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HOME AUTOMATION SYSTEM USING COMPUTER VISION TECHNIQUE

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Abstract - Home automation using computer vision technology is an emerging field that aims to provide seamless and intelligent control of various home appliances and systems. This technology leverages the power of computer vision algorithms to identify and track objects, gestures, and movements, and then use this information to automate various tasks in the home environment. By integrating computer vision technology with home automation systems, homeowners can enjoy the benefits of a more intuitive and personalized home environment. Some of the potential applications of this technology include smart lighting, climate control, security, and entertainment systems. In this abstract, we will explore the key components of home automation using computer vision technology, the benefits and challenges associated with this technology, and some of the promising applications that are currently being developed. In this project we are going to work on home automation using computer vision technique. Normally home automation is controlled by using wireless devices, mobile phone and voice commands which indicated that a user is involved whil0.e accessing devices. In our project we are using facial detection system to check for the presence of human in a particular are and making the devices to operate without and command form the user.

Key Words: Computer Vision, Haar Cascade Classifier, Face detection

1. INTRODUCTION

The following project is a combination of two subject of engineering that is computer vision and the other one is embedded electronics. As home automation project often involve the utilization of computer engineering as well as embedded system development. Software or programs works as soul of the home automation system as they are in the background making decision for a particular device. On the other hand, embedded systems are hardware part of the home automation system in which the actual work takes place. The home automation devices basically used for accessing or switching electrical or electronic devices in our home. We are utilizing face detection system of computer vision to switch ON or OFF an electronic or electrical device. In comparison of PIR sensor, microwave sensor which has limited utilization and often limited by the area it works in, they need to be calibrated which increase the cost of development. Here we are using simple camera that can be of any type, cctv, ipweb cams etc. From these cameras the footage is taken and information about presence or absence of any person in the given space is determined.

1.1 Home automation

Home automation refers to the process of using technology to control and automate various functions within a home, such as lighting, heating and cooling, security systems, entertainment systems, and other household appliances. The aim of home automation is to provide greater convenience, comfort, and energy efficiency to homeowners, as well as to enhance the safety and security of their homes.

There are several components of a typical home automation system, including:

1. Sensors And Devices: These are electronic devices that are installed throughout the home, which detect changes in the environment, such as temperature, humidity, light, or motion. Examples of sensors and devices include thermostats, motion sensors, light sensors, and smart switches.

2. Control System: This is the central hub of the home automation system, which receives data from the sensors and devices and sends commands to them. The control system can be a standalone device or a software application that runs on a computer or mobile device.

3. Network: This is the communication infrastructure that connects the sensors, devices, and control system. The network can be wired or wireless, and it can use a variety of protocols, such as Wi-Fi, Bluetooth, or Zigbee.

4. User Interface: This is the interface that allows homeowners to interact with the home automation system, usually through a mobile app or a web portal. The user interface allows homeowners to monitor the status of their home and to control various functions, such as turning on lights or adjusting the temperature.

Some of the most common applications of home automation include:

1. Lighting Control: Home automation can be used to control the lighting in a home, including turning lights on and off, adjusting the brightness, and changing the color of the lights.

2. HVAC Control: Home automation can be used to control the heating, ventilation, and air conditioning systems in a home, which can help to reduce energy consumption and save money on utility bills.

3. Security Systems: Home automation can be used to control security systems, such as surveillance cameras, motion detectors, and door locks, which can enhance the safety and security of a home.

4. Entertainment Systems: Home automation can be used to control entertainment systems, such as TVs, sound systems, and home theaters, which can provide greater convenience and comfort to homeowners.

Overall, home automation provides a wide range of benefits to homeowners, including greater convenience, comfort, and energy efficiency, as well as enhanced safety and security. With advances in technology, home automation is becoming more affordable and accessible to a wider range of homeowners, and it is likely to become an increasingly popular trend in the coming years.

1.2 Computer Vision

Computer vision is a field of artificial intelligence and computer science that focuses on enabling computers to interpret and analyze visual information from the world around them. The goal of computer vision is to enable computers to understand and interpret images and videos in the same way that humans do, using advanced algorithms and mathematical models to analyze and make sense of visual data.

At its core, computer vision involves the use of sophisticated algorithms and techniques to extract meaningful information from visual data. This can involve processes such as object recognition, facial recognition, image segmentation, and motion detection, among other techniques.

One of the key challenges of computer vision is that visual data can be highly complex and variable, depending on factors such as lighting conditions, camera angles, and image quality. To overcome these challenges, computer vision researchers and practitioners use a variety of tools and techniques, such as deep learning, neural networks, and machine learning algorithms, to help computers "learn" how to recognize and interpret visual data in a more sophisticated and nuanced way.

Some of the applications of computer vision include:

1. Object recognition: Computer vision can be used to identify and recognize objects within images and videos, enabling applications such as automated image tagging and object detection in security and surveillance systems.

2. Facial Recognition: Computer vision can be used to recognize and identify individuals based on facial features, enabling applications such as security systems, access control, and biometric authentication.

3. Autonomous Vehicles: Computer vision is a key technology used in the development of autonomous vehicles, enabling them to "see" and interpret their surroundings in order to navigate safely and avoid obstacles.

4. Medical Imaging: Computer vision is used in medical imaging applications such as MRI and CT scans, enabling doctors and researchers to analyze and interpret complex medical images in order to diagnose and treat diseases.

Overall, computer vision is a rapidly growing field with a wide range of applications in industry, healthcare, transportation, and other fields. As computers become more sophisticated and powerful, and as our understanding of visual data and processing techniques continues to evolve, we can expect to see continued growth and innovation in the field of computer vision in the years to come.

2. SURVEY OF LITERATURE

Home automation using computer vision is a rapidly growing area of research that seeks to improve the functionality and convenience of homes by integrating computer vision technology into home automation systems. The literature on this topic covers a wide range of approaches and applications, and there have been numerous studies that explore the use of computer vision in areas such as security, energy management, and health monitoring.

One of the key areas of research in home automation using computer vision is in the development of intelligent cameras and sensors that can be used to monitor and analyze the behavior of people and objects in the home. For example, cameras can be used to detect when people enter and leave a room, and this information can be used to automatically adjust lighting and heating settings to optimize energy usage. Similarly, cameras can be used to detect unusual activity, such as someone breaking into the home, and alert the homeowner or security services.

Another area of research in home automation using computer vision is in the development of smart home assistants that can be controlled using voice commands or gestures. These systems use computer vision technology to recognize and interpret human gestures and speech, allowing users to control their homes using natural language and movements.

There has also been a growing interest in the use of computer vision in healthcare, particularly for elderly and disabled individuals. For example, cameras and sensors can be used to monitor the movement and activity levels of elderly individuals living alone, and alert caregivers if there are any signs of distress or unusual behavior.

Overall, the literature on home automation using computer vision is diverse and covers a wide range of applications and approaches. While there are still many challenges that need to be addressed, such as privacy concerns and the need for more sophisticated algorithms, there is no doubt that computer vision technology has the potential to transform the way we live in our homes.

3. OVERVIEW OF THE TECHNOLOGY

3.1 Haar Cascade Classifier

The Haar Cascade classifier is a machine learning-based object detection algorithm that is widely used in computer vision applications. It was developed by Viola and Jones in 2001 and has since become a popular technique for object detection in real-time applications, such as facial recognition and human detection.

The Haar Cascade classifier works by detecting features in an image or video stream and using these features to identify objects of interest. The features that are detected are called Haar features, which are simple rectangular features that can be used to represent the contrast between the light and dark regions of an image.

The Haar Cascade classifier consists of a set of trained classifiers, which are cascaded together to form a decision tree. The first classifier in the cascade examines the entire image or video stream and identifies regions of interest based on the presence of Haar features. Regions that do not contain any relevant Haar features are discarded, and the next classifier in the cascade is applied to the remaining regions. This process is repeated until all classifiers in the cascade have been applied, and the final output is a list of detected objects.

The training process for the Haar Cascade classifier involves the use of a large dataset of positive and negative images. Positive images contain the object of interest, while negative images do not. The algorithm then searches for Haar features that are more common in positive images than in negative images, and uses these features to train the classifier. This process is repeated multiple times, with each iteration refining the set of Haar features used in the classifier.

One of the key advantages of the Haar Cascade classifier is its speed and efficiency. The use of a cascaded decision tree allows the algorithm to quickly eliminate regions of the image that are not relevant to the object of interest, reducing the amount of processing required and enabling real-time applications.

Some of the common applications of the Haar Cascade classifier include:

1. Facial Recognition: The Haar Cascade classifier is widely used in facial recognition applications, enabling the detection and recognition of human faces in images and video streams.

2. Object Detection: The Haar Cascade classifier can be used to detect and recognize a wide range of objects, such as cars, buildings, and animals.

3. Pedestrian Detection: The Haar Cascade classifier is commonly used in pedestrian detection systems, enabling the detection and tracking of pedestrians in real-time.

Overall, the Haar Cascade classifier is a powerful and flexible object detection algorithm that has become a key technology in computer vision and machine learning. Its efficiency and accuracy make it a popular choice for a wide range of applications, and it is likely to continue to be an important technology in the years to come.

3.2 ESP8266 Microcontroller

The ESP8266 is a low-cost, low-power microcontroller with integrated Wi-Fi capabilities. It was developed by the Chinese company Espressif Systems and was first released in 2014. Since then, it has become a popular choice for a wide range of Internet of Things (IoT) applications, due to its small size, low power consumption, and ease of use.

The ESP8266 microcontroller is based on the Xtensa LX106 processor, which runs at a clock speed of 80 MHz. It has a 32-bit RISC architecture and supports up to 16 MB of external flash memory. The microcontroller also includes a variety of built-in peripherals, such as GPIO pins, SPI, I2C, UART, and ADC.

One of the key features of the ESP8266 is its integrated Wi-Fi capabilities. It includes a Wi-Fi module that supports 802.11 b/g/n wireless standards, with a maximum data rate of 72.2 Mbps. This allows the microcontroller to connect to Wi-Fi networks and communicate with other devices on the Internet.

The ESP8266 is programmed using the Arduino IDE or the Espressif Systems' official software development kit (SDK). The programming language used is C/C++. The SDK provides a range of libraries and examples to simplify the development process, and the Arduino IDE has a large community with many libraries and examples available for use.

Some of the common applications of the ESP8266 microcontroller include:

1. **Home Automation:** The ESP8266 can be used to control and automate various devices in the home, such as lights, thermostats, and appliances.
2. **IoT devices:** The ESP8266 is a popular choice for building IoT devices, such as environmental sensors, smart locks, and security cameras.
3. **Wearables:** Due to its small size and low power consumption, the ESP8266 is also suitable for use in wearable devices, such as smart watches and fitness trackers.

Overall, the ESP8266 microcontroller is a powerful and versatile platform for building a wide range of IoT devices. Its integrated Wi-Fi capabilities, low cost, and ease of use make it an attractive option for both hobbyists and professional developers alike.

3.3 Methodology

Implementing home automation using computer vision involves several steps and methodologies, including hardware and software design, image processing, and machine learning. Below are the general steps involved in the methodology for the implementation of home automation using computer vision:

1. Hardware Design: The first step in implementing home automation using computer vision is to design the hardware components required for the system. This includes selecting the cameras, sensors, and other hardware components needed to capture images and detect objects.

2. Image Processing: Once the hardware is selected, the next step is to process the images captured by the cameras. This involves removing noise, filtering the images, and enhancing the contrast to make it easier to detect objects.

3. Object Detection: After the images are processed, the next step is to detect objects in the images using computer vision algorithms. The Haar Cascade classifier is a popular algorithm used for object detection in computer vision.

4. Control System Design: Once the objects are detected, the control system must be designed to automate the devices. This includes programming the microcontrollers to send signals to the devices based on the object detected.

5. Testing And Deployment: Once the system is designed and built, it must be tested and deployed in the home environment. This involves testing the system under different conditions to ensure it works as intended and making any necessary adjustments.

6. Maintenance: Finally, regular maintenance is required to ensure the system continues to function correctly. This includes monitoring the system for errors, updating the software as necessary, and repairing any hardware issues that arise.

Overall, implementing home automation using computer vision involves a combination of hardware and software design, image processing, and machine learning techniques. By automating devices based on the objects detected, the system can provide a more convenient and efficient home environment for the user.

4. ALGORITHM

4.1 Face detection

1. Load the necessary libraries like opencv, request.
2. Create two variables for url1, url2 which hold the URL for the sending request to ESP8266 to turn on or turn off the light.
3. Create a flag to check whether a face has been detected or not.
4. Load the cascade classifier which has a pre-trained model for face detection.
5. Initialize the camera.
6. Start a loop to read every frame captured by the camera
7. Create a variable frame to store the single frame received by camera.
8. Convert the colorful image to grayscale image as the HAAR cascade classifier will only work when the image is in grayscale.
9. Create a tuple to store all the details when the HAAR cascade classifier detects a face.
10. If a face is detected then drawa rectangle over the face and set the flag to True.
11. Perform a check on the value of the flag.

12. If the flag is True sed a request to the ESP8266 controller to turn on the light and set the flag to False.
13. Else send the request to the ESP8266 controller to turn off the light.
14. All the step from number 7 to 13 is processed again and again until the user manually exits the program.

4.2 Switching in ESP8266

1. Load the required libraries for this project, i.e. ESP8266WiFi.h, ESP8266WebServer.h
2. Initialize a const char* variable to store the ssid and another const char* variable for the password.
3. Declare the ESP8266WebServer object to set the port address.
4. Declare the GPIO pin for activation on face detection, here we have defined pin 2, which can control the built in led on the ESP8266.
5. Start the WIFI by providing the function WiFi.begin with the ssid and the password.
6. Create an object to listen to the incoming request from the server.
7. On receiving a request check form the URL http://192.168.43.191/off, turn off the led light.
8. Else if the received request is from the URL "http://192.168.43.191/on"
9. The step from 6 to 8 is processed in continuous loop until the system power supply is cut.

5. OUTPUT

5.1 Project Output

After complete development of the project. The result is shown in the given section.
In Fig 1, Program is able to identify human face using haar cascade classifier for human face detection

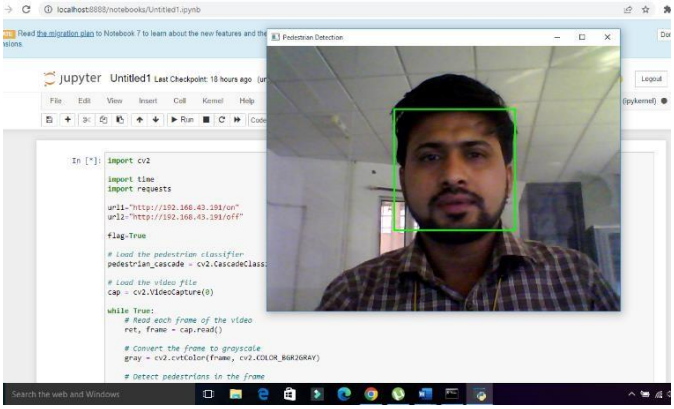

Fig 1: identify human face

As a result of the human face detection, the program detects presence of human in the given space and it instructs the microcontroller in this project ESP8266 microcontroller to turn on the light, which is visible from the given picture.

In, Fig 2. Led on the microcontroller turn ON when human face is detected.

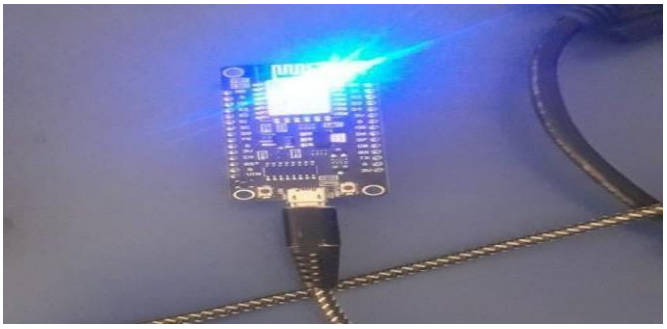

Fig 2. Microcontroller turns ON

In the below figure 3, When No human face is detected hence the signal for turning off the light will be passed to ESP8266 microcontroller.

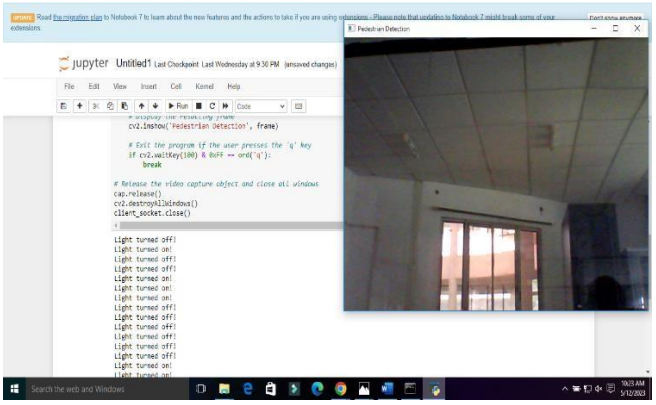

Fig 3. No human face is detected

Now, in the given figure 4, we can see that the led light is turned off due to absence of any human face in the camera which means that the given space is empty.

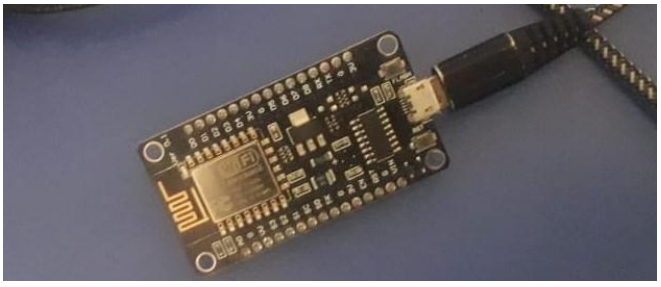

Fig 4: the led light is turned off

5.2 Discussion

The project is divided into two parts one is the image processing and the another one is embedded system part that help to control the switching of the electrical or electronic devices based on presence of human in the given area. Here in this project we are taking into consideration the face detection to identify a human presence in a given area. The project is working as per the requirement of project.
As in every project there are certain limitation in this project:
1. False face detection: Sometime the system identifies false face which gives false command to the system to switch on the light. This can be solved by adopting some morphological operation on the live footage.
2. Poor light condition: In case of poor light condition or no light condition the system fails to work.
3. Lag: Sometime the embedded system lags when the program tries to send large volume of data. Till now no lagging has been reported.

6. CONCLUSIONS

In conclusion, home automation using computer vision technology offers a promising solution to enhance the convenience, security, and efficiency of modern homes. By integrating cameras, sensors, and microcontrollers with sophisticated image processing and machine learning algorithms, the system can detect and recognize various objects and automate devices accordingly. This can range from turning on/off lights and appliances to adjusting the temperature and monitoring the security of the home. With the advancement of technology, the implementation of home automation using computer vision has become more accessible and affordable, making it a viable option for both individual homeowners and commercial applications. While there are still challenges and limitations to overcome, such as privacy concerns and the reliability of the technology, the potential benefits are vast and promising. Ultimately, home automation using computer vision technology can improve the quality of life and contribute to a more sustainable and intelligent future for homeowners and society as a whole.

7. FUTURE SCOPE

There are several potential avenues for future work on home automation using computer vision technology. Some of these include:

1. Enhanced object recognition: While current computer vision algorithms have made significant progress in object recognition, there is still room for improvement. Future work could focus on developing more accurate and efficient algorithms for object detection and recognition, potentially using deep learning techniques.

2. Integration with other technologies: Home automation using computer vision technology could be integrated with other technologies, such as voice assistants, to provide even greater convenience and accessibility to users. Additionally, integrating the system with smart energy management systems could help reduce energy consumption and promote sustainability.

3. Privacy and security: As with any technology that involves capturing images and data from within the home, privacy and security are important concerns. Future work could focus on developing better security protocols and privacy policies to ensure user data is protected and not misused.

4. User interface and customization: To improve user adoption and satisfaction, future work could focus on developing more intuitive and customizable user interfaces for home automation systems. This could include features such as personalized voice commands, customizable device settings, and improved feedback on system performance.

5. Real-time monitoring and response: Finally, future work could explore ways to enable real-time monitoring and response for home automation systems. This could involve integrating sensors and cameras to provide real-time data on the home environment, and developing systems to respond automatically to changes in the environment, such as adjusting the temperature or turning on/off devices based on occupancy.

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