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Design and Implementation of a Smart Door Lock System Using Openvino

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Abstract:
The main intention of the research is to design and implement the smart door lock system using OpenVino. Research is carried out in two stages. In stage 1, face is detected using Intel OpenVINO running on MYRAID X Coprocessor and in 2nd stage, face is recognized based on raspberry Pi3 CPU using parallel OpenVINO inference engine execution. Apart from these, this system recognizes the face from single person inference, two person inference, three person inferences and four person inference using OpenVINO. At a time, up to four person faces are recognized using OpenVINO +OpenCV.. From the findings of the research, it was noted that accuracy rate and prediction rate of door lock system is best in OpenVINO +OpenCV.

Keywords: *Smart door lock system, Coprocessor, inference engine, accuracy rate and prediction rate*

I. INTRODUCTION

Nowadays several instances of robbery and theft have increased all over the world. This has made the implementation of security systems a mandate everywhere. People often remain busy in their day to day life and they need a system to ensure the safety of their belongings. Sometimes they forget to protect their essential things like wallets, keys, credit cards, etc from being stolen. Traditional systems of security need the key of user, an RFID, a password security or Identification card to have access to the system (Deshmukh and Kshirsagar, 2017). Reeta (2017) has mentioned that the most essential feature of any home is the security control system which is used to predict the person who leave or enter the house. Instead of supervising that through pins or passwords distinct faces can be made use of as they are one's biometric characteristic. These are essential and can be changed or stolen easily. The security level can be raised by using face detection. According to Maheshwari and Nalini (2017) in nowadays world of smart devices and connectivity there is an urgent requirement to change their existing day to day objects and make them smart also it is not the period when they can blindly trust the conventional and old measures of security mainly in door locks. To modernize and change any object first the barriers must be eliminated and additional functionality are added. The main barrier in a door lock is that anyone can open a door lock by stealing or duplicating the key conventionally and it is not possible if they require their family and friends to enter their house without being existing over there. Timse (2014) has mentioned that human beings are identified by their distinct facial features. In the approach of face recognition, a given face is compared with the faces stored in database to recognize the person., The main aim is to predict the face in DB which has the greatest difference with the given face. In the biometrics field the face recognition technique is one of the rapidly

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developing sectors. Lwinet al (2015) has mentioned that the benefit of face recognition is that it does not need to be touched by any hardware. Face is predicted automatically using the technique of face recognition and the whole recognition of face is finished without touching any hardware. The detection of face is the first step of face recognition system. The whole face recognition system performance is impacted by the face detection reliability. By utilizing face detection, it can recognize only the face part of the image regardless of the image background.

Gu et al (2018) has mentioned that face recognition is regarded as one of the essential sectors in biometrics and computer vision since it is a challengeable work to recognize an image of face with different occlusion, expression, illumination and disguise. Along with match of fingerprint and retina of eye they become a familiar approach in biometric technique. The face recognition task is to compare a face query against numerous faces in DB to recognize whether it belongs to an individual in a database. In certain applications of identification an individual requires to predict the most common face (Patel, 2016).Najmurrokhman et al (2018) has mentioned that the face detection is the first step in the face recognition system to capture user image to be processed. The face detection employs a sensor of light proximity that comprises of photodiode components. However, these sensors can only predict faces horizontally to the line. For a wide image of face the webcam use can offer much capability than proximity sensor. The face recognition system uses webcam to capture the image of face. Then the face image will be further processed by algorithm to acquire best output. Januzaj et al (2015) has mentioned the steps for identification in door unlocking system. First the user comes in front of camera and press the button so that the identification process initiates. If the system recognizes the face as positive then microcontroller passes the signal to magnetic lock and the door will open in a period of five seconds and after this period the user is needed to be recognized to unlock the door. The user is recognized in the database and if it is identified then green LED light is turned on and the door is unlocked otherwise red light is turned off and the door is locked. Yu (2018) has mentioned that the security of home with only door locker is not enough to secure the family and house however the smart home security system on market is still not familiar for uses of household because of the greater tag of cost. Besides that, smart home security system can be developed to greater level of security and construct with reduced cost material to satisfy the requirement of market. Azeem et al (2017) has stated that face recognition is used in home to resolve the problems like it can set the alarm and seize an image to pass it to owner when a stranger is predicted in door front. Then the theft will get alert so he got no time to initiate breaking the door and destruct the system of security. For overcoming the issue, the face recognition can be used to by pass with the face image of owner so that the door will unlock with proper input password with a keypad. Thus it can be inferred that face recognition system is used in smart door lock system to enhance the flexibility, efficiency and security of the door locks.

II. LITERATURE REVIEW

The study of Patel and Verma (2017) deals with the notion of secure automation locking using Internet of Things for unlocking door to offer important security to their houses, bank lockers and associated security caution and control operations through the module of GSM. It utilizes a technique of image capturing in an expanded system based on the server system of Raspberry Pi. Raspberry pi handles the video camera for capturing it for turning on a relay for unlocking door. The module comprises a secure recognizer of face for automatic unlocking of door. The camera captures the face image and compares it with the image which is stored in DB. If the image is predicted in the database then the lock of the door opens otherwise it will generate a Short Messaging Service that an unknown person is attempting to acquire access and this result is consistent with the

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findings of Bhise, 2018; Patil et al, 2016; Shetty and Prathviraj, 2017.

According to the researches of Gsponer (2018), Vamsi et al (2019) as Internet of Things develops devices becomes available in a reasonable way and face recognition evolves quickly so the requirement for a system using three devices emerges. Integrating these three techniques will permit handling different use cases from changing door locks to smart CCTV systems. Certain products which makes use of these devices integrated occurs but none have been implemented on a low budget system under 100 euros. For this reason, the aim of this study is to perform only with open source software, no service of web and only with the reasonable hardware and the query is whether it is feasible to construct such a system with a provided hardware. This study will present the focus on face recognition and Internet of Things in a theoretical structure which is then followed by its implementation throughout the five phases of project and a final product presentation is provided (Deshmukh et al,2019;Gutgutia et al, 2019;Prasad, 2019; Pawar et al, 2019).

Roy et al (2018) has mentioned in their study that security and privacy are two rights of universal and to assure that in the daily life of human beings they are secure lot of studies is developing in home security field and Internet of Things in the turning point for the sector where everyday objects are connected to share information for betterment. The security of house matters and people often attempt to make life simpler at the same time. Face recognition is a well set up method in which the face is identified and detected out of image. This study main aim is to create a smart door which protects the gateway on who they are basis. This study evolves this system based on Raspberry-pi 3 to make the house accessible only when the face is identified by the algorithms of recognition from library of Open CV and meanwhile the user is permitted in by owner of the house, who could supervise entrance in a remote way. By performing so, the system is less probable to be deceived since the user can verify every visitor in remote console getting identified by camera using a photo which did not work.

Saraf (2018) proposed a study on automated Door access control system using face recognition. Authentication is one of the essential problems in the information system era. Among other things human face recognition is one of the familiar technologies which can be utilized for authentication of user. As an essential biometric verification branch human face recognition has been used widely in several applications such as interaction of human and computer and video surveillance and monitoring system. This study proposes an approach for automatic system for accessing door using face recognition method by using the programming of Python and from library of Open CV Haar Cascade Method. The detection of object using the classifiers of Haar feature based cascade is an efficient method of object detection suggested by Michael Jones and Paul Viola. This is the standalone security component which has been evolved using electronic development board of Raspberry Pi and performed on supply of battery power, wireless connectivity of internet by using the modem of USB. Automatic notification of electronic mail has been accomplished by provided security alert electronic mail to electronic mail id of user. This proposed system is much reliable, efficient and consumes reduced amount of power and data compared to already existing systems (Bhattarai et al, 2018;Sandar and Oo, 2019; Rohith et al, 2016)

Sathe et al (2017) has mentioned in their study that nowadays people employ security cards, keys, pattern or password to open the door. The main purpose of this study is to support people for growth of the security of door of sensitive places using face recognition and detection. Face is a complicate multidimensional structure and requires enhanced techniques of computing for recognition and detection. This study consists of three subsystems namely face recognition, automatic door access control and face detection. The acquisition of image is the method of seizing an image and the face is detected using the Viola Jones approach and face

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recognition is implemented using the Principal Component Analysis. Face recognition based on principal component analysis is usually referred as eigen faces use. If a face is identified it is authenticated vice versa. The door will automatically open for the authenticated user due to the microcontroller command. Since Principal Component Analysis decreases the face image dimension without losing essential features, face images for several users can be stored in database. Although several training images are used the efficiency of computation cannot be reduced essentially. Therefore, face recognition using principal component analysis can be much helpful for security of door than other schemes of face recognition (More and Bodhke, 2017; Bhutra et al, 2018;Liu et al, 2016;Lathajothi et al, 2017; Gowsalya et al, 2014).

Myint (2019) proposed a study on IOT based real time face recognition door lock system using Neural network. Face recognition is one of the most familiar and challenging concept in the field of computer vision and pattern recognition. In this system Raspberry Pi is used for recognition of face. HOG (Histogram of Oriented Gradients), Back Propagation Neural Network and Principal Component Analysis is used for resolving the issues of face recognition. After resolving the issue of Face recognition Pi passes the outcomes to MQTT message broker cloud. It deals with IoT world of linked devices and NodeMCU passes the output messages which denotes the predicted faces are unknown or known by the MQTT cloud. Lastly NodeMCU handles the motor to unlock or lock the door according to the messages (Kumar et al, 2017).

Syed et al (2018) proposed a study on embedded system for automatic door access using face recognition technique and cloud based services. In nowadays digital world it is essential to have security precautions for the property. Security is an essential feature or perspective within the application of smart home in modern times. Automation of home is one among several areas where IoT technique can be used. Internet of Things approaches helps in collaboration of various devices and mainly accomplish effective automation of home as one application. It also supports in accessing and monitoring things remotely. A typical home automation building workflow comprises of some stages such as updating and execution of workflow, workflow triggering and lastly making the system communicate with other systems as well as humans. This study is a trial to build a smart security door lock system for automation of home using interdisciplinary method by using image processing, cloud based services and implicit human computer communication that assures much automation and reduced intervention of human (Dadi and Pillutla, 2016; Vaidya et al, 2018).

Angeline et al (2019) proposed a research on CNN integrated with HOG for efficient face recognition. The faces of human being in the video are subjected to variation in illumination, pose variations and out of focus blur during the process of face recognition in different applications. The proposed system aims to resolve the above-mentioned issues. This is carried out by using HOG algorithm as a descriptor of feature to predict faces. The training data is comprised of blurred and still images. For the system to study variations of pose an extra set of data of artificially aligned images is fed using the algorithm of face landmark estimation. CNN is trained and efficient recognition of face is acquired which makes the surveillance applications perform effectively (Li and Cha, 2019 and Sanghavi et al, 2019).

Software used for automatic secure door lock using mobile communication technology is visual studio. Algorithm used for door lock system is principal component analysis ensures security, handles records and operating gate without physical communication of user (Khalid and Majeed, 2016). Software used for door lock automation system is android and arduino.

It is inexpensive, reasonable and easy implementation (Kamelia, 2014;Singhal et al, 2015;Gaikwad and KalShetty, 2017; Sridhar and Srinivas. 2015;Bhute et al, 2015;Ishrat et al, 2017; Ismail, 2014).

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Software Source Used	Face Recognition Technique Used	Author Year	Algorithm Used	Features of the Technique
Linux And Open CV	IoT based Door Unlocking system	Patel and Verma 2017; Bhise, 2018; Patil et al, 2016; Shetty and Prathviraj, 2017;	Principal Component Analysis	Cheap, Fast and Highly reliable
Open CV	Face Recognition and IoT	Gsponer, 2018; Vamsi, 2019; Deshmukh et al,2019; Gutgutia et al, 2019; Prasad, 2019; Pawar et al, 2019;	Eigen Face, Fisher Face and Local Binary Pattern Histogram	Low budget Hardware and Software and Reliable results
Open CV using Linux	Face Recognition Door Lock System	Roy et al 2018;	Haar Cascade Classifier and Eigen Face Classifier	Efficient and Reliable
Open CV using Python	Automatic Door Access Control Using Face Recognition	Saraf et al 2018; Bhattarai et al, 2018; Sandar and Oo, 2019; Rohith et al, 2016;	Haar Cascade Classifier and Local Binary Pattern Histogram	Effective, Reliable and consumes less amount of power and data
MATLAB	Face Recognition using PCA	Sathe et al, 2017; More and Bodhke, 2017; Bhutra et al, 2018; Liu et al, 2016; Lathajothi et al, 2017; Gowsalya et al, 2014;	Viola Jones Detection Algorithm, Principal Component Analysis	Increases the rate of recognition and reduces the accuracy of recognition
Open Face	Face recognition door lock system using Neural Network	Myint, 2019; Kumar et al, 2017	Histogram of Oriented Gradients (HOG), PCA (Principal Component Analysis) and BPNN (Back Propagation Neural Network)	Accurate and Fast
Open CV and Python	Smart security door system for home automation	Syed et al, 2018; Dadi and Pillutla, 2016; Vaidya et al, 2018;	Histogram of Gradients (HOG) and Support Vector Machine (SVM) classifier	Reduced intervention and much automation
Linux	CNN integrated with HOG	Angeline et al, 2019; Li and Cha, 2019; Sanghavi et al, 2019	Convolutional Neural Network	Less complicate and much efficient technique
Visual	Automatic Secure	Khalid and Majeed,	Principal	Ensures security, handles

Studio	door lock using mobile communication technology	2016;	Component Analysis	records and operating gate without physical communication of user
Android and Arduino	Door lock Automation System	Kamelia, 2014; Singhal et al, 2015; Gaikwad and KalShetty, 2017; Sridhar and Srinivas. 2015; Bhute et al, 2015; Ishrat et al, 2017; Ismail, 2014;	-	Inexpensive, reasonable and easy implementation

Table 1: Reviews of Smart Door Lock System using Face Recognition
Source: Author

III. SYSTEM DESIGN

OpenVINO+ Opencv DNN Implementation was adopted in this research. This method further is extended to implement smart door lock access control based on the recognized face.

The below figure 1shows hardware setup of the project.

Figure 1: A System Set up on Raspberry Pi3 To Perform Door Lock Using Intel NCS

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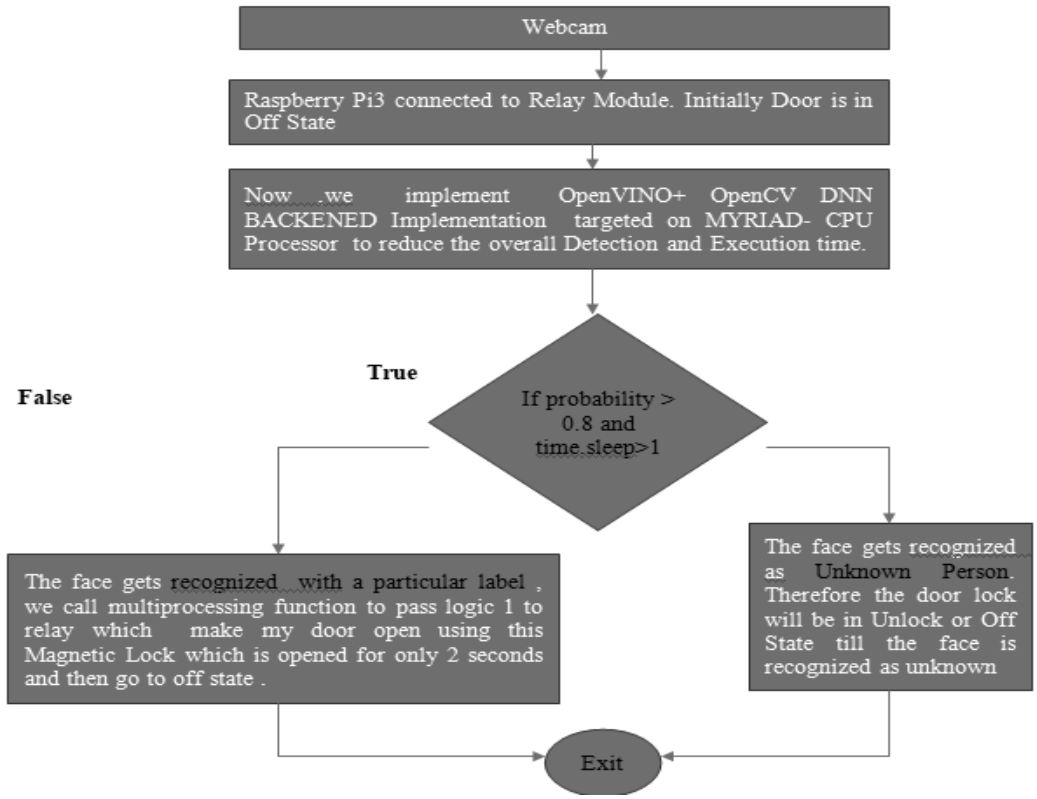

Figure 2: Door Lock Implementation

Figure 2 implements door lock implementation. Webcam is connected then Raspberry Pi3 connected to relay module and initially door will be in off state. Then OpenVINO+ OpenCV DNN backend implementation is targeted on MYRIAD-CPU processor for reducing the overall detection and execution time.

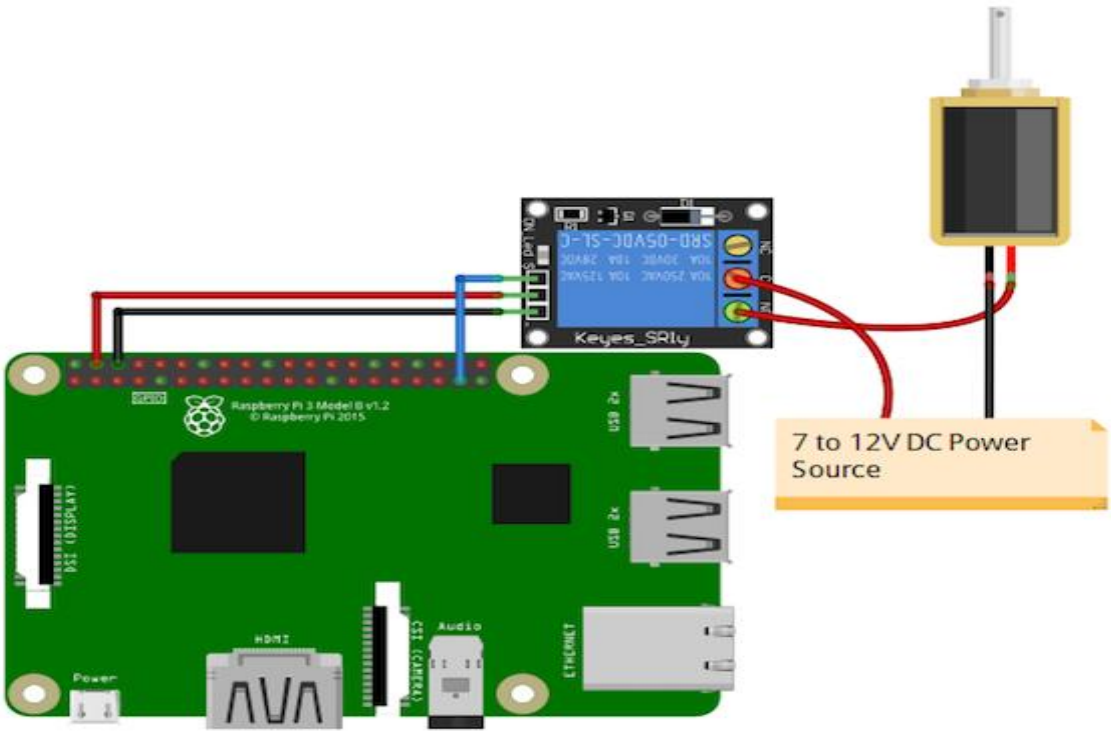

Figure 3: Hardware Circuit Connection on Raspberry Pi3 For Door Lock Implementation

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Figure 3 depicts hardware circuit connection on raspberry Pi3 for door lock implementation. It connects Raspberry Pi3. Relay input pin is linked to GPIO 26. The main intention of adopting external battery source is GPIO PINS gives maximum power of 3.3V but the solenoid lock needs power 7 -8 V. If the probability of prediction is greater than 80 percent the relay is triggered on by calling the multiprocessing function and after 2 seconds it will automatically go to off state. Likewise whenever the probability of prediction is less than 80 percent it will be continuously in off state till known person to open the door.

IV. ALGORITHM

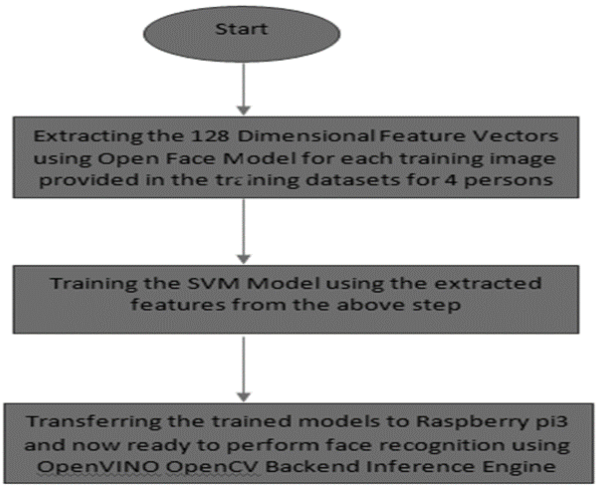

Figure 4: Training models on GPU

Extract the 128 dimensional feature vectors with the help of open face model for every training image given in the datasets for training for 4 persons. Support Vector Machine (SVM) model is trained using extracted features from above step. Then trained models are transferred to Raspberry pi3 and ready for performing face recognition using OpenVINO openCV backend inference engine.

In this research Caffe Face Detector was adopted for detecting the face. Training image is passed through path and setup blob to resize every training image to 300*300. Then blob is passed to model for acquiring the output predictions. Confidence is calculated based on output predictions. Whenever the values of confidence are higher than minimum threshold, then face part is extracted and face blob is constructed. At last, face blob is passed as input to openface model for extracting face embedding values for every identified face in training images. Linear SVM classifier is adopted for classifying the image on the basis of detected faces per each frame by intel NCS.

Steps of the algorithm are categorized into four steps:

Load all models on raspberry Pi3; chose backend and target device; perform face detection running on Intel Myraid X processor and perform recognition of face on the detected face using trained SVM classifier running on Raspberry Pi3 central processing unit processor.

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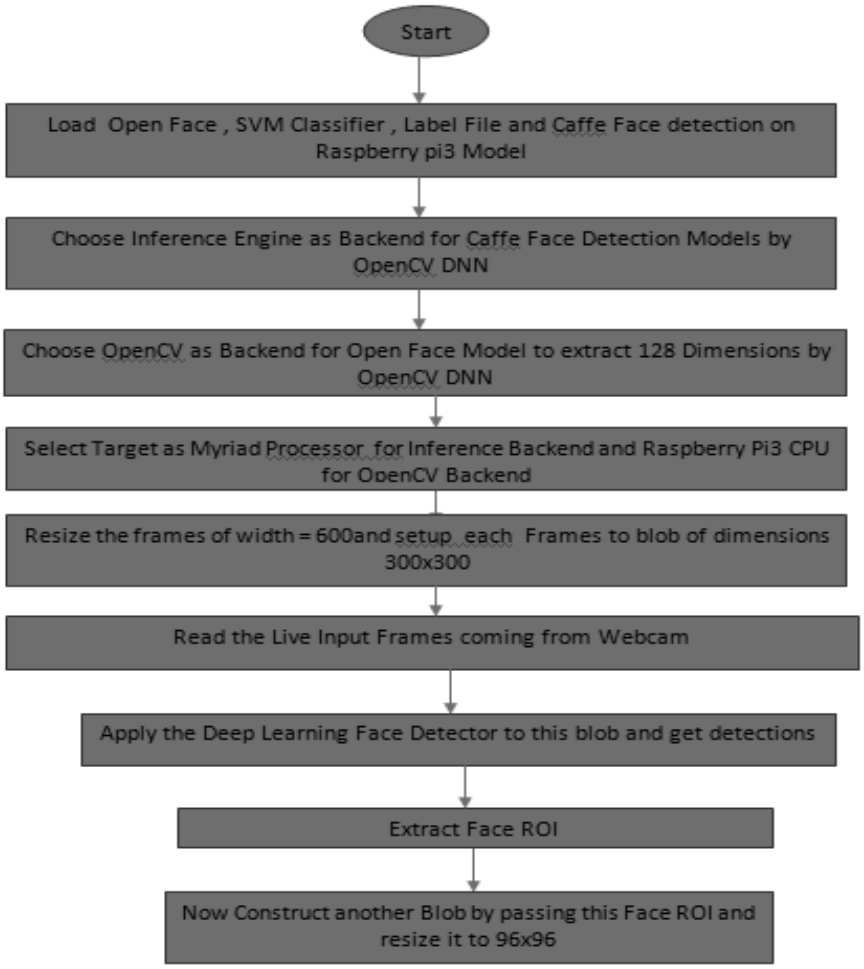

Figure 5: Face Detection algorithm using INTEL NCS and OPENCV DNN module

For starting the process, Open Face, SVM classifier, Label file and Cafee face detection on raspberry pi3 model is loaded. Then inference engine is selected as backend for Caffe face detection models by OpenCV DNN. OpenCV as backend is selected for Open Face model for extracting 128 dimensions by OpenCV DNN. Myraid processor is selected as target for inference backend and Raspberry Pi3 CPU for OpenCV backend. Resize the frames of width =600 and setup each frames to blob of dimensions 300 * 300. Live input frames are read from Webcam and then apply the deep learning face detector to this blob and acquire detections and extract face ROI and at last another blob is constructed by passing this Face ROI and resize it to 96*96.

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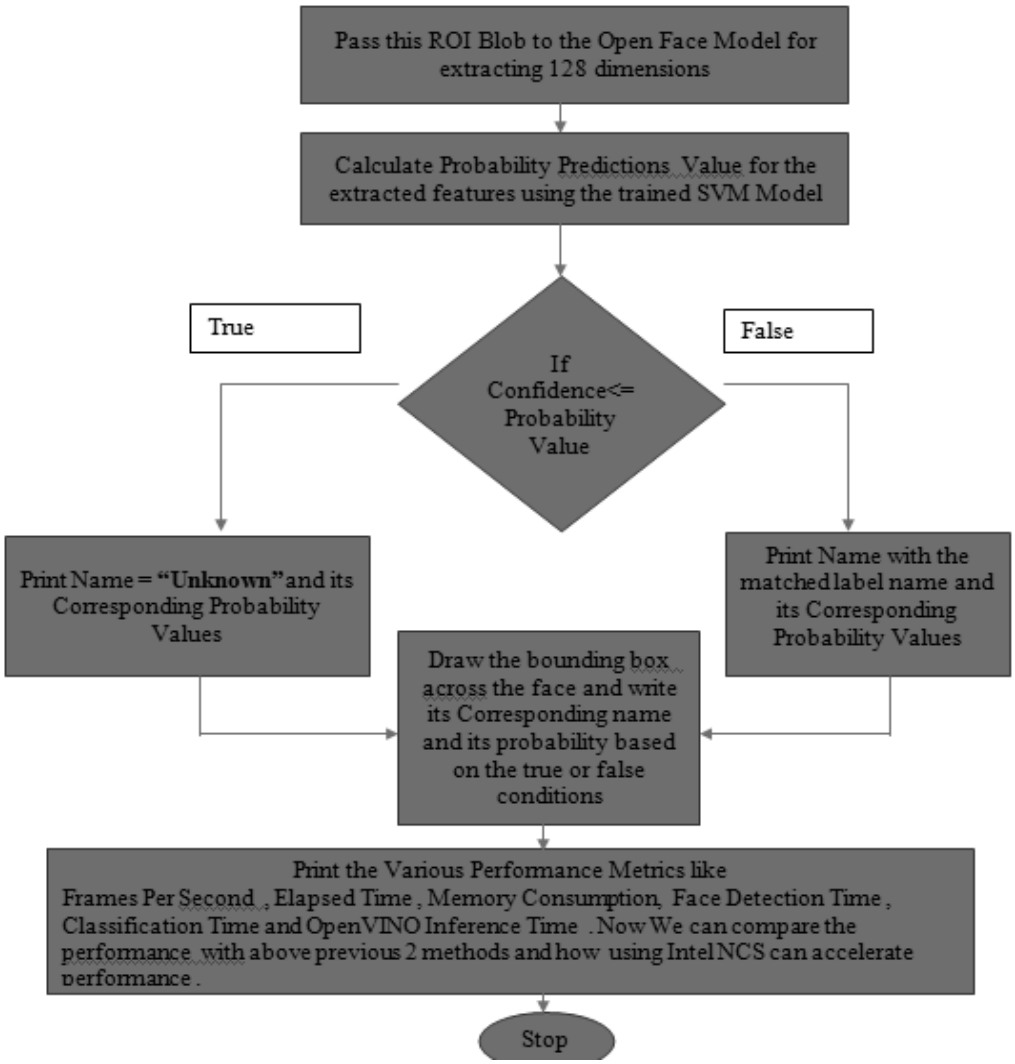

Figure 6: Face Recognition Running On Raspberry Pi3 CPU

Pass ROI blob to Open Face Model to extract 128 dimensions. Probability predictions value is calculated for extracted features using trained SVM model. If confidence is less than or equal to probability value is true then print name is equal to unknown and its corresponding probability values. If confidence is less than or equal to probability is false then print name with matched label name its corresponding probability values. Then draw the bounding box across the face and write its corresponding name and its probability based on true or false conditions. Print the various performance metrics like memory consumption, elapsed time, face detection time, frames per second, OpenVINO inference time and classification time. Performance is compared with above previous 2 methods as well as how using Intel NCS can accelerate performance and stop the process.

Stage 1: Detecting face using Intel OpenVINO running on MYRIAD X Coprocessor

OpenCV support deep learning models like Cafee, TensorFlow, PyTorch and more.

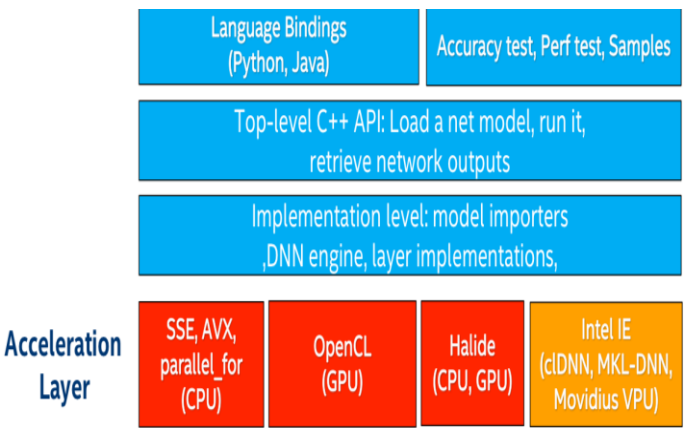

Figure 7: Architecture Of OpenCV DNN Model

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Figure 4 depicts entire architecture of OpenCV DNN model. Acceleration layer involves intel inference engine which is connected to VPU. Now blob is passed to Caffe Convolutional neural network and forward pass to acquire detecting using net variable. Weak detection is filtered based on confidence value obtained for all detections then extracts the face part for each frame.

Figure 8 gives the overall summary on how Face Detection is performed using this blob.

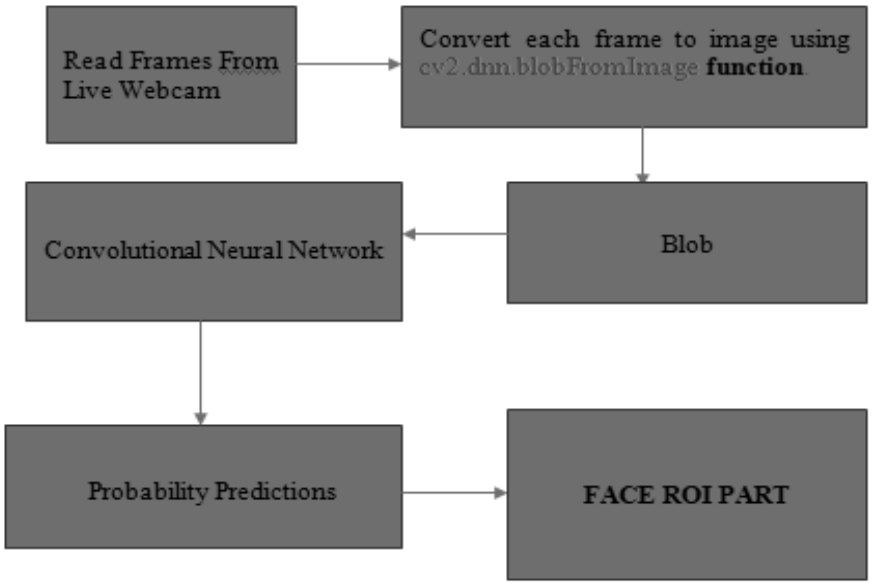

Figure 8: Overall Summary Of Face Detection Running On Intel NCS

Stage 2: Face Recognition On Raspberry PI3 CPU Using Parallel OpenVINO Inference Engine Execution

Face part is extracted successfully from above steps. Now it's time to Perform Face Recognition Using OpenVINO OpenCV Backend And target it on CPU device by transferring the detected faces on MYRIAD X VPU Processor to the Raspberry Pi3 CPU . By using Parallel Movement and Processing we are successfully able to accelerate performance on low power devices like raspberry pi3 at a good speed and accuracy. Below figure explains about loading the OpenFace Model on Raspberry PI3 CPU which is a pre-trained Torch Deep Learning Model to extract 128-D Face Embedding Values .

The below figure 9 shows the overall summary of execution topology between MYRIAD VPU and CPU Processors.

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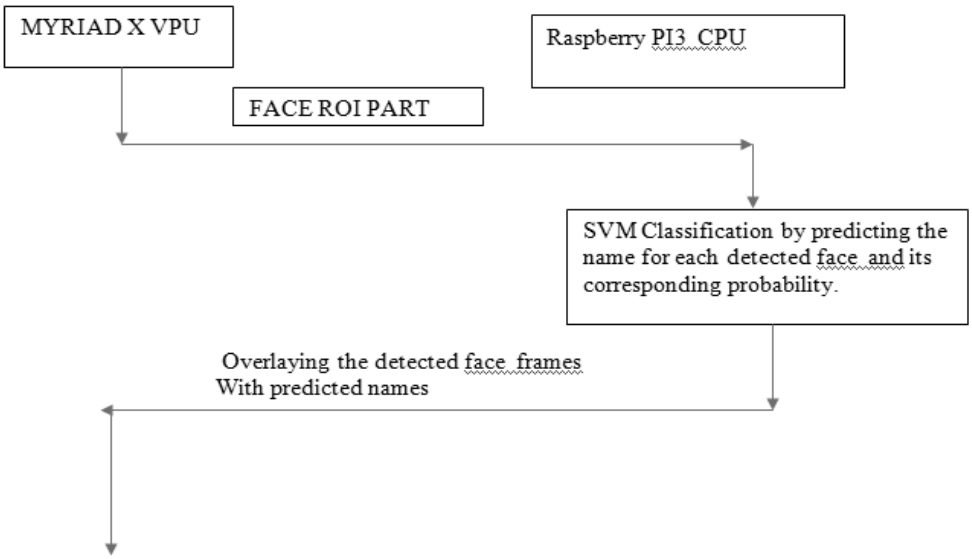

Figure 9 : Overall summary between myriad VPU and CPU Processor

V. MATHEMATICAL MODELING

In this research Linear SVM Classifier and label encoder is used to classify 4 persons. Probability values for each prediction per frame are received. So in order to get accuracy of developed model total of 50 frame counts is considered and noted all the correct predictions by comparing with true labels, also noted 50 confidence values per person. By using machine learning scikit-learn library we import confusion matrix for calculating the accuracy, F1 Score, Precision, and recall.

Table 2: Confusion Matrix For OpenVINO +. OpenCV Based Implementation On Raspberry Pi3

TRUE OUTPUTS	Nimshi	Amit Prasad	Chatchai	Clifford	FN
Nimshi	*49*	*0*	*1*	*0*	*1*
Amit Prasad	*0*	*48*	*0*	*2*	*2*
Chatchai	*0*	*0*	*50*	*0*	*0*
Clifford	*1*	*0*	*0*	*49*	*1*
	FP = 1	*FP =0*	*FP =1*	*FP = 2*	

Table 2 depicts accuracy calculations based on confusion matrix for OpenVINO +OpenCV based implementation on raspberry Pi3.

For above Confusion matrix table the correct predictions for 4 persons out of 50 frame counts are 49, 48,50, and 49.They are also known as True Positives .

Accuracy = True Positives/Total Number of counts. (1)

From the above formula we calculated accuracy as 98%.

F1 score is a good metric when data is imbalanced. F1 Score is the harmonic mean of the recall and precision.

F1 Score = 2 X Precision X Recall / Precision + Recall (2)

Precision = True Positives/ True Positive+False Positive. (3)

Table 3: Overall Summary For Measuring Accuracy Performance Using OpenVINO IR Models And Intel NCS.

METHOD	ACCURACY	Average Precision	Average Recall	1 Score
OpenFace Model (Feature Extraction) +Classification(SVM Classifier)	98%	98.5%	98%	98.2%

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Table 3 depicts overall summary for measuring accuracy performance using OpenVINO IR models and intel NCS. Accuracy of OpenFace model is 98 percent. Average precision of OpenFace model is 98.5 percent. Average recall of OpenFace model is 98 percent.

VI. RESULTS

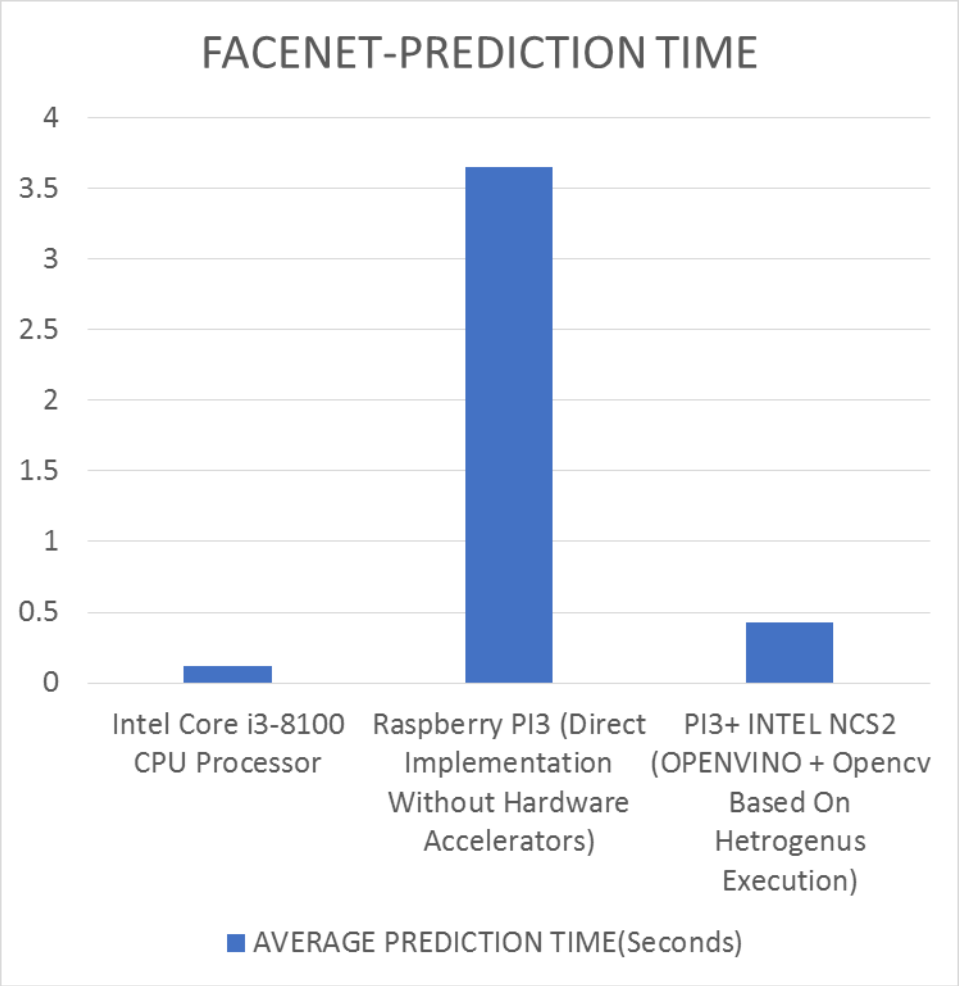

Figure 10: Facenet Prediction Graph

Figure 10 depicts Facenet prediction graph. Prediction time is high at raspberry Pi3 (direct implementation without hardware accelerations whereas Pi3+ IntelNCS2 + Opencv based on hetrogenus execution predicted within 0.5 seconds.

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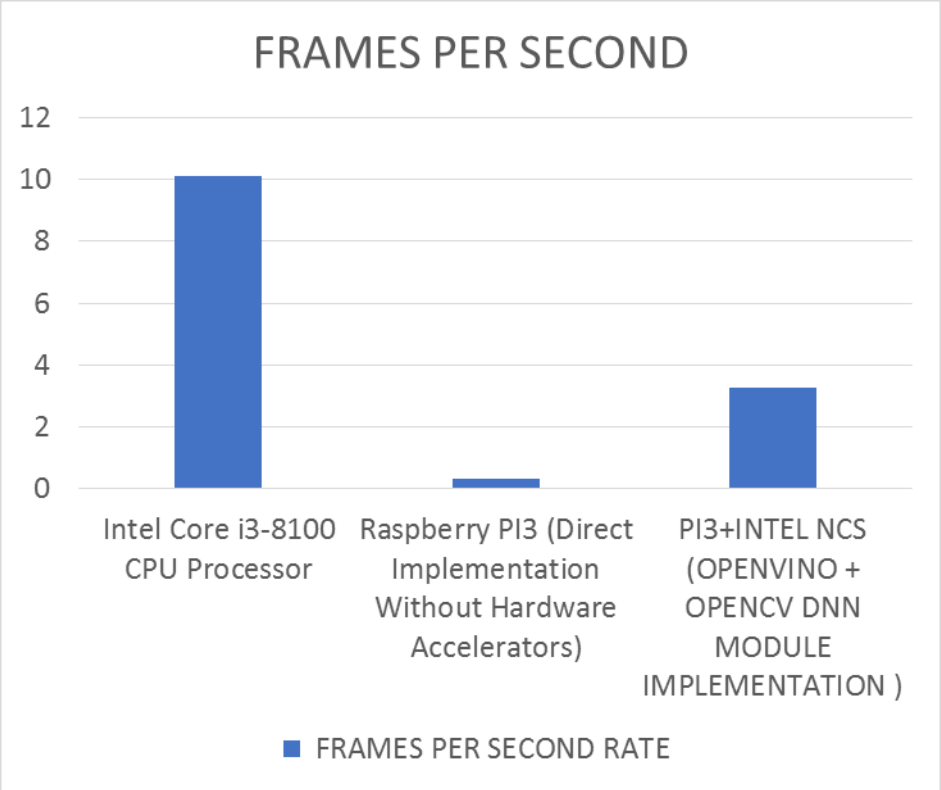


Figure 11: Facenet Frame RateGraphs

Figure 11 depicts Facenet frame rategrpahs. Frames per second rate with Pi3+intel NCS (OpenVINO +OpenCV DNN module implementation is predicted within 3 seconds.

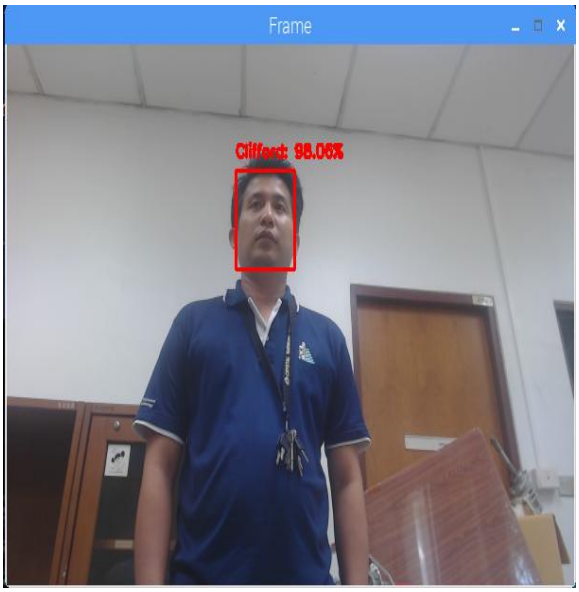
Face Recognition Results on Raspberry Pi3 using Intel OpenVINO + OpenCV DNN

The below figure 12 and figure 13 are Face Recognition results of 4 persons on Pi3 in lighting conditions and multiple face recognition. Deep learning OpenFace Model is performing well compared with previous OpenVINO FP16 Model.

The major improvements are :

Rendering greater accuracy as shown in Table 3 and its able run a 1080 pixel high resolution camera compared with 360 pixel camera as shown in figure 12.

Now using this implementation it can support up to all 4 trained persons in a single frame and recognized perfectly as shown in figure 13.



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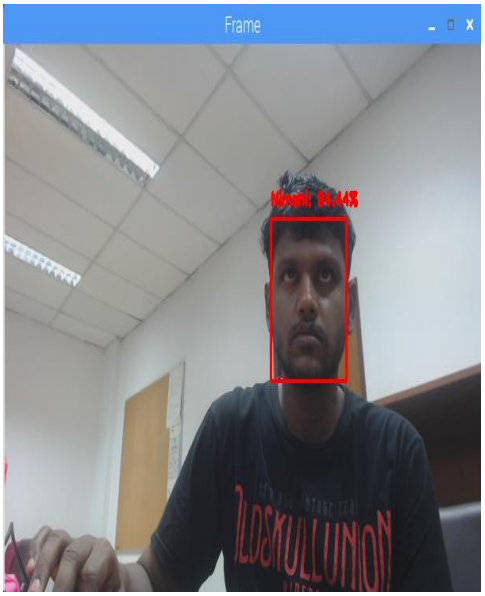


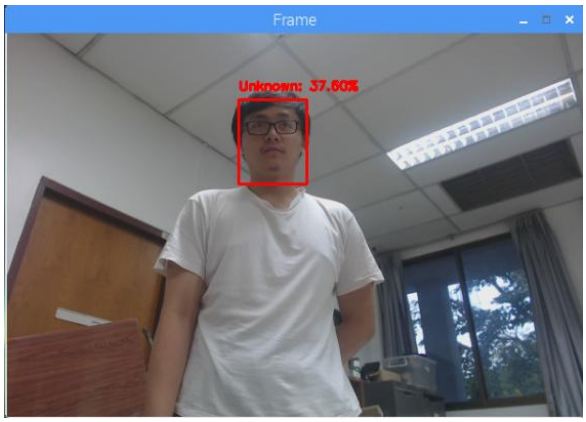
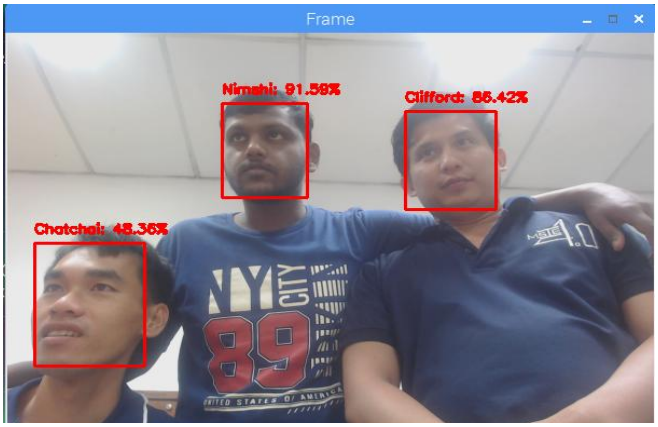


Figure 12: Face Recognition Results on Raspberry Pi3 Using Intel Openvino+ Opencv DNN Module



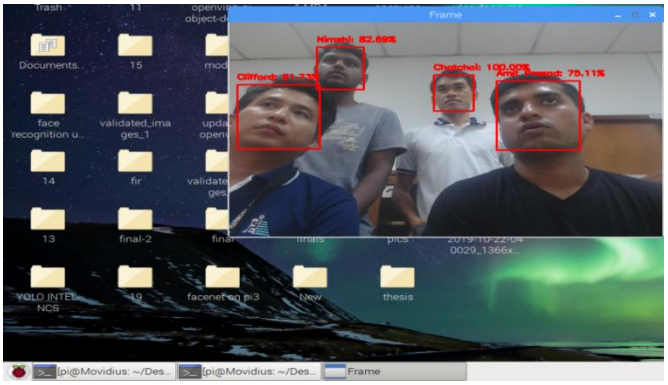
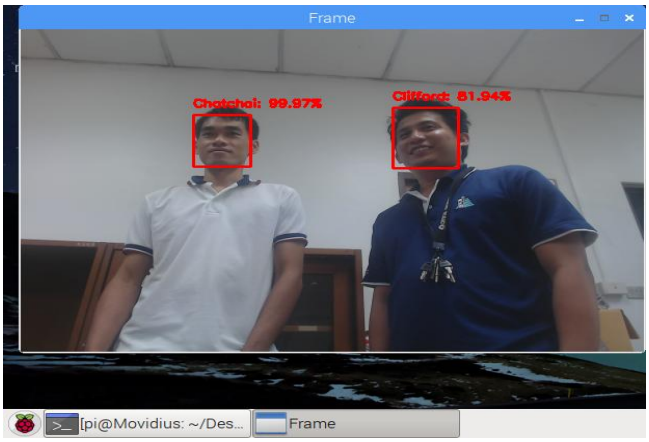


Figure 13: Multiple Face Recognition Results on Raspberry Pi3 Using Intel Openvino+ OpencvDNN Module



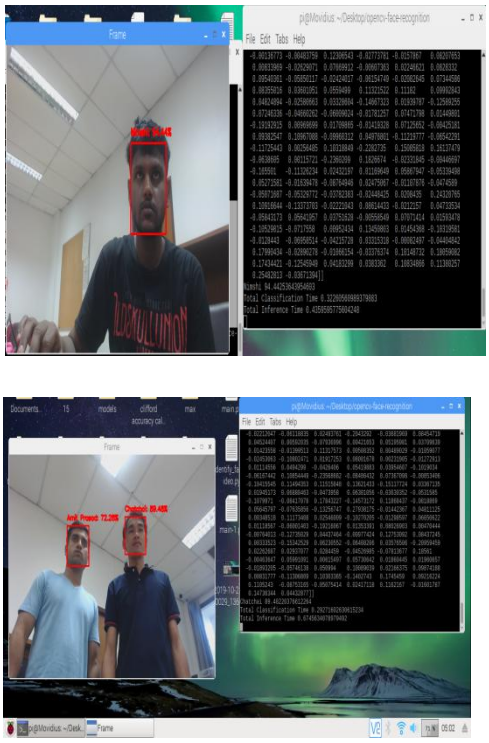


Figure 14: a) Single Person Inference Time Calculation (OpenVINO + OPENCV)
b) Two persons inference time calculation (OpenVINO + OPENCV)

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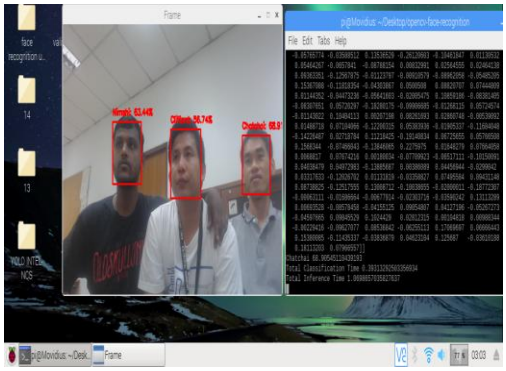

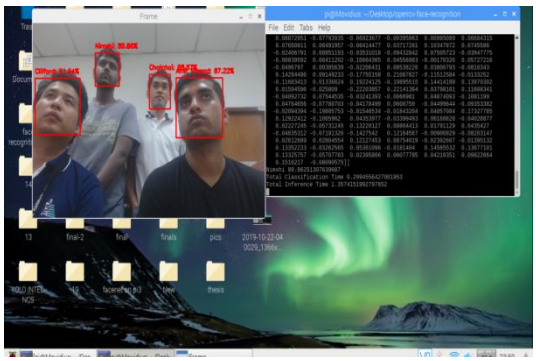

Figure 15: a) Three Persons Inference Time Calculation (OpenVINO + OPENCV)
b) Four Persons Inference Time Calculation (OpenVINO + OPENCV)

```
Total  Time Taken  For Face Detection on MYRIAD  0.0931396484375
[[-0.02024648  0.07362079  0.14652765  0.12699823  0.13565311  0.1416369
   0.01509779 -0.1639373   0.06342331 -0.01749454 -0.0413167   0.07123924
  -0.13866463 -0.04201025  0.13101555 -0.07384846  0.04060799  0.06321052
   0.02426685 -0.0541554  -0.0354441   0.06085791 -0.01956472  0.09245493
   0.13771671 -0.09674559 -0.07745396 -0.01658529 -0.02444086  0.01426894
   0.15915829  0.08113533 -0.04452098  0.04525578  0.13446772  0.12078068
   0.03178649 -0.13569647 -0.03495087 -0.09875437  0.1433685  -0.00661853
   0.02347412 -0.09390856 -0.068505    0.10291511  0.02124668  0.02026855
  -0.03322597 -0.04733472  0.04339189  0.05633263  0.07129689 -0.12965451
   0.09054214  0.08285557 -0.1180267   0.05708794 -0.07638235  0.06939016
  -0.0775488   0.04043507 -0.00083846 -0.21226992  0.2115518   0.03129566
   0.00523176 -0.04738    -0.18268408  0.29593593  0.03154082  0.11567552
  -0.0567358  -0.03738818 -0.04137404  0.04990477  0.02240585  0.05440584
  -0.02372263 -0.09702577 -0.06566306  0.15401267 -0.0081025   0.00300571
   0.03816953 -0.14631832 -0.01373363  0.02720602 -0.13368393  0.17009549
   0.08953381  0.01151445  0.01656293  0.03581878  0.02967038  0.03075442
   0.03562428 -0.06737161  0.06346601 -0.00089103  0.01178192  0.00203359
```

Figure 16: Face Detection Time Running on Raspberry pi3 Using Myraid X Processor

The figure 16 shows the average time taken to perform face detection using SSD Mobile-Net Model on Raspberry PI3 is 0.1 seconds.

Table 4: Overall Summary of Execution Time

Total No of Faces	MYRIAD-X Execution
1	0.43
2	0.67
3	1.003
4	1.36

Table 4 depicts overall summary of the execution time of OpenVINO + OpenCV. Myriad-X execution for single person is 0.43. Myriad-X execution for two persons is 0.67. Myriad-X execution for three persons is 1.003. Myraid-X execution for four persons is 1.36.

VII. CONCLUSION AND FUTURE WORK

The main aim of the research is to design and implement smart door lock system using OpenVINO. OpenVINO+ OpenCV DNN Implementation was adopted in this research. Research is carried out in two stages. In stage 1, detect the face using Intel OpenVINO running on MYRAID X Coprocessor and in 2nd stage, recognize the face on raspberry Pi3 CPU using parallel OpenVINO inference engine execution. The main advantages of using Heterogenous Execution one running on Myriad Processor and pass this detected face frames to the CPU will provide more flexibility and good accuracy compared with previous implementation. This will help developers to modify code according to their own application like building Surveillance System , Object Tracking and more edge IoT devices . The Second advantage of using this parallel execution is Running Main Thread (Face Detection) with ongoing inference on CPU (SVM Classification).

In this research, system recognizes the face from single person inference, two person inference, three person inferences and four person inference using OpenVINO. At a time, up to four person faces are recognized using OpenVINO +OpenCV.. From the findings of the research, it was noted that accuracy rate and prediction rate of door lock system is best in OpenVINO +OpenCV.

This OpenVINO +OpenCV method further is extended to implement smart door lock access control based on the recognized face. Further this work can be extended by comparing the predictions rate with different algorithms used for implementation of door lock system.

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