monitoring software, usually the delay can range from a few seconds to a few minutes.

❖ **Requirement 3:** For monitoring software

- **Parameter display:**
  - Water meter value: display the current water meter value and a tab with the previous ones with associated time.
- **Problem warning:**
  - Abnormal water consumption: Warn people when the water meter show a high water consumption increase in a reduced time.
- **How to warn:**

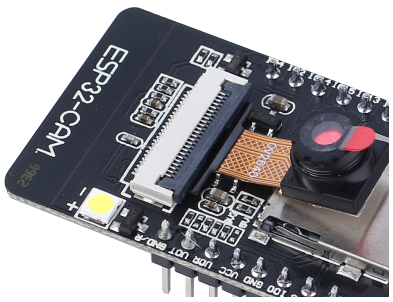
  - Software indicates when the consumption is abnormal et so user have to check if he has any leak.
- **Grafana usage**

  - To display data as a result and maybe warn users of a leak, we will use Grafana where you will be able to follow water consumption through the hours, the days etc..

d. Main components needed for implementation

List all material/device need to be provided or buy to use in this project

Based on the system requirements mentioned in section C, we have decided to choose the following components to design the system:
Camera : choose ESP32-CAM
Battery: choose Lithium Polymer Battery 600mAh, 3.7V.
Protective case: choose a protective case that matches the design and function of the device.
Details about functions, dimensions, and power consumption... will be listed in the following table:

Components	Devices name	Specifications
Camera	ESP32-CAM 	- Dimension: 27*40.5*4.5 (±0.2) mm - Operating temperature: -20 ℃ ~ 70 ℃ - Supply voltage: 4,75-5,25V - Frequency range: 80MHz to 240MHz -Datasheet (already got the component)

Battery	**Lithium Polymer Battery 600mAh, 3.7V** 	- Dimension: 35 x 20 x 6mm - Weight: 8g - Life cycle: 1000 times - Datasheet:[7]
LoRaWAN Module		-Dimension: 90x45mm

Table 1-1 Components detail

1.3. Expected results

If we have time and not so many problems, at the end of the internship we are expecting to have :

An accurate machine learning model able to recognize digits (and predict a digit when it is in transition between two as we can see on the picture)

and able to send the values using LoRaWAN in order to display it on Grafana and provide users with follow-up information.

1.4. Evaluation method

Criteria for system aspects including.. efficiency, cost, complexity, and accuracy,...

- **Evaluation of effectiveness:**
  - Testing accuracy by testing the CNN model.
- **Cost assessment:**
  - System is very cheap, it only uses the ESP32-CAM, a battery and a LoRaWAN to get data.

- **Complexity rating:**

  Easily develop new features in the future without interruption or hindrance. The main data processing will be done. It will be easy to add features on a software.

- **Accuracy and performance rating:**
  - Evaluation methods: product testing in a real environment

    + Compare the data obtained from the system with the set thresholds to evaluate the accuracy of the data.

    + Check that the system response time is within the allowable range.
  - Standards: the results obtained are within the allowed threshold, and the data obtained can be accepted as reliable.

1.5. Plan of implementation

<table>
<tr><td rowspan="3">Timeline
Member</td><td colspan="12">2024</td><td>2024</td></tr>
<tr><td colspan="4">May</td><td colspan="4">June</td><td colspan="4">July</td><td>August</td></tr>
<tr><td>W1</td><td>W2</td><td>W3</td><td>W4</td><td>W1</td><td>W2</td><td>W3</td><td>W4</td><td>W1</td><td>W2</td><td>W3</td><td>W4</td><td>W1</td></tr>
<tr><td rowspan="5">STENGEL Damien</td><td colspan="2">absent</td><td colspan="2">familiarize with the equipment, start some try with the ESP32-CAM</td><td colspan="8"></td></tr>
<tr><td colspan="4"></td><td colspan="2">Design support for camera</td><td colspan="6"></td></tr>
<tr><td colspan="6"></td><td colspan="2">Set-up Lorawan</td><td colspan="4"></td></tr>
<tr><td colspan="8"></td><td colspan="2">Try model on water meter and adapt it</td><td colspan="2"></td></tr>
<tr><td colspan="10"></td><td colspan="2">Connect LoRaWAN with ESP32-Cam</td><td></td></tr>
</table>

												Time to face potential problems
FROMENT Lorenzo	familiarize with the equipment, start some try with the ESP32-CAM											
				Start training model								
							Adapt model and test it					
									Try model on water meter and adapt it			
											Manage data get on LoRaWAN with Grafana	
												Time to face potential problems

References

[7] F. Yang, L. Jin, S. Lai, X. Gao, Z. Li, “Fully Convolutional Sequence Recognition Network for Water Meter Number Reading”, IEEE Access, volume 7, pp. 11679 – 11687, 2019.