

Terrorist Distinguishment with Military Personnel on Attack in Air base Camps – 3 Chamber Approach: Using Real Time Monitoring – Arduino Sensor Detectors, Iris Recognition System & Wireless Communicating Nodes Deployed in Unmanned Drones

^[1] Shubham verma, ^[2] Dipti Ranjan

^{[1][2]} Department of Computer science and Engineering, Lucknow Institute of Technology, Lucknow, India.
Corresponding Author Email: ^[1]sverma705478@gmail.com

Abstract— *The security in the air base camps containing the nuclear assets and aircrafts has become a concern after interagency attacks from neighbouring countries. Manned Approach has proven to be of less efficiency in previous attacks. The research proposed 3C Chamber approach which is to be embedded into unmanned drones that will fly in the sky and recognise the terrorist interencies. 1st chamber constitutes the 3 sensors connected with Arduino named EMAX 5300 which detects the explosives, DHT11 which is used to catch the humidity and body temperature of the running terrorists in the base camps and OV7670 is the Image sensor which will give the clear image and send to the second chamber which deals iris recognition with the image data so obtained and third chamber is basically the communication chamber that contains the database and deals with regional clusters in wireless communications, localisation of suspect area through network topology so mentioned in the later paper in form of clusters, alarm dissemination phase and to be time efficient we have time synchronisation in the third chamber. All the 3 chambers work simultaneously being connected to each other and respond to the centralised node with deals with action & response. In the second chamber experiment is carried out with UBRIS.V1 database and OpenCv with Training : Testing ratios as 60:40, 50-50, 40-60 – the accuracy came out to be approximately 96.54%. Pre-registration phase involves the registration of the military personnel and later this data is retrieved and matched to catch and differentiate terrorists which is the main issue and concern of the research. The research is a combination of Biometrics, electronic sensors – internet of things, wireless network communication.*

Index Terms—3C Chamber, EMAX500, DTH11, OV7670, iris recognition, wireless network, Time synchronisation

I. INTRODUCTION

A. Threat to Air base – Case Study Pathankot Airbase Terrorist Attack on Assets

The 2016 Pathankot assault become a intellectual oppressor assault submitted on 2 January 2016 via way of means of a vivaciously provided assembling which attacked the Pathankot Air Force Station, a bit of the Western Air Command of the Indian Air Force. On the morning of one January 2016 at round 03:30 IST, in any event six severely provided human beings sporting Indian Army formal apparel entered the high-protection fringe of the airbase in Pathankot. The infiltrators probable concealed, the usage of the elephant grass withinside the fringe of the grounds previous making the strike. A nylon rope determined over the 3.4-meter-high (11-foot) aspect divider, circumnavigated starting from the earliest level and some time later down once more appeared to expose the method for segment. It is guessed that one of the aggressors had climbed one of the eucalyptus timber

developing close by the fence: wound it over together along with his weight to expose up at the divider. The floodlights in that reach of the divider have been really now no longer running that evening, which empowered the buying and selling of six aggressors, for precise 50 kilograms (a hundred and ten pounds) of ammunition, 30 kg (70 lb) of explosives, and attack weapons. The Global Security Pulse has a tendency to a essential request: 'How have to we strike (and shield) an universal settlement among the feasible opportunity and the effect of using those new developments, with out then overlooking modified risks?' Putting the communique on intellectual combating withinside the hour of development definitely in placing is fundamental. The public communicate delineates a peril that would with out a totally extremely good stretch divert thus far off from our association that it'll advantage tough to persuade and counter. It for the maximum element acknowledges instances of weaponisation of AI and killer drones. The worry of dread primarily based totally oppressors the usage of 'man-made

brainpower killer robots' runs evaluating to the dialogue on using them withinside the military. While searching on the hazard of using improvement via way of means of intellectual aggressors, close to AI and robots, one requirements to 0 in on the use of Internet. Two recognizable and really a whole lot knowledgeable locales that intellectual oppressors use stepped forward and Internet development for are their publicity tries and their correspondences. This duty revolves round a utilization of on line area via way of means of dread primarily based totally oppressors that has now no longer gotten a comparative thought: using difficult to understand fora, specifically the addition of assaults which have a dating with secretive fora.

B. Problem Statement

The threat is to differentiate the military personnel and terrorists in the same camp with same uniform. We too need to identify them through location, temperature of their body, Image, Communication etc based sensors deployed in unmanned drones connected to the wireless network with central access points. The need and urgency of security of our air base, assets, aircrafts, data has been identified after these attacks and having bordered with terrorist camps.

C. Need of Introduction to Biometrics

Biometrics is a branch that deals with the unmistakable confirmation and approval of customers dependent on their physical or/and lead properties. With the movement of development, we would now have the option to check biometric information of customers with unprecedented precision and quality. A part of the notable biometric systems join exceptional imprint affirmation, iris affirmation, face affirmation, etc. The human body gives a significant wellspring of specific information proper to be used for the task of biometric affirmation. The most particularly analyzed and for the most part got biometric modalities are the fingerprints, the iris, and the face. Some other explored biometric attributes join the palm, the hand math, the ears, the nose, and the lips.[1] The examination of the veins morphology appears as the essential wellspring of biometric features in methods like the vein organizing, and the retinal range. There are also some biometric characteristics that encompass lead properties, for instance characteristics that are most of the way connected with the cerebrum activity. Cases of this class incorporate the talk examination and voice affirmation, the physically composed imprint, keystroke components, step assessment, and the eye advancement driven biometrics. Considering the abundance of the ebb and flow biometric modalities and the heterogeneity of the related features, it may stun nobody that there is a strong example in the biometric research towards the assessment and gathering of Security blend procedures.

D. Need of Sensors in Air base security vs terrorists – Analysis

An expansion in bomb assaults in present period has supported the need to have a consistent observing of explosives openly puts. There could be recommendations of a powerful notice instrument for security dangers in broad daylight places, for example, railroad stations so security corps can make a prompt move against bomb dangers. Utilizing a multi stage remote sensor organization, the framework will give a procedure to diminish, control, and caution about the impending fear monger action by precise and quick location of explosives. Numerous remote sensor hubs incorporated with various kinds of sensors is utilized to distinguish the synthetic structure of explosives. In light of various symmetrical methods, the framework gather information from the detecting hubs progressively total the information and forward to the sink hub for additional examination. A portable hub has been acquainted with affirm the presumed objects, subsequently contributing an upgraded target following component that lessens number of bogus alerts. As of late, psychological warfare is a primary danger to the security of the world. As indicated by worldwide psychological warfare information base the fear based oppressor assaults are expanding in present days. As far as complete fear monger assaults somewhere in the range of 1970 and 2007, India is positioned in the fifth situation in the rundown of highest level nations. It is likewise discovered that almost half of weapons utilized were explosives. The explosives utilized were promptly accessible, particularly explosive, projectiles, and extemporized gadgets put inside vehicles. Far off checking for identification of explosives assists with improving the security of foundation and overall population in metropolitan territories. A remote sensor organization could be utilized for consistently checking and distinguishing hazardous materials. Current frameworks in activity were not created to work distantly in open conditions in a wide region. The trouble with the current methods is that the presumed things need to bring closer to the distinguishing instrument. This includes more human association in the location and can't be constantly observed. Here comes the meaning of distantly distinguishing the explosives were the interaction of discovery is occurring at a sensible separation from the presumed material without influencing the others involved in speculated region. The vast majority of the everyday citizens in India are depending rail routes for voyaging. Powerful components to distinguish the presence of touchy substance are not yet utilized in our railroad stations. So the principle focal point of this work is the rail route stations in India. The region to be checked is furnished with numerous quantities of differing sorts of sensors. These detecting parts are sent in the rooftop and corners of the stages. This is a multi stage engineering in which the primer stage will persistently screen the zone for the presence of

dangerous materials with the assistance of commonly free procedures. In the event that the strength of sign gathered from the sensors is more prominent than a specific limit, the framework will quickly offer admonition to the security staff through web or versatile organization. In the event that the gathered sign strength is not exactly the predefined edge, the framework will perform progressed detecting stage for the affirmation. The utilization of Remote Sensing (henceforth called RS) in the investigation and observing of normal assets acquired via land just as arranging and improvement areas isn't inventive and new to the geospatial local area. Nonetheless, profiting by RS to battle against psychological oppression can be an inventive and another methodology for some nations, for example, India and geospatial local area dealing with this most huge issue in the current worldwide situation. The developing number of psychological militant assaults lately in India has increased the value of the utilization of RS information and its scientific abilities, for example, design acknowledgment in the country. As solid and convenient stock of geospatial information isn't just required by security offices yet additionally by the salvage laborers and groups to save loss of living souls. A potential answer for the circumstance could be to have a crossing point of conventional military fighting strategies and utilizing geospatial information and advances, for example, distant detecting for a symmetric fighting. Thusly, this paper investigates the expected supporting job of RS to help antiterrorism and salvage endeavors in geospatial space of India.

II. PROPOSED WORK

A. Chamber Approach

The research proposed 3C Chamber approach which is to be embedded into unmanned drones that will fly in the sky and recognise the terrorist intergencies. 1st chamber constitutes the 3 sensors connected with Arduino named EMAX 5300 which detects the explosives, DHT11 which is used to catch the humidity and body temperature of the running terrorists in the base camps and OV7670 is the Image sensor which will give the clear image and send to the second chamber which deals iris recognition with the image data so obtained and third chamber is basically the communication chamber that contains the database and deals with regional clusters in wireless communications, localisation of suspect area through network topology so mentioned in the later paper in form of clusters, alarm dissemination phase and to be time efficient we have time synchronisation in the third chamber. All the 3 chambers work simultaneously being connected to each other and respond to the centralised node with deals with action & response. The drone will freely fly in the air and report to the centralised node with 3C approach.

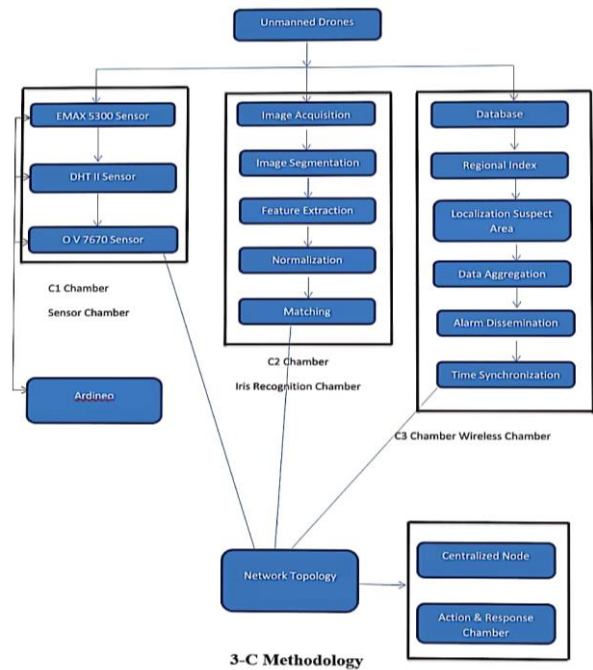


Fig.1 3 C Methodology

B. Chamber 1

a) Sensors for explosive detection

A hazardous material can be recognized synthetically, attractively, thermally and electrically.

EMAX5300 : The EMAX-5300 is the world's first and most perceived convenient explosives follow identifier with extensive explosives discovery abilities. Prepared to work in just 60 seconds, the EMAX-5300 is the solitary hand-held gadget equipped for recognizing the presence of plastic and high-fume pressure explosives, including taggants. In the event that convenience, speedy recognition and clear outcomes are significant, at that point this is the touchy identifier required. The EMAX-5300 identifies hints of the two particulates and fumes, taking into account non-obtrusive inquiries of gear, mail, vehicles, archives and compartments. The EMAX-5300 is adaptable and simple to work, offering both fume and particulate examining without the utilization of a radioactive source or outside transporter gas. Fumes are inspected straightforwardly by means of the examining spout. Particulates are examined by swiping a speculated object with cotton gloves and afterward moving the follows to a screen which is then embedded into the inspecting port. This double ability empowers clients to choose the most reasonable technique for inspecting for the explosives of interest. The EMAX-5300 beginnings preparing tests promptly and gives brings about only seconds. All outcomes are demonstrated on the LCD and by a volume-flexible sound alert, making identification a straightforward one-venture measure.

b) Arduino Temperature and Heat Sensors

The DHT11 and DHT22 sensors are utilized to gauge temperature and relative stickiness. These are well known among producers and security. These sensors contain a chip that does simple to advanced change and let out a computerized signal with the temperature and stickiness. This makes them simple to use with any microcontroller.

The DHT11 estimates relative dampness. Relative moistness is the measure of water fume in air versus the immersion purpose of water fume in air. At the immersion point, water fume begins to consolidate and aggregate on surfaces framing dew. The immersion point changes with air temperature. Cold air can hold less water fume before it gets immersed, and hot air can hold more water fume before it gets soaked. The formula to calculate relative humidity is:

$$RH = \left(\frac{\rho_w}{\rho_s} \right) \times 100\%$$

RH : Relative Humidity

ρ_w : Density of water vapor

ρ_s : Density of water vapor at saturation (1)

Relative humidity is communicated as a rate. At 100% RH, buildup happens, and at 0% RH, the air is totally dry.

```
#include <dht.h>

dht DHT;

#define DHT11_PIN 7

void setup(){
  Serial.begin(9600);
}

void loop(){
  int chk = DHT.read11(DHT11_PIN);
  Serial.print("Temperature = ");
  Serial.println(DHT.temperature);
  Serial.print("Humidity = ");
  Serial.println(DHT.humidity);
  delay(1000);
}
```

Fig.2 DHT 11 Code for displaying humidity after installation with Arduino

c) Image Sensors: OV7670 Arduino Camera Sensor Module

The camera module is filled from a lone +3.3V power supply.

Details

- Opticalised size 1/5 inch
- Goal 642x482 VGA
- Installed controller, just single 3.3V stock required
- Mounted with excellent F1.8/6mm focal point
- High responsiveness for low-light activity
- VarioPixel technique for sub-examining

- Programmed picture control capacities including: Automatic
- Openness Control (AEC), Automatic Gain Control (AGC), Automatic White Balance (AWB), Automatic
- Picture quality controls including variety immersion, tone, gamma, sharpness (edge upgrade), and against blossoming
- ISP incorporates sound decrease and deformity remedy
- Upholds LED and blaze strobe mode
- Upholds scaling
- Focal point concealing adjustment
- Gleam (50/60 Hz) auto location
- Immersion level auto change (UV change)
- Edge upgrade level auto change
- De-clamor level auto change

C. Chamber 2: Iris Recognition System for Terrorists

a) Registration Phase

The registration phase: Involves training of the model. The system will be trained with the iris images of military personnel so during the recognition system after acquisition of the image – matching of the iris would result in differentiation of military personnel vs terrorists entering in the airbase to safeguard our assets.

In Our Model registration would be illustrated in following steps

1. Record Right Iris
2. Record Left Iris
3. Store it in database

After these 3 steps the registration process is completed.

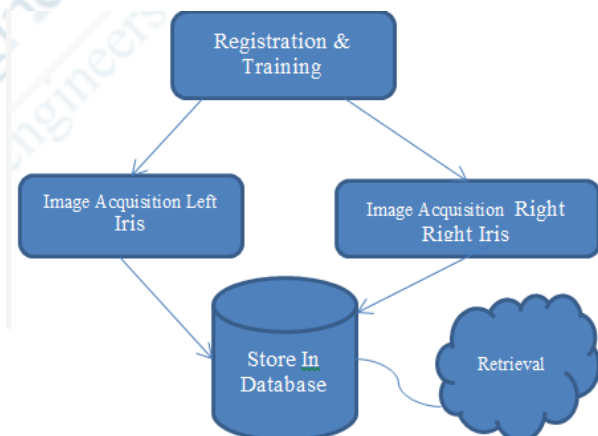


Fig.4 Registration Phase

D. Eye Recognition Using OpenCv

a) OpenCv & Deep Learning in OpenCv

OpenCV (Open Source Computer Vision Library) is an open source library used to perform PC vision endeavors.

OpenCV critical learning execution process:

1. Stacking a model from circle.
2. Pre-process pictures to fill in as responsibilities to the cerebrum structure. (run other PC vision assessments on the data pictures if key)
3. Go the picture through the structure and secure yield approaches.

a) Code for Detection & Matching

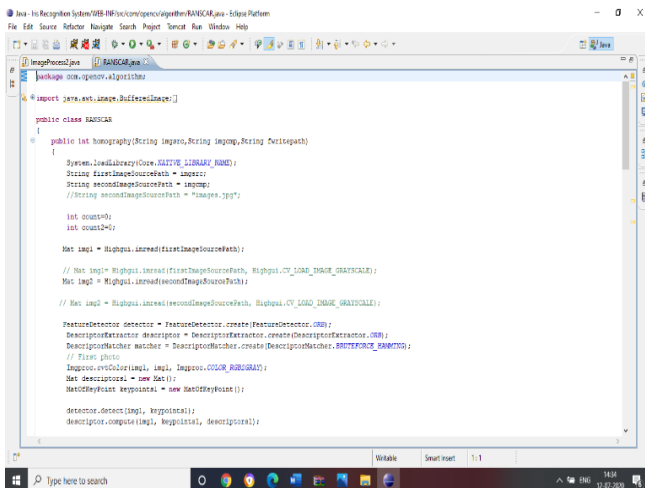


Fig. 5 Code for Eye Recognition System Part 1

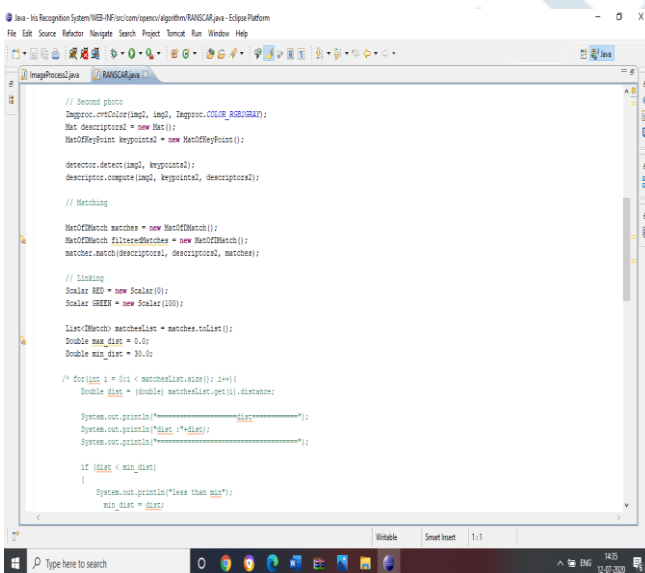


Fig. 6 Code for Eye Recognition System Part 2

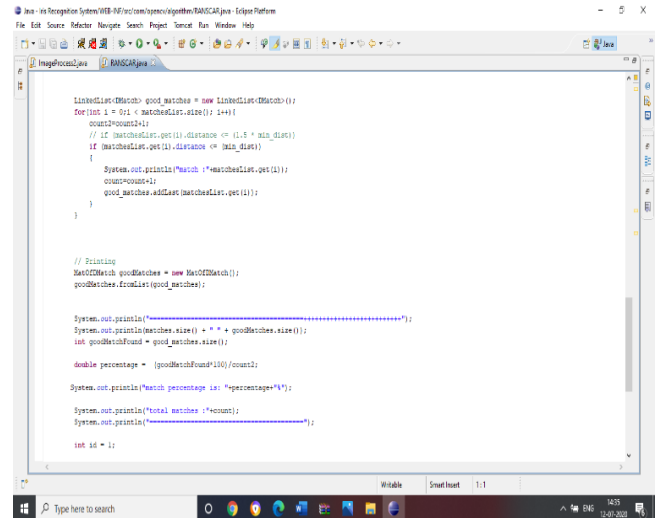


Fig. 7 Code for Eye Recognition System Part 3

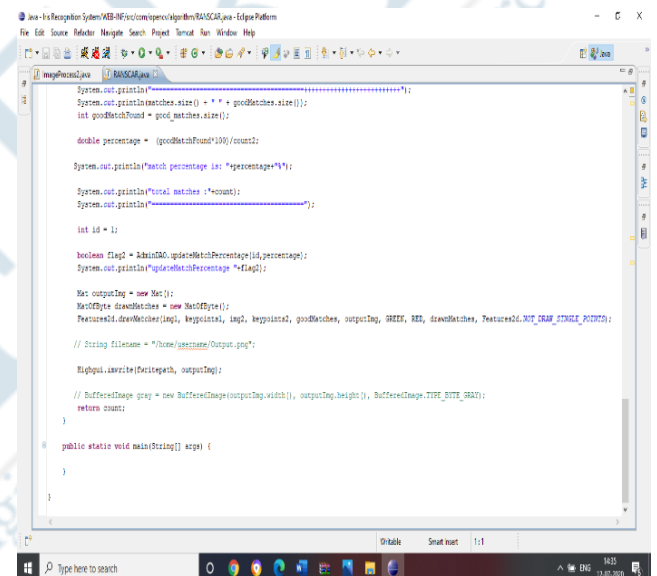


Fig. 8 Code for Eye Recognition System Part 4

III. METHODOLOGY

The hidden improvement is the photograph get. By then pix are introduced to actual plans to play out a few pre-looking after steps. By then the iris is restricted and remotored for extra preparation. The outside layer of the iris is separated through then making use of becoming strategies[4-8]. At lengthy final floor getting taken care of out is completed to aid perceiving confirmation framework. The simple advances may be summed up as:

a) Image Acquisition: Image is gotten below valid illuminating, parcel and extraordinary factors influencing photograph exceptional are taken into thought. This improvement is vital thinking about the manner that photograph exceptional performs a wonderful profession in iris Localization.

b) Image Segmentation: In this improvement, the iris district is eliminated from the given photograph. The iris department is a essential development for all round execution of the construction.

c) Feature extraction: In the element extraction stage, novel element from the separated iris is removed to make an iris plan. This path of motion moreover applied for confirmation.

d) Matching: The disengaged fashions are prepared onto the fashions now segregated and positioned away in informational index. The stage of closeness selections whether or not or now no longer the unquestionable confirmation is to be set up.

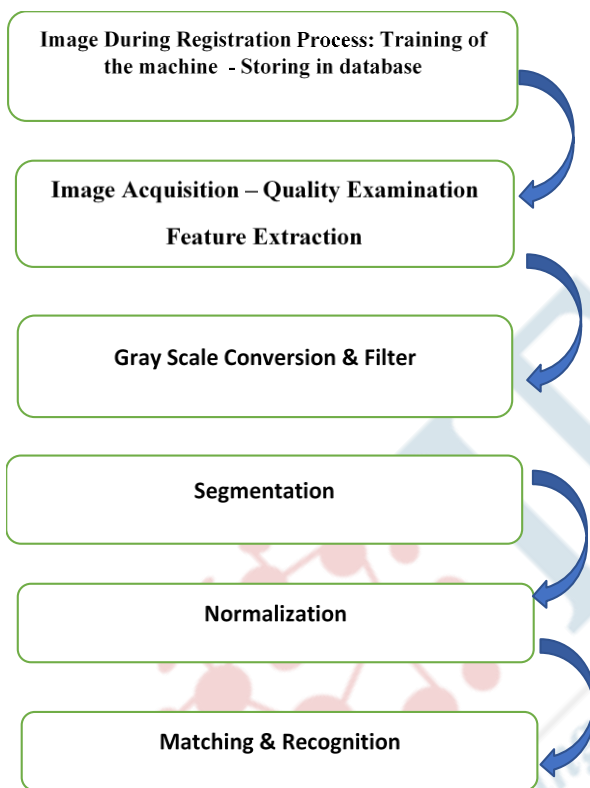


Fig .9 Eye Recognition System flowchart

Table I. Algorithms

Title	Algorithm
Feature Extraction	ORB (Oriented FAST and Rotated BRIEF) Algo
Feature Descriptor & Matcher	Brute Force Matcher
Feature Matching & Homography	HUMMING Distance
Inliners & Outliners	RANSAC
Normalization	Daugman's Rubber Sheet

IV. NORMALISATION

The primary objective is to characterize the zone between the understudy sweep and the iris range. For this the iris a roundabout segment is changed into rectangular.[9-10] For each facilitate in the picture, we decide the polar edge and the separation between the range of the iris and student. We likewise decide the relative good ways from the understudy sweep to 24 the point. Utilizing this data we convert each polar directions to Cartesian directions in every emphasis. For this we utilize the equation:

$$X = \cos(\Theta) * r + (x\text{-facilitate of focus})$$

$$Y = \sin(\Theta) * r + (y\text{-organize of focus})$$

Where,

X= x Cartesian arrange

Y= y Cartesian arrange

r = range of student and relative separation

Θ = edge of the current polar organize

Focus = student focus

V. SIMULATIONS & WORKING

A. Diagnostic Steps: Eye Related Simulation Eye: Training of Datasets Database: UBIRIS.V1

In 2004 we delivered the UBIRIS.v1 informational index. Our motivation was to imitate less obliged imaging structures and get clear repeat pictures with such information ruining the iris rings (considered disturbance). Vast assessments were facilitated on this informational index and pronounced in the organization, regardless of the way that the realness of its clack factors got several reactions. This was a basic inspiration for the progress of another variety of the informational index (UBIRIS.v2) in which the photographs were genuinely gotten on non-obliged conditions (a distance away, moving and on the unmistakable repeat), with taking a gander at continuously practical upheaval factors. The basic motivation driving the UBIRIS.v2 data base is to spread out another mechanical gathering to review the practicality of clear repeat iris insistence under distant from awesome imaging conditions. In this degree, the different sorts of non-astounding pictures, imaging separations, subject points of view and lighting conditions existent on this informational collection could be of solid utility in the confirmation of the detectable repeat iris insistence likelihood and goals. The approach of it is given in the above table to picture framework[11-14]. As shown in figure 1, this plan was introduced on a parlor under both brand name and fake lighting sources. We set several inscriptions on the floor (a few spot in the extent of three and ten meters from the procuring gadget) and referenced volunteers for the picture getting structures. Two certain image gaining social events were worked out, every one during about fourteen days and isolated by a time-frame week. From the first to the second assembling the district and course of the obtaining contraption and phony light sources was changed, to develop

heterogeneity. Volunteers were any place greater part latin caucasian (around 90%) what's more faint (8%) and asian individuals (2%). Around 60% of the laborers performed both imaging social affairs, while 40% performed solely one, either during the first or second gaining time frame. Subjects were supposed to stroll around a scarcely more postponed than typical speed and to take a gander at two or three equivalent connotes that obliged them to turn head and eyes, connecting with the manual getting of 3 pictures for each meter, a few spot in the extent of eight and four meters, giving a measure of 15 pictures for each eye and meeting, for the enormous bigger part of people. It ought to be based on this referred to wonderful lead had the stand-apart legitimization for normalizing how much usable pictures per subject and imaging meeting. A totally secret way of thinking could have been utilized with a from an overall perspective lower number of usable pictures per meeting. As it is illustrated in figure 2, the basically further degree of divisions between the subjects and the imaging system is one of the major observable fixations between the UBIRIS.v2 data base and the excess ones.[15-19]

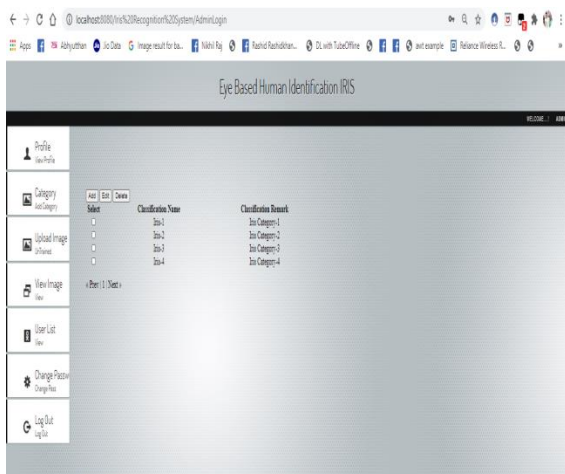


Fig 10 Snapshot for Training Dataset Of Eye into Various Category of Iris

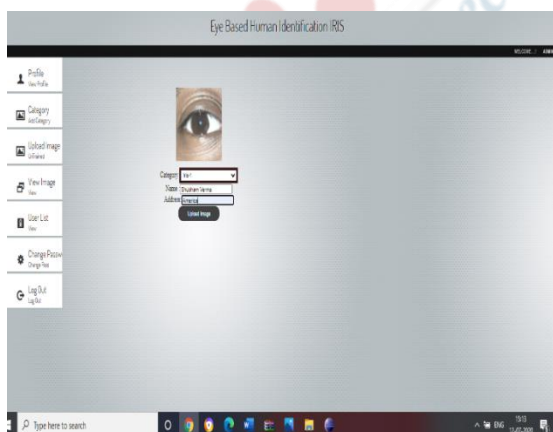


Fig 11 : Snapshot For Training Dataset Of Eye

B. Testing Phase

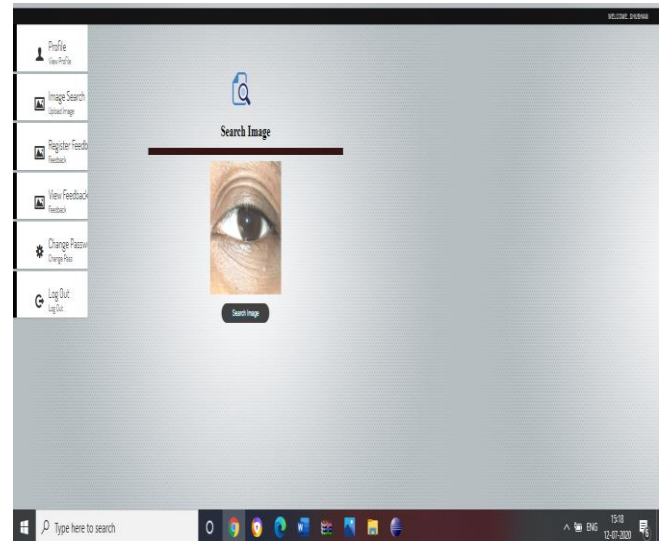


Fig 12 : Snapshot For Testing Dataset Of Eye

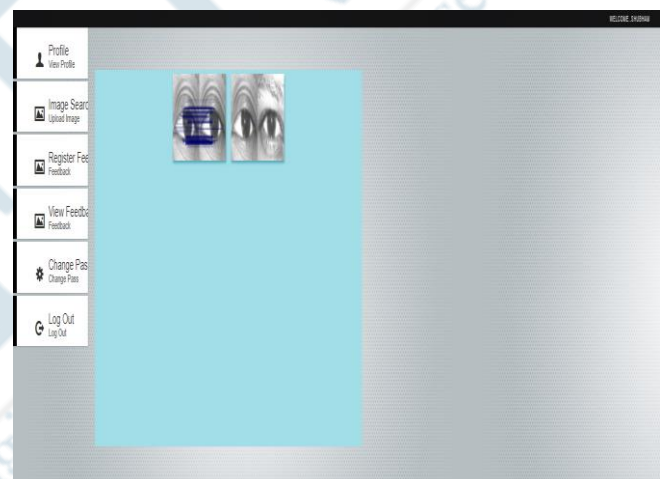


Fig 13: Snapshot for Matching Dataset of Eye

C.Accuracy for Eye Based Recognition

For acknowledgment reason, the Humming Distance is received as the measurement of difference between input iris format and selected iris templates. The execution of iris acknowledgment is evaluated with acknowledgment exactness determined as

$$\text{Accuracy} = \left(\frac{\text{No. of times persons recognizes}}{\text{Total No. of Recognit}} \right) \times 100 \quad (2)$$

From the exploratory outcomes, the normal acknowledgment exactness is gotten as 96.54%.

The ratios of training : testing ratio was made variable as 60:40,50:50,50:50*,40:60 and the different accuracies was obtained as 96.11% ,94.48% ,90.01% ,96.54 %

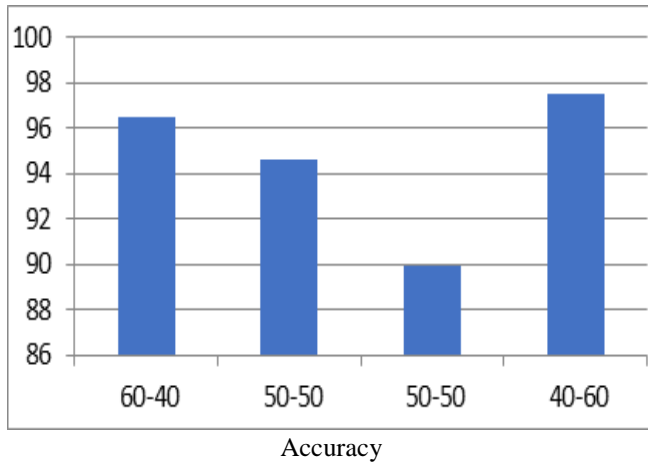


Fig. 14 Training/Testing Ratios with accuracy

D. Chamber 3

Network 3 includes the : Database , Regionalised Clusters , Localisation of Suspect Area Room , Data Aggregation Room , Alarm dissemination room , Time Synchronisation Room and the explained below in respective sequence :

- Database
- Regionalised Clusters
- Localisation of Suspect Area Room
- Data Aggregation Room
- Topology plan



Fig. 15 Shows the Network Topology

Step 1 Pre-requisite	Registration { Store Left Iris(); Store Right Iris(); Database (); } Execute Chamber 1() , 2(),3() Simultaneously
Step 2 Chamber 1	Chamber 1() { EMAX 5300(); DT11 (); OV 7670(); }
Step 3 : Chamber 2	Chamber 2() { Image Acquisition Segmentation Feature Extraction Normalisation Matching } If match1 = Image in step 1 Report () to step after Chamber 3 : Step 5
Step 4 Chamber 4	Chamber 3() { Database Store() Regionalised Clusters() Localisation of Suspect Area Room() Data Aggregation Room() Alarm dissemination room() Time Synchronisation Room() }
Step 5	Reporting to : Centralised Node (); Alert and Action();

Fig. 16 Phases of 3 chamber met6hod

VI. CONCLUSION

The security in the air base camps containing the nuclear assets and aircrafts has become a concern after interagency attacks from neighbouring countries. Manned Approach has proven to be of less efficiency in previous attacks. The research proposed 3C Chamber approach which is to be embedded into unmanned drones that will fly in the sky and recognise the terrorist interencies. 1st chamber constitutes the 3 sensors connected with Arduino named EMAX 5300 which detects the explosives , DHT11 which is used to catch the humidity and body temperature of the running terrorists in the base camps and OV7670 is the Image sensor which will give the clear image and send to the second chamber which deals iris recognition with the image data so obtained and third chamber is basically the communication chamber that contains the database and deals with regional clusters in wireless communications , localisation of suspect area through network topology so mentioned in the later paper in

form of clusters , alarm dissemination phase and to be time efficient we have time synchronisation in the third chamber. All the 3 chambers work simultaneously being connected to each other and respond to the centralised node with deals with action & response. In the second chamber experiment is carried out with UBRIS.V1 database and OpenCv with Training : Testing ratios as 60:40, 50-50, 40-60 – the accuracy came out to be approximately 96.54%. Pre-registration phase involves the registration of the military personnel and later this data is retrieved and matched to catch and differentiate terrorists which is the main issue and concern of the research. The research is a combination of Biometrics , electronic sensors – internet of things , wireless network communication. Since Science is said to be systematic knowledge gained by man through experimentation and observation. This research is also an observation that will prove out to very efficient in the security concerns. As science demand advancements any better and efficient technology could be embedded into 3C model to make it more efficient. There are certain advancements that could be made in terms of 3C model is that inappropriate persons being captured and recognised as a false rate deduction that should minimise with time , accuracy may be a concern that will be advanced with time and training testing experiments.

REFERENCES

- [1] Z. Huang, Y. Liu, C. Li, M. Yang, Chen A robust face and ear based multimodal biometric system using sparse representation, *Pattern Recognition*, 46 (2013) 2156–2168. <https://doi.org/10.1016/j.patcog.2013.01.022>
- [2] N. Alay, H.H. Al-Baity, A multimodal biometric system for personal verification based on different level fusion of iris and face traits. *Biosci. Biotechnol. Res. Commun.*, 2 (2019), 565-576.
- [3] K. Gunasekaran, J. Raja, R. Pitchai, Deep multimodal biometric recognition using contourlet derivative weighted rank fusion with human face, fingerprint and iris images. *Automatika: časopis za automatiku, mjerenje, elektroniku, računarstvo i komunikacije*, 60(2019) 253-265. <https://doi.org/10.1080/00051144.2019.1565681>.
- [4] Z.T. Liu, C-S Jiang, S-H Li, M. Wu, W-H Cao, M. Hao, Eye state detection based on Weight Binarization Convolution Neural Network and Transfer Learning, *Applied Soft Computing*, Volume, 109(2021), 107565, ISSN 1568-4946, <https://doi.org/10.1016/j.asoc.2021.107565>.
- [5] H. Kim, J. Jo, K.A. Toh, J. Kim, Eye detection in a facial image under pose variation based on multi-scale iris shape feature, *Image and Vision Computing*, 57(2017) 147-164.
- [6] P. Majaranta, 2018. Bulling an Eye tracking and eye-based human–computer interaction, In *Advances in Physiological Computing*. Springer, London UK, 39–65.
- [7] L. Świrski, A. Bulling, N. Dodgson, 2012. Robust real-time pupil tracking in highly off-axis images. In *Proceedings of the Symposium on Eye Tracking Research and Applications*, Santa Barbara CA, USA. 173–176.
- [8] A. Păsărică, R.G. Bozomitu, D. Tărniceriu, G. Andrusac, H. Costin, Rotariu C Analysis of Eye Image Segmentation Used in Eye Tracking Applications. *Rev. Roum. Sci. Tech.* 62(2017) 215–222.
- [9] N. Hezil, A. Boukrouche, Multimodal biometric recognition using human ear and palm print. *IET Biom*, 6(2017) 351–359.
- [10] A.A. Jarjes, K. Wang, G.J. Mohammed, Improved greedy snake model for detecting accurate pupil contour. *IEEE 3rd international conference on advanced computer control*, 2011, 515-519.
- [11] J.D. Bustard, M.S. Nixon, Robust 2D ear registration and recognition based on SIFT point matching, In *2008 IEEE Second International Conference on Biometrics: Theory, Applications and Systems*, 2008, 1-6.
- [12] J. Zhou, S. Cadavid, M. Abdel-Mottaleb, Exploiting Color SIFT Features for 2D ear recognition, *18th IEEE International Conference on image processing*, 2011, 553 – 556.
- [13] R.A. Priyadarshini, S. Arivazhagan, M. Arun, Deep learning approach for person identification using ear biometrics, *Appl Intell* 51, 2161–2172 (2021). <https://doi.org/10.1007/s10489-020-01995-8>
- [14] F. Khurshed, A.H. Mir, AR model based human identification using ear biometrics, *International Journal of Signal Processing, Image Processing and Pattern Recognition*, 7(2014) 347-360. <http://dx.doi.org/10.14257/ijsp.2014.7.3.28>
- [15] L. Alvarez, E. González, L. Mazorra, Fitting ear contour using an ovoid model, In *Proceedings 39th Annual 2005 International Carnahan Conference on Security Technology*, 2005, 145-148. doi: 10.1109/CCST.2005.1594829.
- [16] B. Zavar, Arbab, S. Mark, On guided model-based analysis for ear biometrics, *Computer Vision and Image Understanding*, 115(2011) 487-502. <https://doi.org/10.1016/j.cviu.2010.11.014>
- [17] J.G. Daugman, High confidence visual recognition of persons by a test of statistical independence, *IEEE transactions on pattern analysis and machine intelligence*, 15(1993) 1148-1161. doi: 10.1109/34.244676
- [18] M. Rahul, R. Shukla, P.K. Goyal, Z.A. Siddiqui, V. Yadav, Gabor Filter and ICA-Based Facial Expression Recognition Using Two-Layered Hidden Markov Model, In *Advances in Computational Intelligence and Communication Technology*, 2021, 511-518. Springer, Singapore. https://doi.org/10.1007/978-981-15-1275-9_42
- [19] R.P. Wildes, Iris recognition: an emerging biometric technology. *Proceedings of the IEEE*, 85(1997) 1348-1363. doi: 10.1109/5.628669