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IoT Based Two Way Safety Enabled Intelligent Stove with Age Verification Using Machine Learning

Prof. Swetha V, Mohammed Raquim, Saniya Farnaz, Ravind Singh, Sowmya

Computer Science &Engineering

RGIT

Abstract— **Smart embedded systems have become a core component in the latest technologies, and IoT based smart embedded system is the trendiest field in the research area. In our research, we are proposing an IoT based smart stove. Any accident might occur at any time from a stove. So we are designing a two-way safety enabled stove with a child lock system and gas leakage detection feature. The intelligent stove will try to ensure safety and will detect age from real-time video streaming. Our main focus is a child would not be able to turn the stove on. As well as, the stove can *entitle* safety via gas detection alarm. We are using a Raspberry Pi and Gas Detection Module with a buzzer for the hardware implementation. Also, we are applying a**

Machine Learning object detection algorithm (Haar Cascade) and a deep learning architecture (CNN) for the system execution. Since our stove is IoT-based, the stove is ensuring safety remotely as well as manually which will try to prevent accidental occurrences.

Key words— IoT, Embedded System, Smart Embedded System, Child Lock System, Age Detection, Raspberry Pi, Buzzer, Machine Learning

I. INTRODUCTION

Internet and embedded systems are one of the major growing fields that can change the way people live their daily lives. The objective of embedded devices is that they build a unique computing system. An embedded system generally runs as a single operation. However, these embedded devices that are connected to the internet can communicate through other network devices. Moreover, these devices provide flexibility and facilities to improve the domestic environment. People have the control to operate and monitor the devices remotely through the IoT (Internet of Things) features.

In this research, we are presenting a smart embedded device that is an IoT based smart stove. The stove will provide us two- way protection: Real-time age detection for child lock and safety from accidental gas leakage. We are doing this research in the perception of Bangladesh. The stove will be both manual and electric. In our work, we are introducing an IoT based smart system that will be representing the concept of our smart stove. For the system, we are using Raspberry pi which is a microcomputer. Other necessary sensors, modules, and apparatus are interfaced with the raspberry pi.

The Raspberry Pi is a credit-card sized, low-cost computer that connects to a PC screen or TV, and utilization a common console and mouse. It is a capable little device that permits people of all ages to explore. It is capable of doing everything an individual would expect a personal computer to try to, from browsing the web and playing high-definition video, to creating spreadsheets, word-processing, and playing games. Moreover, the Raspberry Pi has been utilized in a good array of digital maker projects, from parent detectors to weather stations and music machines. [17]

On account of the safety measures, we have proposed the child lock in our system. Hence, we have appended the age detection method so that a child below 12 years old cannot turn on the stove. For the age detection, we are using the Raspberry Pi Camera Module which is directly connected to the raspberry pi. And, for the software implementation, we have interfaced with OpenCV (a library) python codes with algorithms and trained datasets. Python supports both procedure-oriented and object-oriented programming which is one of all the key python features. Python joins astounding force with clear syntax. Python has exceptionally abnormal state dynamic information types and dynamic composing including modules, classes, exemptions. There are interfaces to numerous framework calls and libraries, even as to different windowing frameworks. [1] Two algorithms are being used in the age detection procedure. One is the Haar Cascade Classifier Algorithm. Haar Cascade is a machine learning object detection algorithm that can identify objects present in a picture or video. The HAAR-like features used in the system are tested across a standard face database where the caffe model file contains the information of the trained neural network (trained model) and the prototxt file defines the layers in the neural network, each layer's inputs, outputs, and functionality. Here, we have collected trained datasets for age detection and the datasets are trained from a machine learning classifier. [2] Machine learning a utilization of Artificial Intelligence (AI) that gives systems the capacity to

consequently take in and improve from experience without being expressly modified.

Another algorithm is a deep learning architecture, which is a classification algorithm (CNN) for the system execution. CNN (Convolutional Neural Network) is a class of deep neural network in deep realizing which comprises of different convolutional layers where each layer measures the yield of the past layer to deliver a vigorous and reduced yield. [3] The convolutional neural network (CNN), utilizes learned convolutional pieces and downsampling techniques to perform AI errands with pictures. CNN's are more qualified to picture-based assignments than perceptron's since they learn dependent on gatherings of pixels instead of considering every pixel autonomously. [4]

In our work, the system has another safety measure that is accidental gas leakage detection. Therefore, we are using a Gas and Smoke Detection Module. For the detection, we are interfacing python codes with the raspberry pi system.

Since our system is IoT based, both features (age and gas leakage detection) will be associating with the IoT server providing the necessary values and outcomes. The Internet of Things (IoT), likewise called the Internet of Everything or the Industrial Internet. It is another innovation worldview imagined as a worldwide network of machines and gadgets fit for communicating with one another. The IoT is perceived as one of the most significant territories of future innovation and is increasing immense consideration from a wide scope of enterprises [5]

Here, ThingSpeak is introduced as the IoT server. ThingSpeak is an open-source Internet of Things (IoT) application and API to store and bring information from things utilizing the HTTP and MQTT convention over the Internet or employing a Local Area Network. It empowers the making of sensor logging applications, area following applications, and an interpersonal organization of things with announcements. [18]

II. RELATED WORK

A. *Age Detection:*

For age detection several articles and journals have been published over years. Untung et al. [6] states that the availability *of* computer systems has created a variety of automated applications in personal identification. From the different attributes of biometrics, face recognition procedures predominantly face verification has become a region of research. Marques, I. et al. [7] have informed, researchers became interested in face recognition techniques in the 1960s, it was started by Woodrow W. Bledsoe cooperate with the U.S. Department of Defence and Intelligence Agency. Bledsoe design and implement a semi-automated system, some facial coordinates are calculated manually by a human and then a computer calculates the information for face recognition. In 1999, Kwon and Lobo [8] built up the very first technique for age detection focusing on geometric features of the face that decide the proportions among various dimensions of facial features. These geometric features separate children from adult effectively but are unable to recognize between young adult and senior adult. In another research article in 2020, Viriri, S. et al. [9] proposed a novel one after another CNN approach, to accomplish robust age group and gender classification of unfiltered real-world faces. Nevertheless, the impact of age progression on face verification become a challenge to decide the resemblance of image pairs from singular faces considering extremely restricted of data base accessibility. In recent years, face verification techniques based on age progression has not been widely studied. This is because of the limitations of the database. [6]

B. *Haar Cascade: A Machine Learning Object Detection Algorithm:*

In early 2000's Haar-like features and Cascade had been introduced. Before that many face detection methods were approached. Viola, P. et al. [10] had portrayed an machine learning approach for visual item detection which is capable of preparing images very quickly and accomplishing high detection rates. The authors proposed a strategy for joining progressively more perplexing classifiers in a cascade structure which permits background areas of the image to be immediately disposed of while spending more calculation on promising object-like areas. In another research article, Chris et al. [11] presented an all-inclusive arrangement of Haar-like features past the standard vertically and horizontally aligned Haar-like features and the 45° twirled Haar-like features. Likewise, they expressed that the extended rotated Haar-like features depend on the standard Haar-like features that have been rotated dependent on entire integer pixel based rotations. These rotated feature values as well can be calculated utilizing rotated integral images.

C. *Convolutional Neural Network: A Deep Learing Architecture:*

The first approach for Convolutional Neural Network (CNN) was proposed by Yann LeCun in 1994.He is notable for his work on optical character recognition and computer vision utilizing convolutional neural networks (CNN), and is an establishing father of convolutional nets. [12] Then many research articles have been published regarding deep learning and its architectures i.e. CNN. In 1997, Lawrence, S. et al. [13] presented a hybrid neural-network solution which compares favourably with other methods. The system joins local image sampling, a self-organizing map (SOM) neural network, and a convolutional neural network. Another article in 2015 has been published over age and gender classification using deep-CNN. Hassner, T. et al. [2] introduced that by learning representations using deep convolutional neural networks (CNN), a significant increment in execution can be achieved on these tasks. Hence, they proposed a simple convolutional net architecture that can be used even when the amount of learning data is limited.

D. *Gas Detection:*

There are lot of works for detecting gas in different articles. Many methodologies for gas detection have been approached in different articles and journals. Previously, in 1989 Heinrich et al. [14] have developed a leak detection system using flexible hydrocarbon sensing cable that is installed in pipelines. The system also has a simple electrical circuit which can detects a leak anywhere along the length of the sensor. In the early 2014

Tanvira et al. [15] have developed a GSM based gas leakage warning system using microcontroller. The authors claimed that, the system will also turn on an exhaust fan for throwing the gas out. Raspberry pi is now frequently used for IoT based smart home appliances. Sourabh et al. [16] proposed an IoT based industrial monitoring system using raspberry pi in 2019. They have affirmed, their system can detect both gas and fire and after detection this system will notify by using GSM.

III. Proposed Methodology

A. *Overall methodological aproach:*

In this research, a device is developed which is constructed of a microcomputer (Raspberry Pi), a pi camera and other embedded system project apparatus. The device will be attached to the stove which will be providing the safety features. Furthermore, the stove is IoT-based, therefore people may also monitor it from anyplace with their internet-activated smart devices i.e. Smartphone, tablet, PC etc.

B. *Softwares for System Execution:*

The raspbian version we are using is Raspberry Pi OS (32-bit) with desktop and recommended software. The software coordinated with raspberry pi and IoT based server utilizes python 3.8 software. Moreover, we are using Thingspeak for the remote access and to monitor the whole system i.e. the stove. In our research, we have created a private channel using local area network. The channel has two fields named "Gas Detection" and "Age Detection". We have copied the given API key (write) and interfaced it with the python codes. So that, we can monitor the system remotely. Also, we are using Fritzing 0.9.3b software for designing the physical and schematic diagram of the system.

C. *Apparatus We are Using:*

For the hardware implementation we are using Raspberry Pi 3 Model B v1.2, MQ-2 Flammable Gas & Smoke Sensor, Raspberry Pi Camera Module Rev 1.3 - 5MP, TMB12A12 *Electromagnetic* Active buzzer 12V DC, LED Light, Resistor-330 ohm, Breadboard and Jumper Wires.

The raspberry pi supports the UNIX system and python language. Different apparatus such as gas detection module, buzzer, LED light and resistor are connected with the raspberry pi's GPIO header. Also, the pi camera module plugs directly into the 15-pin MIPI CSI (Camera Serial Interface) connector on the Raspberry Pi and it is designed especially for interfacing to cameras. The MQ-2 Gas and smoke detection module is used for detecting any atmospheric gas leakage or smoke. It basically recognizes H2, LPG, CH4, CO, Alcohol, Smoke or Propane. Because of its high sensitivity and quick response time, actions can be taken at the early as possible. And the buzzer is used in our work as an alarming tool. If the gas detection module could sense any gas the buzzer will give continuous beep sound. Furthermore, the LED light is connected to the raspberry pi GPIO header with jumper wires through breadboard also we are using the resistor from preventing the full voltage of the LED light. It is 330 ohm and the colour code is orange, orange, brown and gold.

D. *Analytical Procedure:*

a) Physical Diagram: The physical diagram indicates the interfacing of the hardware tools with the raspberry pi.

In Figure 1, the raspberry pi camera is directly connected to the CSI connector of the raspberry pi. Additionally, here in this research, the LED light is representing the switch of the stove. If a person will try to turn the stove on, then the camera will be detecting his/her age from their faces. If the person is an adult *ICCCI* the stove will turn on i.e. the LED light will light up. In contrast, if a child is trying to switch on the stove, the stove will not allow the child to turn it on i.e. the LED light will remain off. We are using a 330-ohm resistor for averting full voltage which will prevent the Raspberry pi from any damage.

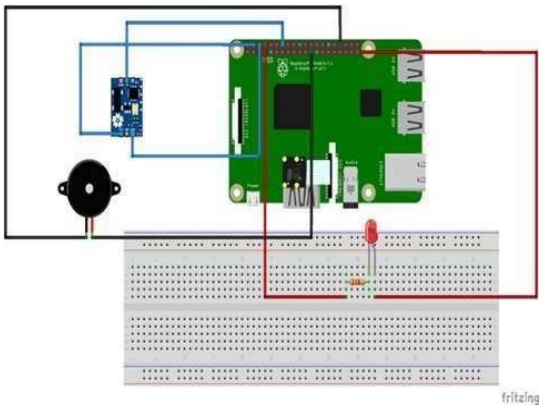

Figure 1: Physical Diagram of the System

The Gas detection module and 12V active buzzer are attached to the GPIO header with jumper wires. The gas detection module will be sensing if there is any gas leakage plus the buzzer will immediately alarm while detecting gas. We are also using a breadboard and jumper wires for connecting LED light, resistor, buzzer and gas detection module with the raspberry pi.

a) Schematic Diagram: Here, the schematic diagram depicts the connections of the apparatus with the raspberry pi's GPIO header and CSI connector. The diagram shows in a form of a picture that shows the main features or relationships but not the details. Moreover, the wiring does not entirely corresponds to the physical arrangements of the real device. Moreover, the wiring does not entirely corresponds to the physical arrangements of the real device.

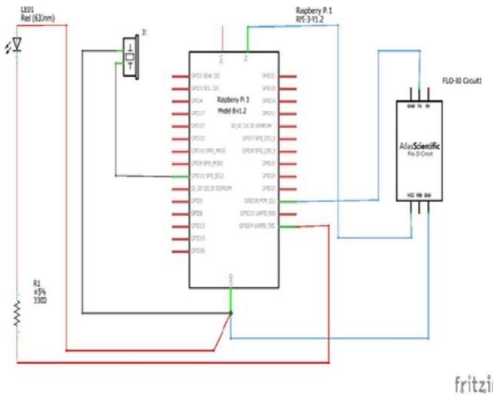

Figure 2: Schematic Diagram of the System

In Figure 2, in the gas detection module, DO (Digital Output) is connected to the GPIO pin 18, VCC of the module is connected to the 5V of raspberry pi and the GND of the module is connected with the GND of the raspberry pi. The buzzer is interfaced with the gas detection module and its positive end is attached with raspberry pi's GPIO 11 pin and the negative end is connected with the GND of the raspberry pi. Furthermore, the LED's positive (anode) lead is interfaced with a 330-ohm resistor and connected with the raspberry pi's GPIO 14 pin. And, the negative (cathode) lead is connected with the raspberry pi's ground. Though the CSI connector of the raspberry pi is not showing in the schematic diagram, the raspberry pi camera module is directly attached to the CSI connector of the raspberry pi (which is shown in the physical diagram of the system).

IV. Result And Discussion *A.*

Entire Hardware Setup:

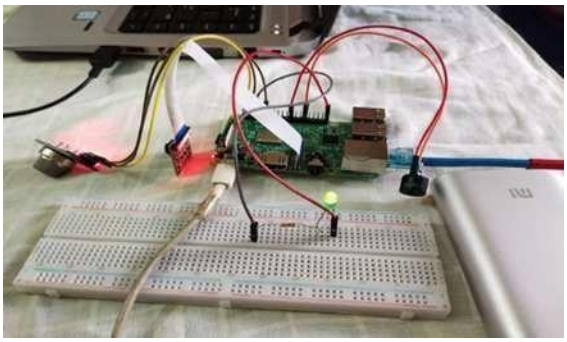

Figure 3: Entire Hardware Setup

Here are the apparatus and raspberry pi is assigned. Figure 3 below demonstrates the trial setup of the whole system. Also, the setup gives briefs data (which is also shown as line chart form) with values as well as time and date on the ThingSpeak server.

TABLE I. Test Condition For Raspberry Pi Camera Module And Led (For Age Detection)

SI. NO	Raspberry Pi Camera Module	LED Light
1.	Child's face detected (age<12)	Remains off
2.	Adult's face detected (age≥12)	Turns on

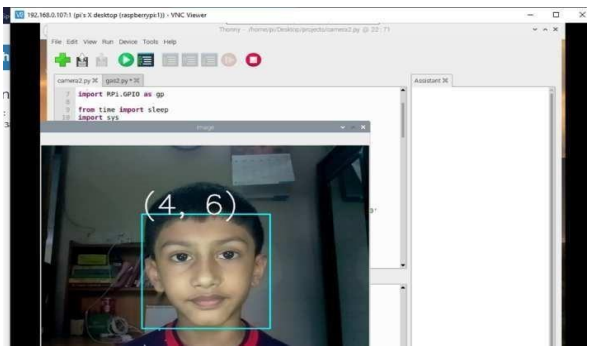

Figure 4: Age Detection Output Picture (Child)

ICCCI

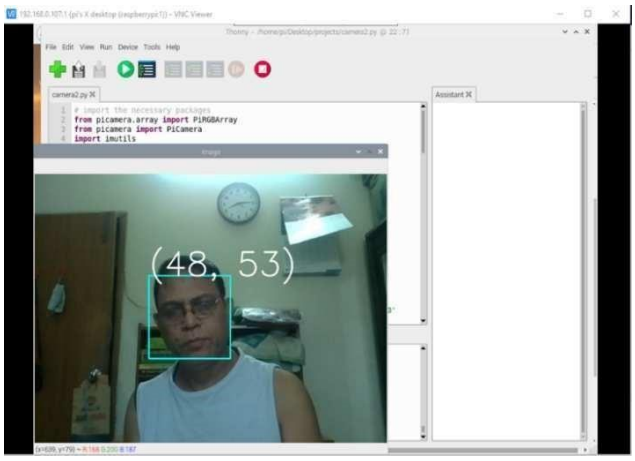

Figure 5: Age Detection Output Picture (Adult)

In Figure 4 and Figure 5, OpenCV Age detector predicting a Child's as well as an Adult's age range from their real-time facial images through the video streaming. Here, the child's age is 5 years old and the adult's age is 49 years old. Though the accuracy of the age prediction is not 100%, the range of the age estimation is almost accurate. The age range has been shown above the frame.

TABLE II. Test Condition For Gas Detection Module And Active Buzzer (For Gas Leakage Detection)

SI No.	Gas Detection Module	Buzzer
1.	No gas detected	Off
2.	Gas detected	Sound

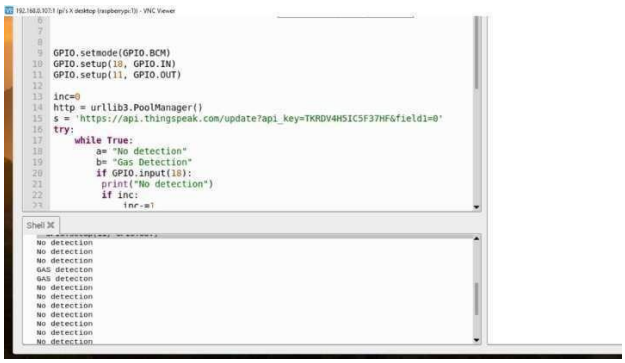

Figure 6: Gas Detection Output Picture

In Figure 6, here is the output of the gas detection module sensing gas. Furthermore, if the gas detection module senses any gas then the buzzer will give a beep sound. Conversely, if the gas sensor does not sense any gas the buzzer will remain off.

B. Outputs for IoT (Thingspeak):

In Figure 7, Field-2 Chart has detected two person's age and depicted it as a line chart form too. Here, one person's age is 50

(adult) and the other one is 5 (child). The line chart will continue to go up and down with the value of age.

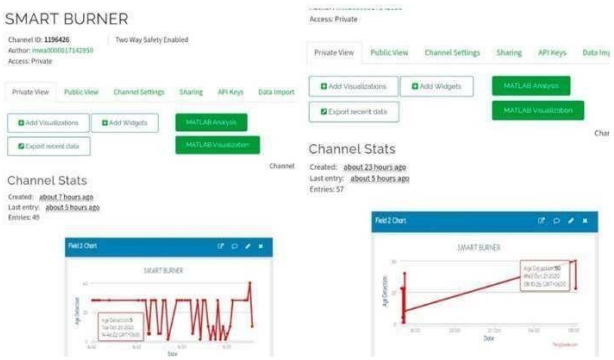

Figure 7: Field 2's Output (Age Detection)

In Figure 8, after the system execution, Field-1 Chart has detected gas and depicted it as a line chart form. When there was no gas detection the line remained flat giving the value of 0. Then after the gas detection, the value here is 1 and it is slowly decreasing over time.

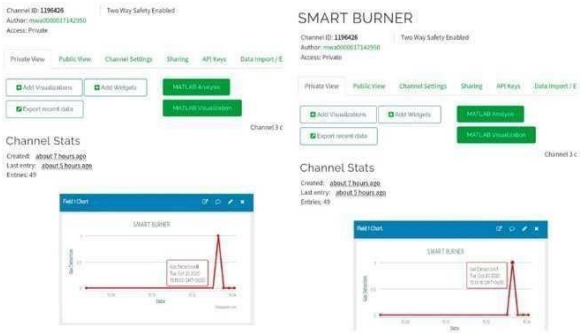

Figure 8: Field 1's Output (Gas Detection)

C. Benefits:

Our proposed smart stove has two-way safety enables i.e. a child lock system and an accidental gas leakage alarming system. Since the stove is IoT based the users can ensure safety by monitoring it remotely. Moreover, the people who are deaf or have mutism can also ensure safety by monitoring it from the IoT server. Also, blind people can hear the accidental gas leakage alarm and take action accordingly.

V. CONCLUSION

Though many works have been done previously relating age detection and gas leakage detection separately, we have proposed a combined method of both regarding the safety measurements. We have enabled two-way safety features in our smart stove i.e. a child lock system in the stove. And the other feature is, our smart stove will give an alarm if there is any accidental gas leakage. Since our smart stove, we have proposed in this paper is IoT based so the users will be able to monitor the stove remotely and prevent any accidental *ICCCI* occurrences. Moreover, our system has been established in the perception of Bangladesh.

The system of the smart stove is IoT based so the users can monitor it remotely to ensure safety. A GSM module can be installed in our system so that the users can not only monitor the stove but also be notified via an email or SMS.

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