

# Web Cam Security Using Beagle Bone Black

Vivekananda Reddy Sappidi  
dept. of Computer Science  
George Mason University  
Fairfax, USA  
vsappidi@gmu.edu

Mahaveera Sai Teja Veluduti  
dept. of Computer Science  
George Mason University  
Fairfax, USA  
mveludut@gmu.edu

**Abstract**—Security and surveillance systems play a pivotal role in safeguarding homes and businesses against unauthorized access and potential threats. In this paper, we present a novel security door camera system implemented on the Beagle Bone Black platform, a low-cost, open-source embedded computer. Our system leverages the power and versatility of the Beagle Bone Black to create a robust and cost-effective solution for monitoring and securing entry points. We explore the hardware and software components of the system, including camera integration, real-time image processing, and remote access capabilities. Additionally, we discuss the system's performance and security features, demonstrating its potential as a reliable tool for enhancing security and providing peace of mind to users.

## I. INTRODUCTION

Security issues have grown rapidly in the past few months and years, necessitating the development of novel solutions that combine price, functionality, and ease of use. Doorbell cameras, often known as video doorbells or security door cameras, are becoming increasingly popular as an essential component of modern security systems. As we all know it is important to keep out homes safe for us and our kids to have a happy family. Web cameras can lead this to the factor. These gadgets offer real-time surveillance and remote access, letting home owners know whenever or whoever presses a switch, they can view the person. [1] The Beagle Bone Black, a single-board computer created by the Beagle Board.org community, has proven to be a viable platform for a wide range of embedded applications. Because of its small size, low cost, and extensive networking choices, it is an excellent contender for designing security systems. We offer a full overview of our security door camera system built on the Beagle Bone Black platform in this article. Organizational editing before formatting. We use a simple switch i.e., doorbell, we will connect a vibration detector whenever a person knocks on the door. So, if the bell is pushed the camera opens and takes a picture and sends an email notification to the owner. It uses a Webcam as the Security camera. This Webcam is directly connected to the Beagle Bone Black, we power the Webcam through USB. The project is used for the purpose when the owner of the house is out, and any person comes and knocks, they can view through there and phone and even if they are at home they can check before opening the door. The selection of the project involving a web cam security doorbell using Beagle Bone Black was driven by several like Relativity, Security and Surveillance systems have become increasingly vital in today's

world due to rising concerns about safety and property. Beagle Bone Black is an open-source Linux – based platform. This project gain hands on experience in embedded systems, real-time image processing, networking, and security protocols, contributing to our technical skill development. Home security is a top priority for both homes and businesses. Traditional security systems frequently rely on passive measures like motion detectors and alarms, which only notify authorities or tenants after an intrusion has happened. These solutions, however, lack the ability to provide real-time monitoring and remote action, leaving households susceptible during sensitive times. Technological advancements have created new opportunities for proactive security solutions. Doorbell cameras, often known as video doorbells or security door cameras, have grown in popularity as a way to improve home security. These devices combine real-time monitoring with remote access, letting households and businesses to remotely watch their entry points and receive rapid notifications of activity. Our suggested system employs a simple switch, or doorbell, in conjunction with a vibration detector to initiate the capturing of an image and the transmission of an email notification to the homeowner. As the security camera, a webcam is immediately linked to the Beagle Bone Black and powered via USB. This setting allows the system to collect clear photos of people approaching the entry point, which is useful for security evaluations and decision-making. In the subsequent sections of this paper, we provide a detailed account of our system's architecture, hardware components, software design, and performance evaluation, showcasing its effectiveness as a security tool in today's dynamic and evolving security landscape. [4]

## II. METHODOLOGY

The security door bells are introduced to the industries in mind using a define software technologies. Firstly, conduct an interviews with the users who are home owners to understand their security needs and expectations. we can analyze the existing security systems and get a grip about it. Creating a detail structure about the web camera security using beagle bone black. defining the software modules, including the Beagle Bone Black control software, image processing algorithms, and email notification functions. Choosing appropriate languages and modules to use such as performance, quality and expectations of the video. Developing the software modules

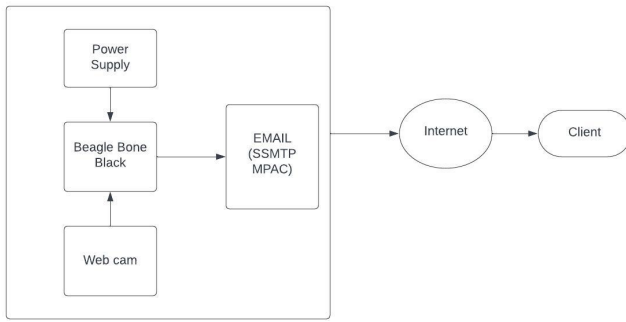


Fig. 1. Software Architecture

related to design specifications, and understanding to Code standards. Working with the email integration [2]. The Beagle Bone Black is powered by a Linux-based operating system, allowing for the creation of custom software suited to specific camera security requirements. Custom apps for managing webcam security settings, data processing, and remote access can be constructed. Conduct testing each software module to ensure individual components functioned correctly. The accuracy of running the above test can say if the model is properly running or not. Teach a software module to guarantee that specific components work properly. The Web camera using beagle bone black needs to be approving all the rules so whenever a person presses the buzzer the user can view who came to the house. It is safe for kids to use and there will be no large technical aspects to use the following device if the person is not technically inclined. This results the safety for the family and if the client is not in the home they can view it happily wherever they are about who are visiting their house. This is the conceptual understanding for the security door bell. [4]

### III. SYSTEM DESIGN

The video streaming using Beagle Bone Black consists of the webcam and inbuilt angstrom linux OS.

#### A. System Architecture

This architecture provides a foundation for a basic webcam security system using Beagle Bone Black. This diagram says that power supply is given to Beagle Bone Black and there is a logitech cam connected to the beagle bone and then after pressing the buzzer the person gets a email. The system starts with a webcam or a camera module connected to the Beagle Bone Black. This webcam captures video feed or images for surveillance. [3]

The system design for webcam security utilizing Beagle Bone Black involves an orchestrated setup integrating key components. The Beagle Bone Black acts as the central hub, interfacing with both the webcam and a buzzer mechanism. The webcam continuously captures the surveillance area, relaying video feed to the Beagle Bone Black, where a motion detection algorithm, developed using libraries like Open CV, scans for any anomalies or movement. Upon detection of

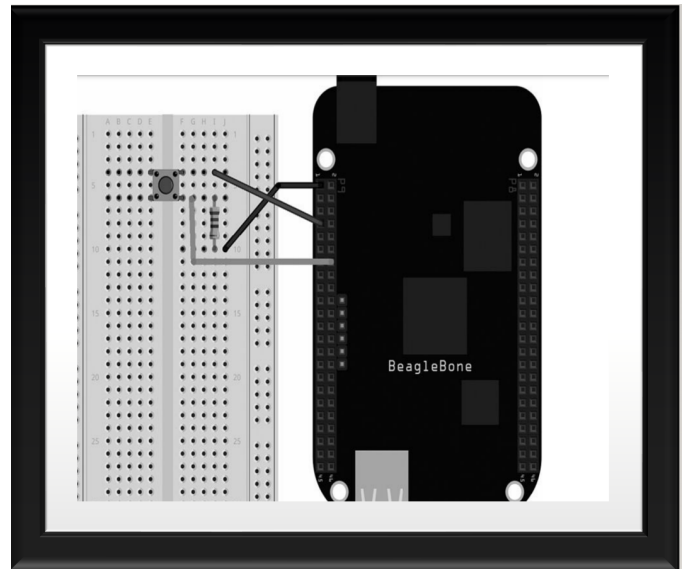


Fig. 2. Beagle Bone Black

suspicious activity, or through manual activation, the buzzer, connected to GPIO pins, triggers an alert. Simultaneously, the Beagle Bone Black, configured with an SMTP server, initiates an email notification. These emails are promptly dispatched to alert users, providing essential details such as event timestamps, trigger types (motion or manual), and potentially attached visual evidence, empowering swift responses to potential security breaches. This system architecture enables seamless surveillance and immediate email notifications upon buzzer activation, fostering proactive security measures and rapid responses to potential threats.

#### B. Beagle Bone black

- Used in industrial settings for prototyping, automation, and control systems. Ideal for rapid prototyping in IoT, robotics, and embedded systems.
- Compatible with various Linux distributions like Debian and Ubuntu.
- Positioned as a budget-friendly embedded computing platform. Compact design and low power consumption make it versatile.
- Beagle Bone Black Wireless (BBBW) is a single board computer consisting of a TI Sitara AM335 processor along with 46 header pins, an input power port jack, and a USB port. To facilitate the storage of data, it has an SDRAM of 512MB, with a speed of type DDR3 [5]. It also has an 8-bit embedded Multi Media Card(eMMC) flash memory, of about 4GB. The input power to the BBBW can be provided by means of both a mini USB port and a DC jack. Power thus obtained, can thus be efficiently managed by making use of TPS65217C PMIC, which is used along with a LowDropout (LDO) regulator. [4]

### C. Power Consumption

**The class file is designed for, but not limited to, six authors.** The Beagle Bone Black is a powerful single-board computer, but it can also draw a lot of power. It is critical to consider the power consumption of each system component when creating a web cam security system for low-power applications.

The table below displays the power consumption of the Beagle Bone Black in various states:

Idle	1.5W
Full Load	5W

As you can see, the power consumption of the Beagle Bone Black can vary depending on its workload. When the Beagle Bone Black is idle, it consumes very little power. However, when it is processing images or sending email notifications, it consumes more power.

### D. Hardware Components

- **Beagle Bone Black:** The Beagle Bone Black acts as the system's central processing unit, managing video collection, processing, and email notification.
- **Web Camera:** Select a web camera that is compatible with the Beagle Bone Black. Consider resolution, frame rate, and compatibility with the operating system of the Beagle Bone Black.
- **Buzzer:** Choose a buzzer with proper voltage and current ratings that is compatible with the GPIO pins of the Beagle Bone Black.

### E. Software Components

- **Open CV:** On the Beagle Bone Black, install the Open CV library. Open CV provides image processing and video manipulation computer vision methods. [1]
- **C Language:** C programming language should be installed on the Beagle Bone Black. C program manages that we can do video, audio, recording.

### F. How to manage Power

A way is not specific for web cam security using beagle bone black to power consume because there are so many categories to do. These techniques can be divided into two categories: hardware optimisations and software optimisations.

- **Under locking the CPU:** The Beagle Bone Black's CPU can be under clocked to reduce its power consumption. This will result in a slight decrease in performance, but it can significantly reduce power consumption.
- **Using a low-power supply:** A low-power power supply can be used to reduce the power consumption of the entire system.
- **Using low-power peripherals:** Low-power peripherals, such as low-power web cameras and low-power relays, can be used to reduce the power consumption of the system.

The influence of power reduction techniques on the performance of a web cam security system will vary based on

the exact tactics used. However, power reduction strategies will generally result in a drop in performance. This is because power reduction solutions frequently include decreasing the system's processing power or the amount of data processed.

The amount of performance loss will be determined by the techniques employed and the application. In other circumstances, the performance drop may be insignificant. In other circumstances, the drop in performance may be more obvious.

## IV. SECURITY CONSIDERATION

Security Considerations for Web Cam Security Systems Using Beagle Bone Black Web cam security tool can be very useful to your homes. However, we all know they will be some consequences related to this. Beagle Bone Black is a powerful single-board computer that can be used to build a web cam security system. However, it is important to take steps to secure the system to protect it from unauthorized access. [4]

### Potential Security threats:

- An attacker might be able to get access and use the beagle bone black without the user knowledge.
- **Malware:** The Beagle Bone Black may be infected with malware, where they might steal the data and use it for wrong purposes.
- **Denial-of-service attacks:** A denial-of-service attack on the Beagle Bone Black could render it unreachable to authorised users.

### A. Mitigation Strategies

To lower the risks of above mentioned strategies we came up with a bunch of solutions

- **Using Strong Passwords:** All passwords for the Beagle Bone Black should be complicated and strong. This makes it harder for an attacker to guess the passwords.
- **Keeping the system up to date:** The operating system and software on the BeagleBone Black should be kept up to date with the latest security updates. This will help to safeguard the system from known vulnerabilities. [7]
- **Use a Virtual Private network (VPN):** To encrypt traffic between the Beagle Bone Black and the email server, a VPN can be utilised.

## V. SYSTEM OPERATION

:The system functioning of a web cam security system based on Beagle Bone Black is as follows:

**Initialisation:** The Beagle Bone Black is turned on and ready to use. The operating system loads and initialises the web camera, buzzer, and relay drivers. The email server is set up to send notifications to the email address supplied. [6]

**Motion Detection:** The Beagle Bone Black has been powered up and is ready for usage. The web camera, buzzer, and relay drivers are loaded and initialised by the operating system. The email server is configured to deliver notifications to the provided email address.

**Alert and Notification:** The Beagle Bone Black activates the buzzer to notify the user of the observed motion. An email

with a timestamp and a description of the occurrence is sent to the supplied email address.

**Always Monitoring:** The system continues to gather images from the web camera and detect motion at regular intervals. When motion is detected, the buzzer and email notifications are enabled.

**Shut down the System:** The Beagle Bone Black can be powered off manually or via a scheduled shutdown procedure. When the system is turned off, the web camera, buzzer, and relay are turned off, and the system enters a low-power state.

## VI. TESTING

**Power Consumption Test:** Connect a power meter to the Beagle Bone Black and measure its power consumption under idle and active conditions. Compare the measured power consumption to the expected power consumption to ensure that the system is operating within its power budget. [5]

**Detection Test:** Put the webcam in a controlled area and experiment with different sorts of motion, such as walking, waving, or moving things. Check that the motion detection algorithm recognises the motion and sets off the alert. To reduce false positives and ensure reliable motion detection, adjust the sensitivity of the motion detection algorithm. [11]

**Email Notification Test:** Configure the email server settings and ensure that the system sends email alerts when motion is detected. Examine the format and content of the email alerts to ensure that they contain all of the relevant event information. Whenever a person hits the switch then the house owner gets an email notification where they can see the video whenever and wherever they are. Experiment With different email addresses and network circumstances to see how the email notification system works. [4]

**Buzzer Testing:** Experiment with various email addresses and network conditions to observe how the email notification system functions. Test the buzzer with various sorts of motion and tweak the motion detection algorithm's sensitivity accordingly. Ensure that the buzzer does not activate needlessly or interfere with normal operation.

**System Integration Testing:** Integrate all system components, such as the Beagle Bone Black, web camera, buzzer, relay, and email server. Check that all components are communicating effectively and that the system as a whole is operational. Perform a thorough test of the system under a variety of scenarios to confirm its dependability and resilience. Provide a thorough report summarising the SIT process, emphasising significant findings, suggestions, and overall system performance. [5]

**Security Testing:** Conduct unprotected scans and penetration tests to discover system security issues. Implement appropriate security measures, such as strong passwords, firewalls, and intrusion detection systems, to protect the system from unauthorized access and cyber attacks. Conduct vulnerability scans and penetration tests to uncover any potential security issues in the system. To prevent unauthorised access to the

Beagle Bone Black device's hardware and software components, ensure that it is physically protected. These are some of the ways we can do for safety testing. We need to implement strong passwords which will be hard to crack and make sure you should always use more than characters. Security Testing can be unprotected scans, system security where any one can access the security tasks.

### How to do Testing :

- To test your program we have divided our code into two part First , task is to capture the image and save it as image.jpg ,Secondly the saved image.jpg will be sent to email as notification using mpack and smtp library .
- Task is to capture the image and save it as image.jpg To do the task 1 we used fswebcam library : This is the software used to capture images from the webcam. And after capturing the image we gave specific path to save the image that is "/home/debian/image.jpg"
- Task 2 : The saved image.jpg will be sent to email as notification.
- Task 3: This should send an email with a subject line to your specified email address.

## VII. CHALLENGES

- **Power Optimization:** It might be difficult to balance power consumption with real-time motion detection and picture processing. Power can be saved by optimising the motion detection algorithm and lowering image resolution without sacrificing detection accuracy. [2]
- **False Positive Detection:** It is critical to reduce false positives in motion detection to minimise unwanted alarms and retain user trust. False positives can be caused by factors such as lighting changes, shadows, and moving objects in the background. [5]
- **Security Vulnerabilities:** Like any embedded device, the Beagle Bone Black is vulnerable to security flaws that could allow unauthorised access or malware infection. It is critical to use strong passwords, firewalls, and intrusion detection systems.
- **Network Connection:** It is vital to maintain a reliable network connection between the Beagle Bone Black and the email server in order to send timely notifications. Network failures or network disturbances can reduce the system's effectiveness.
- **Hardware Compatibility:** Selecting suitable hardware components, such as the web camera, buzzer, and relay, is critical for easy integration and system stability. Hardware failures and system faults might result from compatibility difficulties.
- **Software Integration:** To ensure seamless operation and minimise conflicts, integrating multiple software components such as the motion detection algorithm, email notification module, and system control software necessitates careful coordination and testing. [1]
- **User Interface Designing:** It is critical for customer pleasure and simplicity of use to create a simple and user-

friendly interface for adjusting system settings, viewing notifications, and managing alerts.

- **Maintenance and updates:** Regular firmware, operating system, and software library updates are required to resolve security vulnerabilities and maintain system performance on the Beagle Bone Black.
- **Optimization:** A cost-effective solution requires balancing the costs of hardware components, software licences, and ongoing maintenance with the desired degree of security and performance. [6]

## VIII. SOLUTIONS

**Power Optimization:** To offload computationally heavy activities such as image processing and motion detection, use hardware acceleration techniques such as Beagle Bone Black's DSP capabilities or specific hardware accelerators. Implement adaptive algorithms that dynamically modify processing power and image resolution based on motion detection status, lowering resource consumption during inactivity. [1]

**False Detection:** To distinguish between true motion and irrelevant changes in the scene, improve the motion detection algorithm by adding background reduction techniques, temporal filtering, and object size and shape analysis. Train the system on massive data sets of motion and non-motion events using machine learning algorithms such as convolutional neural networks (CNNs), to improve the system's ability to identify actual motion patterns.

**Security Issues:** Implement a secure boot process to verify the integrity of the operating system and prevent unauthorized modifications. Regularly update the Beagle Bone Black's firmware and software packages to patch known vulnerabilities. Employ secure coding practices, such as input validation and proper memory management, to minimize the risk of exploitable software flaws.

**Network Connectivity:** To maintain continuous connectivity between the Beagle Bone Black and the email server, use network redundancy measures such as fail over routing and cellular backup connections. Use network monitoring tools to discover and address network connectivity issues before they disrupt system operation.

**Hardware Compatibility:** To avoid compatibility difficulties, thoroughly verify and validate the compatibility of hardware components before deploying the system. To reduce compatibility difficulties and facilitate troubleshooting, use standardised interfaces and protocols for communication between components.

**Software Integration:** Use modular software design concepts to divide the system into well-defined modules with clear interfaces, allowing for easier integration and lowering the likelihood of conflicts. To ensure seamless software integration and early detection of any issues, use thorough testing approaches such as unit testing, integration testing, and system testing.

**Interface Design:** Conduct user research and usability testing to learn about the needs and preferences of your users. Use

a user-centered design approach to build an intuitive and user-friendly interface that meets user expectations. To guide users through the interface, employ clear and succinct language, consistent design components, and effective visual cues.

**Maintenance and Updates:** Implement an automated updating method to check for and install security patches and software upgrades on a regular basis, minimising manual intervention. To avoid performance deterioration and security vulnerabilities, create a maintenance schedule that includes regular system checks, hardware inspections, and software updates. [7]

**Conditions Systems:** To protect the Beagle Bone Black and other hardware components from dust, humidity, and temperature fluctuations, place them in protective enclosures. To regulate the operating environment and prevent overheating, use temperature monitoring and control devices. To ensure long-term reliability, choose hardware components that are rated for the expected environmental conditions.

**Optimization:** To cut licensing expenses and simplify maintenance, explore open-source software alternatives and cloud-based services. Investigate low-cost hardware choices without sacrificing performance or quality. Implement energy-saving practises to reduce power use and expenditures. [5]

## IX. INTEGRATION WITH WEB CAMERAS WITH SMART HOMES

Integrating a security door camera system with a smart home system enables seamless interaction between the security system and other smart devices in the home, improving overall home automation and giving a more integrated security solution. This integration can be accomplished through a variety of means, including, API Integration refers to the use of application programming interfaces (APIs) given by smart home platforms such as Smart Things, Amazon Alexa, or Google Assistant to facilitate communication and data exchange between the security system and the smart home platform. Homeowners can gain a variety of benefits by combining their security system with smart home solutions, including Automated Actions Triggering automated actions based on security system events, such as turning on lights when the doorbell is touched or sending notifications to smart speakers when motion is detected. Centralised operate, [8] Using a central smart home hub or app to access and operate the security system, offering a uniform interface for managing multiple smart devices in the home. Enhanced Security, Extending the capabilities of the security system by combining with other smart devices, such as smart locks or smart thermostats, to build a more comprehensive security web cam network. Whenever a buzzer is pressed where we can insert a alarm when it rings so the person can know some one is at the door and it rings whenever the person presses the buzzer. Personalised experience Personalised Experiences Creating personalised smart home automations based on information obtained by the security system, such as personalised lighting or climate management.

Protocols for Common Communication, Using standard communication protocols such as Zigbee, Z-Wave, or Wi-Fi

to connect the security system to other smart devices in the home.

## X. HOW TO CONNECT BEAGLE BONE BLACK

- Connect Beagle Bone Black to Internet on Windows OS Via USB Port
- We need share the internet network of our computer with beagle bone black . once the network is shared we need to set the default gateway by using below command <https://www.digikey.com/en/maker/blogs/how-to-connect-a-beaglebone-black-to-the-internet-using-usb>.
- `debian@BeagleBone: ping 8.8.8.8.`
- `ping: connect: Network is unreachable` **debian@BeagleBone: sudo /sbin/route add default gw 192.168.7.1**
- The OS used :**debian@BeagleBone: uname -a Linux BeagleBone 5.10.168-ti-rt72 1bullseye SMP PRE-EMPT Sat Sep 30 03:37:21 UTC 2023 armv7l GNU/Linux**

### A. Libraries Used

- **fswebcam:** On Linux platforms, the fswebcam library is a easy going and simple program for taking photos from webcams or other video devices . It has a direct command-line interface for taking screenshots, recording movies, and altering images such as resolution, format, and brightness.
- **mpack:** MPACK (MessagePack) is a binary data transfer where it has messages library. It is a tiny and lightweight format that is optimised for performance and compactness. MPACK is comparable to JSON, but it is more compact and efficient in general, especially for data types like arrays and maps.The MPACK library implements the MPACK serialisation format in C. It includes routines for encoding and decoding MPACK data, as well as other operations like validation and manipulation. The MPACK library is available for Linux, macOS, Windows, and embedded systems, among others.
- **ssmtp:** sSMTP is a lightweight and easy-to-use send-only MTA (mail transfer agent) for Linux systems. It is designed to replace sendmail on workstations that primarily receive their mail via POP, IMAP, or other fetchmail-like mechanisms and only occasionally need to send mail. sSMTP does not receive mail, expand aliases, or manage a queue. Instead, it simply forwards mail to the configure mailhub.Overall, ssmtp is a wonderful option for folks who want to send email from their Linux PCs in an easy and secure manner.Overall, ssmtp is a wonderful option for folks who want to send email from their Linux PCs in an easy and secure manner.This one is a light weight and easily can be used so that the mails can transfer easily for the light to get all the mails.ssmtp can be installed from the package repository of your operating system.

## XI. ADVANTAGES

- **Real Time Monitoring:** Live video allows the users to allow view the image when a person is front of the door and presses it.Allows for immediate viewing of visitors or prospective intruders, allowing for prompt response. It Increases security by providing proactive steps instead of depending entirely on alarms.Allows homeowners to monitor their property from anywhere by permitting remote monitoring of the video feed via a web browser or mobile app.When the doorbell button is pressed, an image of the person at the door is captured, providing more context for the homeowner. [10]
- **Instant Message:** When the doorbell button is hit, an email is sent to the homeowner's smartphone or email account.Even when the homeowner is not physically present, the system alerts them to activity at the door.This enables quick decision-making and responsiveness to guests or potential threats.
- **Cost - Effective Solution:** The Beagle Bone Black, an inexpensive and adaptable single-board computer, is used, greatly lowering hardware expenses.Removes the need for costly proprietary security systems, making protection more affordable to a wider variety of homeowners.Provides a low-cost alternative to typical security systems while maintaining functionality.
- **Ease of Implementation:** It has a simple design and readily available components, making it simple to implement and maintain.Minimal technical knowledge is required, allowing homeowners with basic technological skills to set up and operate the system.Reduces the need for expert installation services, cutting total expenditures. [5]

## XII. CONTRIBUTIONS

The Open CV library is used by the system to capture, process, and analyse images from the webcam in real time. This allows the system to recognise and respond to events such as motion detection or doorbell activation.To interface with email servers and transmit real-time notifications to homeowners, the system uses networking protocols. This ensures that homeowners are notified as soon as any activity occurs at their access point.To safeguard collected photographs and email messages from unauthorised access and data breaches, the system applies security mechanisms. This protects sensitive data and ensures the system's integrity.The system takes advantage of the Beagle Bone Black's low cost, adaptability, and vast networking capabilities to provide a scalable and cost-effective security solution.Real-time monitoring and immediate notifications are provided by the system, enabling households to take preventative action against possible dangers.The system's remote access and real-time notifications provide homeowners with greater peace of mind, knowing they can watch their property from anywhere and receive alerts of activity immediately.When compared to standard proprietary security systems, the system's use of the Beagle Bone Black and generally available components dramatically reduces hardware expenses.The system's simplicity and low

technical requirements enable people with basic technical abilities to set up and run it, avoiding the need for professional installation services. [8]

### XIII. FUTURE WORK

Future work for this security system includes enhancing image processing capabilities, expanding notification channels, enhancing security measures, exploring cloud-based integration, and investigating alternative hardware platforms. Improved Image Quality, To improve the quality of acquired photographs, use advanced image processing techniques such as noise reduction and contrast enhancement. Implement object detection and recognition algorithms to identify specific individuals or things in collected images, offering more context and information. Motion detection methods should be integrated to start image capture only when significant motion is detected, avoiding unwanted captures and preserving resources. Integration with Mobile Messaging services, Integrate with mobile messaging services such as SMS or WhatsApp to give additional notification channels in addition to email, hence increasing the reach and accessibility of notifications. Consider integrating with speech assistants such as Alexa or Google Assistant to enable voice-based notifications, providing a hands-free and easy notification option. Augmented Reality Overlays, Investigate the use of augmented reality overlays to display notifications directly on the camera feed, enabling a more immersive and context-aware notification experience. Implement two-factor authentication for email notifications to offer an extra degree of protection and prevent unauthorised email account access. Encrypted Email Communications, To protect sensitive information during transmission, encrypt email communications using secure protocols such as TLS/SSL. This ensures data confidentiality and integrity. Consider implementing hardware-based security modules, such as Trusted Platform Modules (TPMs), to safeguard sensitive data stored on the Beagle Bone Black, adding an additional layer of hardware-based protection. Cloud-Based Image Processing: Look into shifting image processing operations to cloud services such as Amazon Recognition or Google Cloud Vision API to boost scalability and performance. Consider integrating cloud storage services such as Google Cloud Storage or Amazon S3 to store collected photographs and email notifications, giving redundancy and access to data from anywhere. Exploration of the feasibility of using cloud-based machine learning services for improved object detection and recognition, leveraging powerful cloud computing capabilities for sophisticated picture processing. Other Single-Board Computers Assess the performance and suitability of other single-board computers for the security system, such as the Raspberry Pi or Arduino, taking into account issues such as cost, power consumption, and processing capabilities. Consider employing specialised hardware accelerators for image processing and machine learning workloads, such as GPUs or FPGAs, to improve performance and reduce energy consumption for computationally intensive jobs. Edge Computing Devices: Investigate the viability of deploying edge computing devices

to reduce reliance on cloud services and enhance response times. In the future project, video streaming is implemented can be implemented using the Beagle Bone Black, and the video is saved on the server, where the client can download it with proper authentication. The client can also upload files to the server and adjust settings as needed. The Beagle Bone Webcam Server prototype model can be used as a standalone access point, selectively saving videos to the system server for security applications. The system can be expanded by incorporating wireless technologies such as Bluetooth, WI-FI, GSM, GPRS, and so on. Web browsers for TV and security camera analyzer, streamer, recorder, and monitor are among the applications. The integral part of the future projects is that APIs can be created and whenever a person hits a buzzer the house owner can see there video on the interface and even control all the communications. The future can be very well with the system can be integrated with the real time where if there is a safety threat then there will be a direct contact to the police so they could come and help. Then you and the officer would get a call regarding the safety. [4]

### XIV. CONCLUSION

The security door camera system with Beagle Bone Black and email notifications offers a viable approach to improving home security with easily available hardware and software components. The software system can do as such as fast email notifications, and low cost of implementation make it an appealing alternative for homeowners looking to protect their properties. The Beagle Bone Black platform provides a versatile and cost-effective solution, while the use of an RTOS ensures the timely and predictable execution of key activities. The modular architecture and ease of implementation of the system make it accessible to people with minimal technological skills, hence broadening its potential adoption. To further improve and expand image processing capabilities, expand notification channels, strengthen security measures, investigate cloud-based integration, and investigate alternative hardware platforms, future development can focus on these areas. Proper resource and quality-of-service management would enable the implementation of embedded systems that are more flexible, yet more deterministic, than it is possible today. Since such systems would be better specified, their properties would also be verified more easily. By supporting explicit resource allocation and quality-of-service functionality, the system would regain to its original position after the system is set. [8]

### XV. RELATED WORKS

[1] Mohan Aishwarya, Choski Meghavi and A.Mukesh Zaveri [2019] proposed ML approach for Video Based Surveillance [2] Beagle Board.org [3] H.Sun, X.Liang, and W.Shi [2017] proposed Large Scale Video Surveillance Systems [4] Shubangi S, Kose, Prof. Mrs. Jyothi M Varvedkar [2014] has proposed Motion Detection.

## REFERENCES

- [1] Mohan Aiswarya, Choksi Meghavi and A.Mukesh Zaveri, "Anomaly And Activity Recognition Using Machine Learning Approach For Video Based Surveillance", 10th International Conference On Computing Communication And Networking Technologies (ICCCNT), 2019.
- [2] Beagleboard, "BeagleBone Black Wireless" Beagleboard.org, 2020. [Online]. Available: <http://beagleboard.org/black-wireless>. [Accessed: Mar 7, 2020].
- [3] H. Sun, X. Liang, and W. Shi, "VU: Video Usefulness and Its Application in Large-Scale Video Surveillance Systems: An Early Experience," in Proc. of the Workshop on Smart Internet of Things (SmartIoT '17), New York, NY, USA, 2017,
- [4] Shubhangi S. Kose, Prof. Mrs. Jyoti M.Varvadekar [2014], —Application Development for Video Monitoring System Motion Detection System using ARM9 Processor International Journal of Scientific Research Engineering Technology (IJSRET), ISSN 2278 – 0882 Volume 3, Issue 4, PP 806- 811.
- [5] S. Bimenyimana, A. Ishimwe, G. N. O. Asemota, C. M. Kemunto, and L.Li, "Web-based design and implementation of smart home appliances control system," IOP Conference Series: Earth and Environmental Science, vol. 168, article 012017, 2018..
- [6] S. Xu and K. Hung, "Development of an AI-based System for Automatic Detection and Recognition of Weapons in Surveillance Videos," in 2020 IEEE 10th Symp. on Computer Applications Industrial Electronics (ISCAIE), 2020, pp. 48-52, doi: 10.1109/ISCAIE47305.2020.9108816.
- [7] Georgievski, b: Object detection and tracking in 2020. Medium.<https://blog.netce-tera.com/object-t-detection-and-tracking-in2020-f10fbff9af3> (2020)
- [8] Z. Xiaodong and Z. Jie, "Design and implementation of smart home control system based on STM32," in 30th Chinese Control and Decision Conference (2018 CCDC), Shenyang, 2018
- [9] S. Ghosh, "How to Create a Face Recognition Model Using FaceNet Keras?" Medium, Clique Community, 10 July 2020, <https://medium.com/clique-org/how-to-create-a-face-recognition-model-using-facenet-keras-fd65c0b092f1>.
- [10] P. Ippolito, "SVM: Feature Selection and Kernels." Medium, Towards Data Science, 4 Sept. 2021, <https://towardsdatascience.com/svm-feature-selection-and-kernels-840781cc1a6c>.
- [11] S. Ghosh, "How to Create a Face Recognition Model Using FaceNet Keras?" Medium, Clique Community, 10 July 2020, <https://medium.com/clique-org/how-to-create-a-face-recognition-model-using-facenet-keras-fd65c0b092f1>.