UNIVERSITY OF CARTHAGE

NATIONAL SCHOOL OF SCIENCES AND ADVANCED TECHNOLOGIES OF BORJ CEDRIA

Synthesis Project Report I

Smart House

Elaborated by :

Yasmine Ayed (1 TA3)

And Walid Jbeli (1 TA 3)

Defended on may 2023 in front of the jury:

Mrs.Kardous Faten	**ENSTAB**	**Examining board chair**
Mr.Kermani Marwen	**ENSTAB**	**Supervisor**

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Résumé

L'Internet des objets et les technologies d'intelligence artificielle prennent de plus en plus d'importance dans nos vies. En fait, AIoT joue déjà un rôle important dans les affaires et voici le cadre de notre projet : Smart Home. Il comprend deux parties : la première est un système de portes intelligentes où le contrôle de l'entrée des propriétaires de maison se fait par reconnaissance faciale. Nous avons formé notre modèle sur 2 propriétaires en utilisant la bibliothèque OpenCV. La deuxième partie du projet est un espace comprenant un tableau de bord pour l'acquisition de la température, de l'humidité et de la pression et une alerte par courriel à l'aide d'une caméra de sécurité personnelle. Ce projet est avantageux pour les propriétaires, car il offre une sécurité, confort et profit.

Mots clés : IA, AIoT, reconnaissance faciale, reconnaissance vocale, Node-RED, IoT Dashboard, porte intelligente

Abstract

The internet of things and artificial intelligence technologies are getting more and more important in our lives. In fact, AIoT plays already a significant role and here comes the framework of our project: Smart Home. It consists of two parts: the first part is a smart door system where the control of homeowner's entrance is done using facial recognition. We trained our model on 2 homeowners using OpenCV library. The second part of the project is a dashboard for temperature, humidity and pressure acquisition and an email alert using a personal security camera. This project is beneficial for homeowners as it provides security, comfort and profit.

Keywords: AI, AIoT, face recognition, voice recognition, Node-RED, IoT dashboard, Smart door lock

École Nationale des Sciences et Technologies Avancées à Borj Cédria
Adresse : *Campus Universitaire à Borj-Cédria, BP 122 Hammam-Chott 1164*, Tunisie
Tél. : +216 79 326 795 / +216 79 326 767 /**Fax :** +216 79 326 797
Web: www.ucar.rnu.tn

Dedication

This work is wholeheartedly dedicated to our beloved families who have been our source of inspiration and gave us strength when we thought of giving up, who continually provide their moral, spiritual, emotional and financial support.

To our brothers, sisters, friends and classmates who shared their advice and encouragement to finish this project.

Thanks

We want to express our gratitude to our supervisor Mr. Kermani Marwen.

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"Thank you".

Our sincere thanks to the parents and our families for their encouragement, support and love ... "Thank you".

Summary

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List of abbreviations

AI: Artificial Intelligence

AIoT: Artificial Intelligence of Things

CPU: Central Processing Unit

CSI: Camera Serial Interface

DL: Deep Learning

DNN: DotNetNuke

GPIO: General Purpose Input/Output

HDMI: High-Definition Multimedia Interface

IoT: Internet of Things

LAN: Local Area Network

LCD: Liquid Crystal Display

ML: Machine Learning

OpenCV: Open-Source Computer Vision Library

OS: Operating System

RAM: Random Access Memory

SOC: System on a Chip

USB: Universal Serial Bus

General Introduction

The basic traditional way of living is changing thanks to the high technology. In the past few years, a lot of transformations have happened due to the revolutionary approach for future that internet of things and Artificial intelligence has given us.

Today, we are living in a world where there are more IoT connected devices than humans, from smart phones to smart industries. IoT promises many positive changes for health, safety, business, industrial performance and global environmental issues where everything is connected: IoT Analytics and Artificial Intelligence. Advanced analytics, including AI, is the way to harness value from the internet of things. “AI in IoT can make our world a better place to live”.

Already, internet of things and artificial intelligence capabilities play a significant role in businesses. We decided to create a smart House with a better security system and better conditions by putting together extensive variety of smart system and setting new factors that determine a home’s comfort.

This project is divided into four main chapters. The first chapter is dedicated to a general context and the presentation of this project, the second chapter explains the architecture of OpenCV library and the supporting technologies of internet of things. The third chapter contains hardware and software tools used in this project. Finally, the last chapter is devoted to the project realization.

Chapter 1: Project presentation

Introduction

In this chapter, we begin by providing an overview of the project's context. Next, we discuss related works in which AI and Internet of Things (IoT) technology have been used. Finally, we outline the primary features of this proposed project intitled Smart Home.

1. General context

1.1. Internet of Things (IoT)

In recent years, IoT becomes increasingly important. It connects physical things and places to the internet using software, sensors, and network connectivity. This allows to collect data and make intelligent decisions. IoT enhance people's lives by enabling smarter living and working and giving them greater control. In various industries, IoT enables automation, analysis, production, and performance monitoring, while also helping businesses improve efficiency, customer service, and decision-making. Many startups today are focused on technology, with smart voice assistants, 5G, and machine learning revolutionizing the way businesses, homes, and cities are managed. Moreover, IoT is also transforming sectors such as agriculture, healthcare, smart homes, and smart cities as given in figure 1.

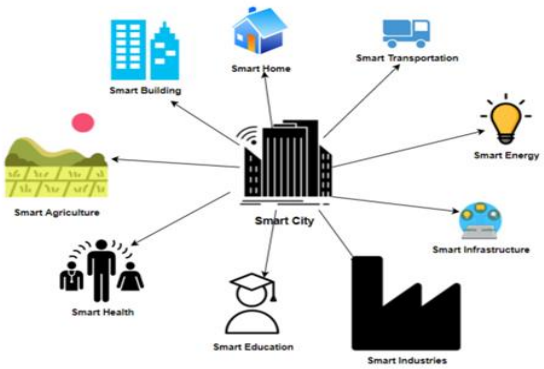

Figure 1 : Smart City [1]

1.2. Artificial Intelligence (AI)

AI is a branch of computer science that aims to create intelligent machines that can perform tasks that typically require human intelligence.

AI can be broadly divided into two categories:

- Narrow AI, also known as weak intelligence, is designed for specific contexts, and is often focused on performing one task extremely well.
- Artificial General Intelligence (AGI), also known as strong intelligence. is capable of understanding and learning intellectual tasks in a similar way to humans.

Much of narrow AI is powered by breakthroughs in machine learning and deep learning.

Machine learning is a method of statical learning that help the computer "learn" how to perform better at a task.

Deep learning is a type of machine learning that runs inputs using neural networks with hidden layers, big data, and powerful computational resources.

Figure 2 explains the relation between AI, DL and ML.

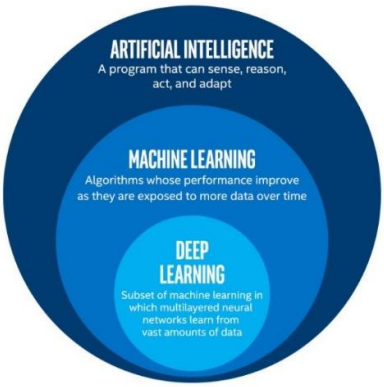

Figure 2 : Relation between AI, ML and DL [2]

There are primarily three types of ML as shown in figure 3.

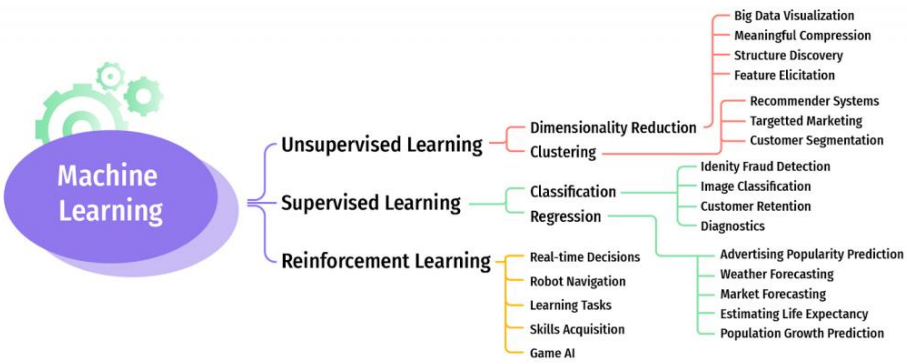

Figure 3 : Types of ML [3]

The most used algorithms are supervised and unsupervised learning. The difference between them is that supervised learning is using algorithm to learn the mapping function from a known input to output so the machine can approximate the mapping function from a new input data and predict the output, when the unsupervised learning is that both inputs and outputs are unknown.

1.3. Artificial Intelligence of Things (AIoT)

AIoT refers to a subtle mixture between IoT and AI. In other words, AIoT opens the doors of a new world in which connected objects benefit from AI techniques.
Relying on AI and analytics, connected objects are now able to adjust their decisions within autonomous systems. IoT is like the digital nervous system and AIoT is the brain that controls this system, to make better business decisions.

2. Most known systems using AIoT

In this subsection, we will present some known systems using AIoT.

2.1. Biometrics

Biometrics is the measurement and statistical analysis of people's unique physical and behavioral characteristics. The technology is mainly used for identification and access control or for identifying individuals who are under surveillance.

2.2. Drone traffic monitoring

Smart cities use AIoT in various ways, including traffic monitoring by drones. The use of drones for traffic monitoring helps to reduce congestion by allowing real-time adjustments to traffic flow. Drones can cover a large area and transmit traffic data, which AI can then analyze to make informed decisions about how to manage congestion. This can include changing speed limits and timing traffic lights, all without human intervention. By using AIoT in this way, cities can achieve better traffic flow and reduced congestion as shown in figure 4.

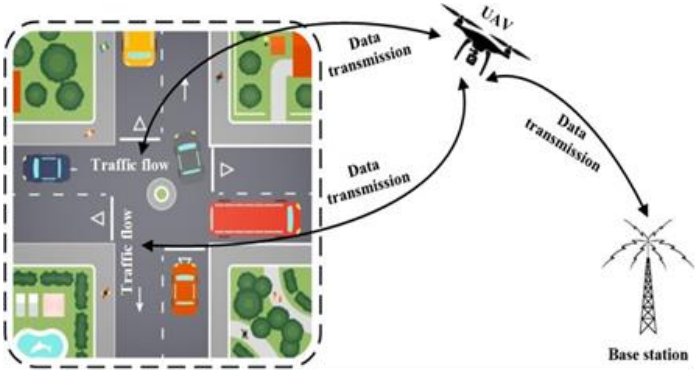

Figure 4:Drone traffic monitoring [4]

3. Motivation

Smart home technology has revolutionized the way we interact with our living spaces, making our homes more comfortable, convenient, and energy efficient. We have always been fascinated by the potential of smart home technology to improve our daily lives. Therefore, we undertook a smart home project with the goal of exploring the capabilities of this technology and creating a system that could simplify various tasks and enhance the overall quality of life. Through this project, we aimed to gain hands-on experience in the field of home automation and contribute to the growing body of knowledge on this topic. The goal of this smart home project is to create a system that can be easily controlled and customized to meet the user's unique needs and preferences. By achieving this goal, smart home projects can help people live more comfortably and efficiently, also contributing to the development of new technologies and solutions in the field of home automation.

4. Problem statement

Non-connected homes have various issues related to energy efficiency, comfort, and ease of use, which can make it challenging for homeowners to maintain a sustainable and comfortable living environment. In fact, non-connected homes lack modern technology that can simplify daily tasks, like automated lighting and appliance control and home security systems. Also, homeowners must manually adjust temperature and lighting, leading to inconsistent conditions throughout the home. A solution that integrates smart home technology into their living environment can help homeowners overcome these challenges, enabling them to maintain a comfortable indoor climate, and enjoy the convenience and security of a connected home.

5. Developed project: Smart Home

The Smart Home project aims to address the needs of security and comfort in a home.

The project is divided into two parts. The first part will be focused on the implementation of a smart security and face recognition, while the second part will involve controlling and monitoring temperature through a dashboard and receiving email notifications with security camera footage.

Conclusion

Throughout this chapter, we have set the general context of this project by providing an explanation of AI, IoT and giving projects that use AIoT. We have also set out the general structure of this project. The next chapter will be dedicated to describe AI and IoT techniques in more details.

Chapter 2: Theoretical background

Introduction

In this chapter, we will focus on computer vision and explain the function of OpenCV in this field. Then we delve into the topic of face recognition and its applications. We will also discuss about IoT and its features.

1. Computer Vision

Computer vision is a field of AI that enables computers and systems to derive meaningful information from digital images, videos and other visual inputs and take actions or make recommendations based on that information. If AI enables computers to think, computer vision enables them to see, observe and understand.

1.1. Classification

Classification in computer vision is a technique that involves categorizing visual data such as images or videos into distinct groups or classes. This process usually involves using machine learning algorithms to analyze the features and patterns present in the input data and assigning each item to its appropriate class. For example, an image classification model could be trained to distinguish between pictures of cats and dogs. Once trained, the model could then predict the correct classification of new, unseen images with a high degree of accuracy. Classification is a fundamental tool in computer vision and is used in a wide range of applications, including object recognition, facial recognition, and medical imaging.

1.2. Detection

Object detection is a complex process that relies on various methods and techniques, which are chosen based on the number of objects present in the input data. For instance, if the image contains a single object of interest, the process of image localization is used. During this process, the computer interprets the numerical values of each pixel in the image and displays the appropriate colors and hues.

The object is then identified by drawing a bounding box around it, allowing the computer to differentiate it from the background. On the other hand, if there are multiple objects of interest in the image, a technique called object detection is applied to detect and label each of these objects with their respective bounding boxes.

2. OpenCV Library

OpenCV is an open-source computer vision and machine learning library. It provides tools and functions that allow developers to build computer vision applications with features such as image and video processing, object detection and tracking, machine learning, and augmented reality. It supports multiple programming languages such as Python, and Java. Additionally, the library provided an extensive range of image processing techniques that were instrumental in achieving high accuracy rates. With OpenCV, we were able to create a face recognition system that is both efficient and reliable.

2.1. Face recognition using OpenCV library

OpenCV provides several tools and algorithms that can be used for face recognition tasks. Here are the general steps for implementing face recognition using OpenCV:

- Data collection: Collect a dataset of faces that you want to recognize. You can either use an existing dataset or create your own by taking photos of the people you want to recognize.
- Face detection: Use OpenCV's face detection algorithms, such as Haar cascades or deep learning-based face detectors, to detect faces in each image.
- Face alignment: Align the detected faces to a common reference frame so that they are all in the same orientation and size.
- Feature extraction: Extract features from each face, such as local binary patterns or deep features from a pre-trained neural network.
- Face matching: Compare the extracted features of each face to those of the faces in your dataset to find the closest match.
- Recognition: Assign a label to each detected face based on the closest match in your dataset.

OpenCV provides several functions and modules to implement these steps, including the CascadeClassifier and DNN modules for face detection, the alignFace function in the facemark module for face alignment, and the LBPHFaceRecognizer and EigenFaceRecognizer classes in the face module for face matching and recognition.

3. Relation between OpenCV and computer vision

There is a strong link between OpenCV and computer vision, as OpenCV provides the necessary tools and functions to implement computer vision algorithms and applications. OpenCV is commonly used in computer vision research and development, as it allows researchers and developers to easily experiment with and test various computer vision techniques.

To use OpenCV for computer vision tasks, you can start by importing the OpenCV library in your Python code and using its functions and tools to perform various computer vision tasks. For example, you can use OpenCV's image processing functions to manipulate and enhance images or use its object detection functions to detect and track objects in videos. Overall, OpenCV and computer vision are closely linked, with OpenCV providing a powerful and versatile toolset for implementing various computer vision algorithms and applications. By using OpenCV, developers and researchers can accelerate the development of computer vision applications and contribute to the advancement of the field.

4. Face recognition

4.1. Steps of the typical face recognition system

Facial recognition is the method used to confirm or identify a person's identity through their facial features. This involves capturing, analyzing, and comparing patterns based on the individual's facial characteristics. The technology behind recognition is designed to process information of facial features to automatically detect and track faces. It then proceeds to analyze each image captured by webcams or cameras in still images and video streams to identify the user's identity. the process is given in figure 5.

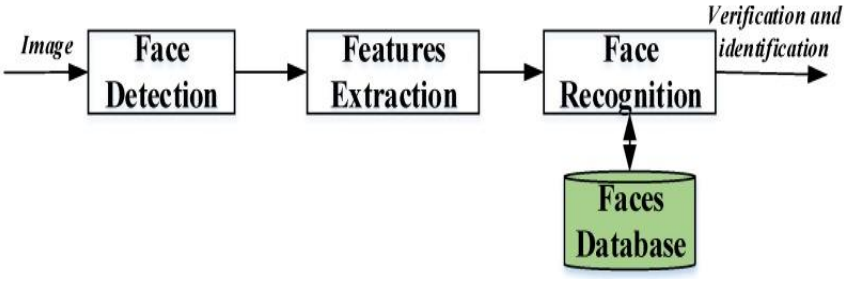

Figure 5: Basic process of Face Recognition system [5]

4.1.1. Face detection and tracking

To initiate the face recognition process, the system first locates the presence of human faces within a given image. This initial step serves the purpose of verifying whether the input image includes any human faces.

4.1.2. Feature Extraction (Face capture and analysis)

By using the key points of the face, such as the eyes, nose, and mouth, feature extraction is used to convert the analog information of a face into a set of distinct information. This process enables the identification of individuals based on their unique facial expressions.

4.1.3. Face recognition

After feature extraction, the extracted features from the background are compared to the known faces stored in a designated database. Face recognition has two general applications: identification and verification.

In the identification process, a test face is compared to a collection of faces to find the closest match. Meanwhile, in the verification process, a test face is compared with a known face in the database to determine whether it should be accepted or rejected.

4.2. Applications of face recognition technology

Face recognition has various applications across different fields such as security, entertainment, and healthcare. Some applications of face recognition include:

4.2.1. Security and law enforcement

Face recognition is commonly used in security systems to identify individuals in real-time and monitor access to secure areas. It is also used in law enforcement to identify suspects and aid in investigations as shown in figure 6.

Figure 6: Face recognition in security [6]

4.2.2. Healthcare

Face recognition in healthcare can have several applications such as patient identification, access control to secure areas, monitoring patient compliance with medication and treatment plans, and tracking patient health status through facial analysis. It can also be used for contactless patient check-in and for detecting signs of certain medical conditions through facial recognition algorithms.

4.2.3. Banking and Finance

Face recognition can be used to improve security and prevent fraud. For example, banks can use face recognition to verify the identity of customers making transactions and to detect suspicious behavior.

4.2.4. Other examples

For security purposes, many phones are using face recognition as a means of unlocking the device. This technology provides protection for personal data.

5. IoT and its Enabling Technologies

IoT is a platform created in the purpose of allowing the users to connect the devices and technology to the internet and exchanging the information through sensors, electronics, software, and other technologies. IoT devices are capable of interacting with one another, which results in a more advanced system that can offer a multitude of services. We can see in figure 7 an example of IoT applications.

Figure 7: IoT applications [7]

5.1. Cloud computing

Cloud computing refers to the delivery of computing services, such as storage, servers, databases, software, and networking, over the internet. Cloud computing enables organizations to access shared computing resources on-demand, without the need for owning and managing their own infrastructure.

IoT devices generate a massive amount of data, and processing this data requires significant computing resources. This is where cloud computing comes in. Overall, the combination of IoT and cloud computing enables organizations to leverage the benefits of both technologies and unlock new opportunities for innovation and efficiency.

5.2 IoT features

IoT is one of the major technologies in the world today that can help other technologies reach their complete potential as well. Now there are mainly three aspects to Internet of things and how it works [12].

IoT devices have a wide range of features that enable them to connect to the internet, collect and transmit data, and interact with other devices and systems. Some of the key features of IoT devices includes:

- Connectivity: IoT devices are equipped with wireless communication capabilities, such as Wi-Fi, Bluetooth, or cellular connectivity, that enable them to connect to the internet and other devices.
- Sensors: IoT devices often have sensors that can detect various types of data, such as temperature, humidity, motion, light, and sound.
- Data processing: IoT devices can process the data they collect locally or send it to a cloud server for processing and analysis.
- Actuation: IoT devices can also perform actions based on the data they collect, such as adjusting temperature, turning on lights, or activating alarms.
- Security: IoT devices have security features that protect them from unauthorized access and ensure the integrity and confidentiality of the data they collect and transmit.
- Power management: IoT devices are designed to operate on low power and have features that help conserve battery life, such as sleep modes or power-saving algorithms.
- Scalability: IoT devices can be easily scaled to accommodate many devices and data streams, making it possible to deploy IoT solutions on a global scale.

Overall, these features enable IoT devices to collect and transmit data in real-time, automate processes, and improve efficiency and productivity in various industries and applications.

Conclusion

In this chapter, we have explored the relation between OpenCV and Computer Vision. We included major components such as face detection, tracking, and feature extraction and the various applications of face recognition system. We have also touched on the topic of IoT and its supporting technologies. In the next chapter, we will discuss the different software and hardware tools we'll be using in our project.

Chapter 3: Software and hardware tools

Introduction

This chapter provides an overview of the hardware and software components that will be employed in this project. We will discuss about the equipment that will be used for data collection and explore the software tools that we have selected for this project, including the Node Red and Python.

1. Hardware tools

In this part, we will provide the hardware tools.

1.1. Smart door

1.1.1. Raspberry Pi

The Raspberry Pi is a compact single-board computer that can be easily connected to a computer monitor, keyboard, and mouse. It supports multiple programming languages such as C, C++, Python, and more, it is an ideal tool for people interested in learning programming. Moreover, the Raspberry Pi is equipped with various input/output options that enable it to interact with the outside world and has been used in numerous digital maker projects.

For our project, we employed the Raspberry Pi 3 Model B+. This model is the latest addition to the Raspberry Pi 3 series and features a powerful 1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and Power-over-Ethernet support as given in figure 8:

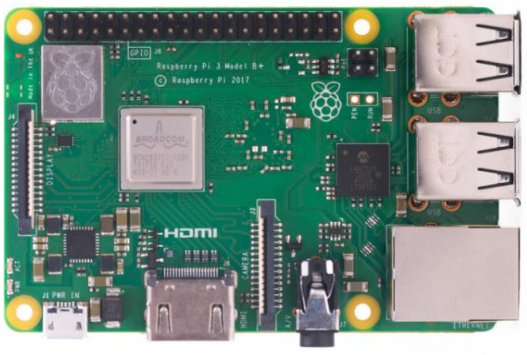

Figure 8: Raspberry Pi 3 Model B+ [8]

These are the standard components of a Raspberry Pi board:

- **SoC**: it is an integrated circuit that includes many computer components: CPU, memory, and RAM. The raspberry Pi B+ uses 512 MB of RAM
- **DSI display connector**: it is used to connect an LCD panel.
- **GPIO**: these are pins used to connect electronic devices. The raspberry Pi B+ has 40 pins.
- **HDMI port**: it is used to connect a monitor or TV.
- **Ethernet port**: it is a standard 10/100 Mbit/s Ethernet port used to connect the device with the rest of the network.
- **USB ports**: standard USB 2.0 ports used to connect peripherals such as a keyboard and mouse. The Raspberry Pi Model B+ Model has 4 USB ports.
- **Audio port**: a 3.5mm jack used to connect speakers.
- **Micro-USB power connector**: it is used to power the Raspberry Pi.
- **USB and Ethernet interface chip**
- **Camera connector**: enables the capturing of photographs and videos.

On the other side of the board there is a micro-SD card slot that holds the operating system. The Raspberry Pi suits best for our needs as it is 40 times faster than an Arduino in terms of clock speed and has 128,000 times more RAM. It is quite powerful as opposed to STM32 and can perform multiple tasks.

Add to that, the Raspberry Pi has additional connections (HDMI, Ethernet port, USB port, etc.) compared to STM32 and Arduino.

1.1.2. Raspberry Pi camera

In this project, we used the Raspberry Pi camera module v2, which boasts an 8-megapixel Sony IMX219 sensor and has a compact form factor measuring only 25 mm x 23 mm x 9 mm, weighing just over 3 grams.

The camera module can capture high-definition videos and still images with a resolution of 3280 x 2464 pixels. It is connected to the Raspberry Pi via a 15-cm ribbon cable and is plugged into the Camera Serial Interface (CSI) connector on the Raspberry Pi board as shown in figure 9.

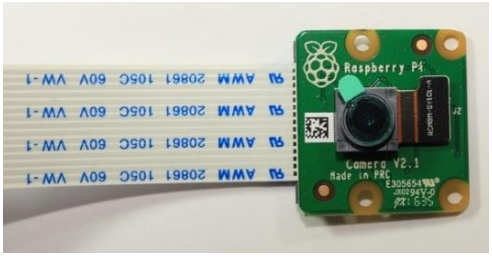

Figure 9 : Raspberry pi camera module v2

The device works with all models of Raspberry Pi 1, 2, 3 and 4 and can be accessed through numerous libraries build on it includes the Pi camera python library.

1.1.3. 5 volts Relay module

A 5 Volts relay module is a single or multi-channel relay module that works with a low-level trigger voltage of 5 Volts DC. The input voltage can be from any microcontroller or logic chip that outputs a digital signal.

Like most other relays, the 5 Volts relay module is an electrically operated, electromagnetic switch that can be used to turn on or turn off a circuit. In our project we used 5 Volts Relay module to open the smart door as show in figure 10.

Figure 10: 5 Volts Relay module [15]

1.2. Smart home space

1.2.1. BME280 I2C sensor

The BME280 I2C is a high precision combined digital pressure, humidity, and temperature sensor module with I2C interface and 5 Volts or 3.3 Volts operation. widely used in various applications such as weather monitoring, indoor air quality monitoring, and IoT devices. It is shown in figure 11.

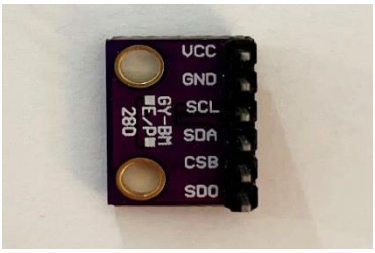

Figure 11: BME280 I2C sensor

The characteristics of this sensor are given in table 1.

Table 1: BME280 sensor characteristics

	Power	Readings	Accuracy
Temperature	3.3 to 5V	[-40, 80] °C	±1.0°C
Humidity	3.3 to 5V	[0, 100] %	±3%.
Pressure	3.3 to 5V	[300, 1100] hPa	±1.0 hPa

2. Software tools

2.1. Raspberry Pi OS

Raspberry Pi OS or Raspbian is a Linux-based operating system built specifically for Raspberry Pi. It is packed with all the necessary tools and features that are required for day-to-day use. With a vast collection of over 35,000 packages, it is a Linux variant customized to work seamlessly with the Raspberry Pi as shown in figure 12.

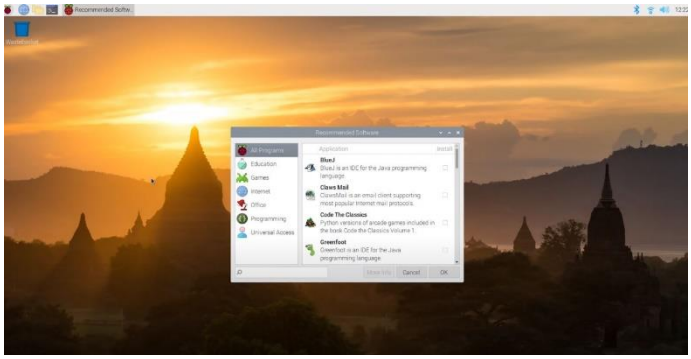

Figure 12: Raspberry Pi Os interface [12]

2.2. Python

Python is an interpreter, object-oriented, high-level programming language with dynamic semantics [11].

It is famous for its simple syntax and the large and robust standard libraries. It is used in numerous applications such as data analysis and visualization, desktop applications and software development and AI tasks. In our project, we used python 3.9.2 and its libraries as it supports modern techniques such as machine learning and AI.

2.3. Node-RED

The visual programming tool, Node-RED, is used for wiring all the hardware devices, APIs (accept the polities of the site web) and the online services in an easy and flexible way.

The system contains a browser-based flow editor that uses a wide range of nodes which look simply to be icons that can be wired together which can be shown in figure 13:

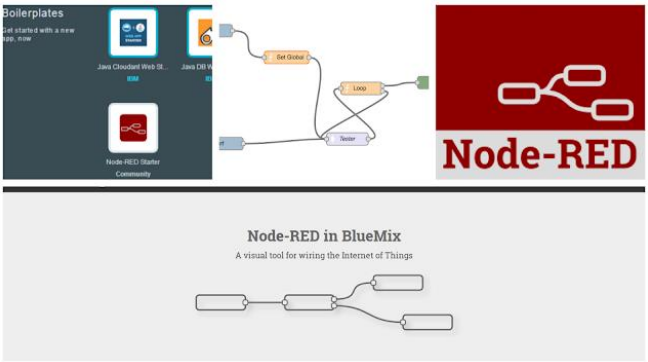

Figure 13 : Node-RED [9]

Node-RED is built on Node.js that makes it easy to run on low-cost hardware and resource constraint devices such as Raspberry Pi.

Conclusion

In this chapter, we did a study of both the hardware and software components that are necessary for the implementation of this project. In the upcoming chapter, we will focus on the implementation and testing of this project.

Chapter 4: Project realization

Introduction

This chapter provides an overview of this project we have developed, consisting of a smart door and a comfort home space. Moreover, it includes the testing and evaluation of the system's results. Finally, we will briefly discuss the system's performance based on the obtained results.

1. Overall design concept

The smart home project aims to create a comfortable and secure living space for homeowners. The proposed feature is a smart door framework that use human detection and interaction analysis. The first segment involves face recognition through a camera, which automatically opens and closes the door when it recognizes the homeowner. The second segment of this project focuses on a smart and comfortable living space, which features a dashboard that shows temperature, humidity, and pressure levels. Moreover, a security camera has been used to capture any unauthorized individuals and send an email with their photo. The structure of the proposed system is presented in figure 14.

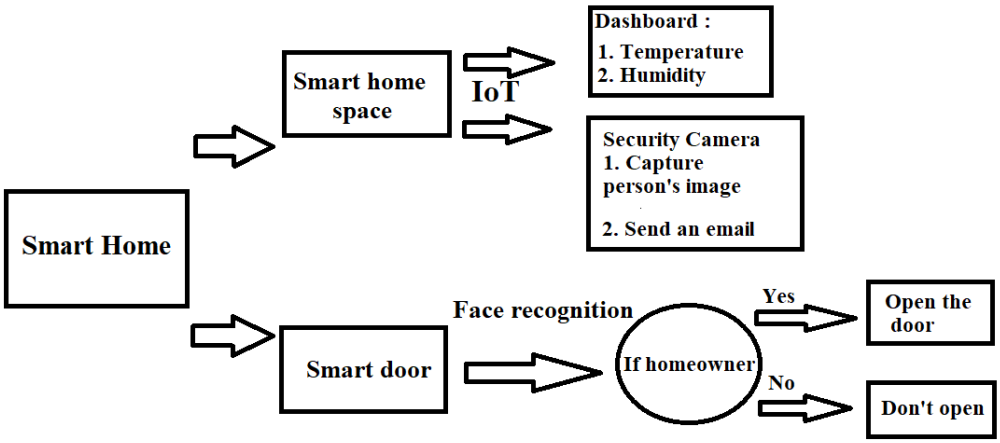

Figure 14 : Smart Home Structure

2. Smart door system

The control of entrance to the home is done using facial recognition by identifying the homeowners through a facial recognition process.

Given a complete database of the homeowners of the home, they can be identified easily, and the system can differentiate between a homeowner or a visitor which is a good way to ensure a safe space.

2.1. Dataset Acquisition

The first step of the project is collecting the data of the homeowners. We collected the data of two homeowners and for each one of them; we took photos using a program that captures their faces.

2.2. Live camera testing

This application is done directly through raspberry pi camera footage. The live application showed promising results as we can see in figure 15.

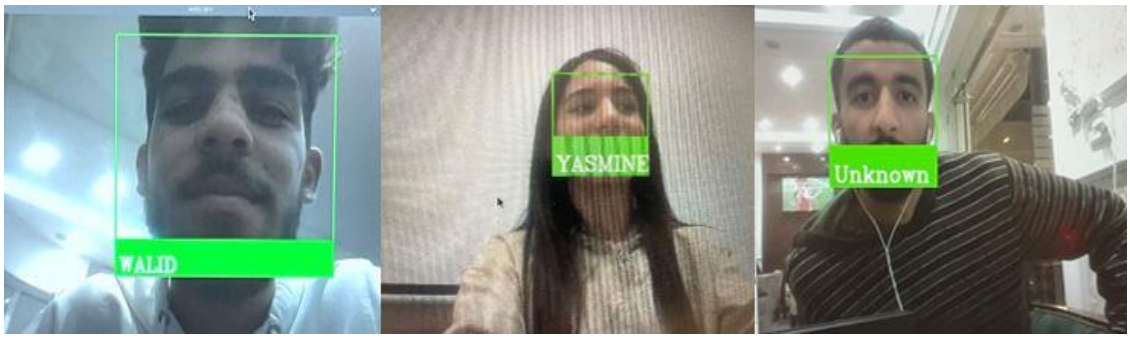

Figure 15:Live Camera Testing

2.3. Smart door lock system

When the homeowner is recognized via the camera, access is granted, and the door is unlocked automatically. If the person in front of the camera does not belong into the database and is not recognized, then the access is denied, and the door remains unlocked as showing in figure 16.

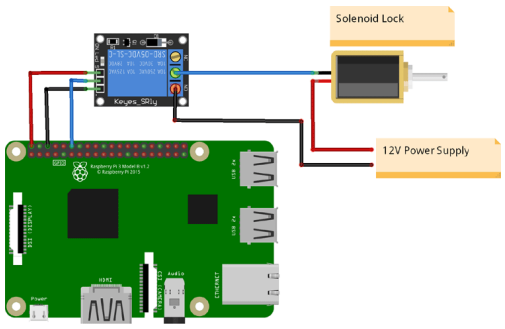

Figure 16 : Relay connected to Raspberry Pi [14]

3. Smart homespace

The second part of this project is dedicated to the smart homespace.

The homeowner can control different operations such as:

- Dashboard for temperature acquisition and adjustment
- Personal security camera with e-mail notification

3.1. Dashboard

The product is an air quality monitoring system collecting information from BME280 sensor across the open workspace.

The sensor, which is connected to our raspberry pi, measures temperature, humidity and pressure then gives the exact value to the user in the dashboard bellow via a communication protocol to exchange the data. The connection between the sensor and raspberry is shown in figure 17.

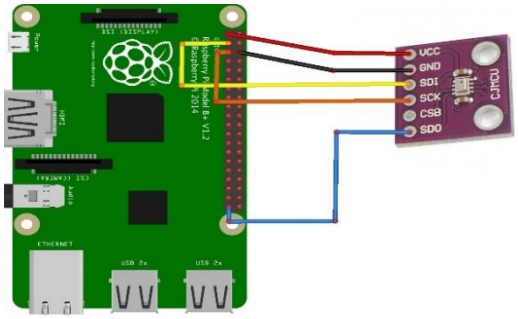

Figure 17: BME280 connected to Raspberry Pi [13]

3.2. Security camera

For a more secure environment for homeowners, we used a security camera, connected to the raspberry pi, that can detect the face of any person that enters other homeowner's personal space and takes a photo then sends it as an email to the homeowner with the object of "mail from Node-RED" as it can be shown in figure 18.

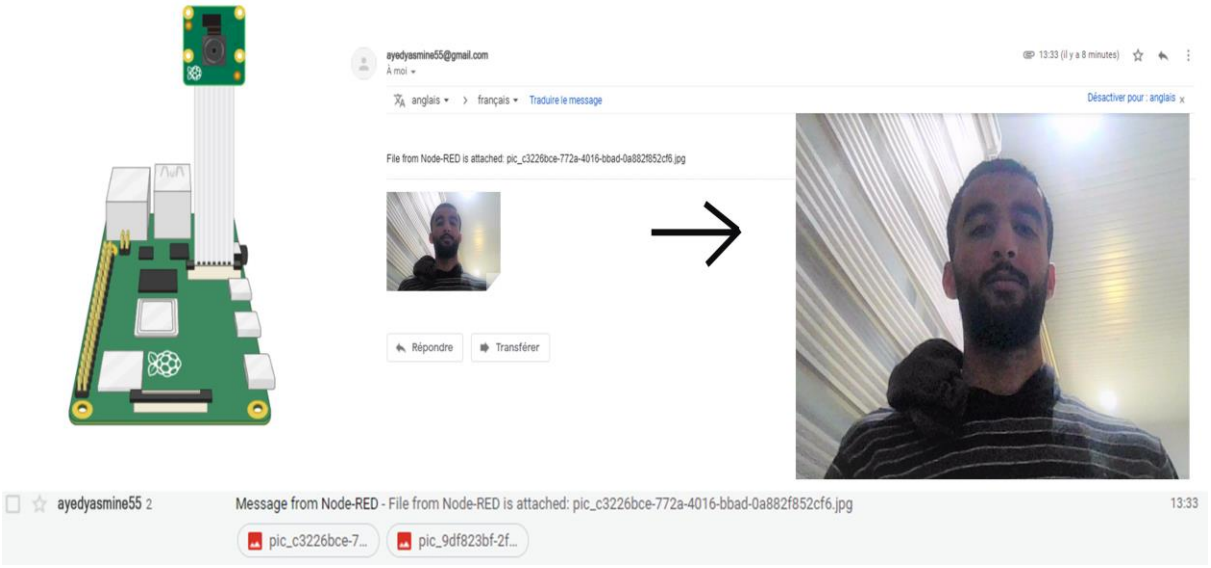

Figure 18:Sending an Email by the security camera system

4. Designed system: testing and evaluation

The performance of the system, in general, is good, we did the things that we wanted to accomplish in the project and our smart home is working the way we wanted. However, that doesn't mean that our system is perfect, we can improve it and add more to the system and make it better and more effective for the company needs and priorities.

4.1. Smart door

The smart door lock system worked perfectly. We have tested the smart door lock on two homeowners.

4.2. Smart homespace

The dashboard that we designed contains three major features: temperature, humidity and pressure reading through two gauges, shows the difference of the values through time in two charts, sends notifications if the value of the temperature, humidity or pressure is too high. With all these features, we can add more devices and tasks to the system.

With the security camera in the workspace, the homeowner can feel safer as he can know about every person that comes to his personal space. The performance of the security camera is accurate since it sends an email of the captured photo immediately after someone was detected more than one minute.

5. Discussion

During our work on this project, we found that the results were accurate and reliable and we made sure that the system worked well by testing it a lot to reduce errors and make sure it ran smoothly. We found that the system provided accurate results after enough testing. However, we did encounter some negative points in our progress, such as issues with the efficacy of the BME280 sensor. where the accuracy of the BME280 can be affected due to its sensitivity to electromagnetic interference and ambient light, and like any other sensor, it may exhibit measurement errors, especially when it is poorly calibrated or used in extreme environmental conditions

Conclusion

This project did an excellent job of bridging the gap between concept and reality by using the OpenCV library, which incorporates numerous computer vision and image processing algorithms based on AI techniques, to recognize homeowners and create a better living space for them through IoT. With additional time and a larger budget, many more features could be incorporated into this project.

General conclusion and perspectives

Thanks to this project, we did a notable step in the world of AI and we also discovered the world of IoT, its architectures and different applications.

The main aim of our project is to develop a system that allows both head of home and homeowners to live in a safe space.

We have designed an affordable and efficient home automation system that not only provides security through a smart door, but also creates a smart living space where technology meets comfort. With the help of an IoT dashboard, homeowners can easily manage and control various devices and appliances in their homes from a single interface.

Actually, we can add more to this project by inserting a smart assistant allowing homeowners to control various devices using voice commands. And with adding more features to IoT dashboard, we can manage the machines remotely and add other features to the dashboard based on the home requirements and needs.

The “Smart Home” project’s fundamentals are discussed and it can be changed and improved to satisfy specific needs of the users and the various approaches available for developing this system are based on adapted technology.

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