Multimodal Biometric Authentication System Using Face and Fingerprint Biometric

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I. INTRODUCTION


A Picture Might Be Considered As A Two Dimensional (X,Y) Area, Where X And Y Are Spatial Directions, And The Adequacy Or Value At Any Combination Of Directions (X, Y) Is Known As The Fixation Or Dark Level Or Pixel Value Of The Picture. Pixel Is The Smallest Element In A Picture. Pixel Is Itself Signified As “Picture Element”. Whenever X, Y, And The Focus Estimations Of An Image Are For The Limited Part Or Discrete Amount, We Call The Picture A Computerized Picture. A Computerized Picture Is Made Up Of A Limited Number Of Components, Each Of Which Has A Specific Place And Esteem. These Components Are Called Picture Components, Buddies, And Pixels. Pixel Is The Term Utilized Most Broadly To Mean The Components Of A Computerized Picture. It Is Not Wrong To Say That Pictures Play The Most Essential Part In Human Mindfulness. Even For People Who Are Lacking To The Visual Band Of The Electromagnetic (EM) Range, Imaging Contraption Cover Nearly The Whole EM Range, Going From Gamma To Radio Waves. They Can Work On Pictures Produced By Source That People Are Not Comfortable To Connect With. These Include Ultrasound, Electron Microscopy, And PC Produced Pictures. Now And Then A Refinement Is Made By Characterizing Picture Handling As A Control In Which Both The Information And Yield Of A Procedure Are Pictures [1].

Multimodal Biometric System: Biometric System Is A System Which Identifies Or Authenticates The Person Based On Biometric Traits. Biometric Are The Unique Features Or Characteristics Of The Individual. Biometric System Can Be Used For Variety Of Purposes Like Access Control, Person Identification, Attendance In Various Departments Etc. It Is A Pattern Recognition System That Gives Results By Acquiring Biometric Information From An Individual, Extracts The Feature-Set From The Acquired Data And Calculates The Characteristic Set Against The Pattern Set In The Database. Biometric Systems Can Use One Or More
Biometrics Characteristics For The Purpose. For Instance, Uni-Modal Biometric System Works On One Biometric Like On Fingerprints Or On Facial Expressions Etc. On The Other Hand Multi-Modal Biometric System Works On More Than One Unique Feature Of A Human Being Like Both On Fingerprints And Facial Expressions. Basically Biometric Are Of Two Types:
1. Physiological
2. Behavioural


II. LITERATURE SURVEY


Jagadiswary Et Al. [7] Proposed A Fused Multimodal System. It Has Various Benefits As Compared To Uni-Biometric Framework Like Improved Verification Accuracy, Bigger Space To Coordinate With More Examples. Biometric Authentication Systems Are Just An Add-On Of Pattern Recognition Framework. Optical Sensors Such As Scanning Devices And Cameras Are Used To Record Images And Unique Features. The Aim Is To Minimise The FAR (False Acceptance Rate) And Maximise The GAR (Genuine Acceptance Rate). The Proposed And Improved Multimodal Confirmation Framework Depends Upon Feature Extraction By Using


Omran Et Al. [11] Proposed A Multimodal System Using Iris And Finger-Print Recognition Framework. Fingerprint Identification Formula Is Revised To Create Delaney Triangulation Framework In Which Neighboring Triangles Were Compared Among Stored Templates And Input. Whereas Iris Recognition System Was Revised Segmentation Method Based On Correlation Filter. Such Method Was Applied To Lower Part Of Iris Region Which Is Supposed To Be Least Affected By Noise. The Suggested Multimodal System Provides High Accuracy And Less Error Rate Close To (0.9%).


Awalkar Et Al. [13] Devised An Algorithm Which Uses The Combination Of Iris And Face. Iris Is Chosen For Its Good Recognition Power. Face Is Easily Available And Can Be Captured Easily. Score Level Fusion Is Used For Fusing The Match Scores. LBP (Local Binary Patterns) And Gabor Filters Are Used For Extracting Features From Face Images And Daugman’s Algorithm Is Used For Iris Feature Extraction. The Performance Was Evaluated And EER (Expected Error Rate) Was Turned Out To Be 1.48%.


### III. MINUTIAE EXTRACTION


- **Ridge Ending:** Ending Of The Ridge Flow.
- **Bridges:** It Denotes That Ridge Which Joins Two Ridges.
- **Ridge Islands:** It Denotes The Ridge Which Is Surrounded By Other Ridges.
- **Ridge Bifurcation:** It Denotes The Point Where One Ridge Divides Into Two.
- **Ridge Dots:** These Are Small Ridges Of Similar Size To A Dot.
- **Ponds / Lakes:** These Are Blank Spaces Among Diverging Ridges.
- **Crossovers:** It Denotes The Point Where Two Ridges Cross Each Other. [17]

![Figure 1: Minutiae Points](image)

### IV. BACTERIAL FORAGING OPTIMIZATION ALGORITHM

BFOA Is An Algorithm Used Globally For Optimization Of Problems And Inspired From Behaviour Of Enzymes Namely Escherichia Coli. It Is Invented By Passino. It Is Encouraged From Chemo Taxis Behaviour Of Bacteria. E. Coli Bacteria Search For Nutrients In Such A Way To Get Maximum Energy In A Unit Time. The Movement Of Bacteria In Search Of Nutrients Is Termed As Chemo Taxis. When They Get Sufficient Nutrients, They Become Lengthier In Size And Break Down Into Two Bacteria. This Activity Of Bacteria Is Termed As Reproduction. Due To Some Reasons Like Environment Changes, Some Bacteria Dies And Some Shifted To Another Part Or Group, Which Results In The Constancy Of The Population. This Behaviour Of Bacteria Can Be Termed As Elimination-Dispersal Activity. All These Activities Are Also Depicted In The Algorithm. So, Here, We Can Say The Said Algorithm Consists Of Four Main Processes As Depicted Below:

- **Swarming:** Group Behaviour Has Been Observed In E. Coli Bacteria To Form Patterns Or Swarms. They Form Groups Or Rings While Travelling Through The Medium.
- **Reproduction:** The Least Healthy (Or Highest Cost In Terms Of Its Application) Dies And Some Healthier Bacteria Breaks Down Into Two. The Population Size Hence Remains Intact.
- **Elimination And Dispersal:** As Described Above As Well, Changes In The Living Environment Of The Bacteria Results In The Killing Of A Group Of Bacteria Or Shifting Of A Group Of Bacteria To Other Place. To Implement This In Algorithm, A Probability Is Used To Eliminate Some Features And Some Are Replaced In The Search Space.

**Steps Of BFOA**

**Parameters:** The Parameters Used In The Algorithm Are As Follows:

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*International organization of Scientific Research*
• D: Dimension Of The Search Space
• T: Total Number Of Bacteria
• Zc: Number Of Chemotactic Steps
• Zs: Swimming Length
• Zr: Number Of Reproduction Steps
• Zd: Number Of Elimination-Dispersal Steps
• Ped: Elimination-Dispersal Probability
• S(I): Size Of Step Taken Randomly (Tumble)

Let \( P(A,B,C) = \{ \Theta (A,B,C) \} \), Where I = 1, 2, ..., T} Represent The Position Of Each Member In The Population At A\(^{th}\) Chemotactic Step, B\(^{th}\) Reproduction Step And C\(^{th}\) Elimination-Dispersal Step. Let J(I,A,B,C) Denotes The Cost At The Location Of The I\(^{th}\) Bacterium \( \Theta (A,B,C) \in \mathbb{R}^d \) (Rational Numbers With D Dimensions)

Step 1: Initialise Parameters D, T, Zc, Zr, Zd, Ped, S(I) (I=1,2,...,T), \( \Theta^i \)
Step 2: Elimination-Dispersal Loop: C=C+1
Step 3: Reproduction Loop: B=B+1
Step 4: Chemo Taxis Loop: A=A+1
1. For I=1,2,...,T Repeat The Below
2. Compute Fitness Function \( J(I,A,B,C) \)
   Let J(I,A,B,C)= J(A,B,C)+Jcc((\Theta(A,B,C), P(A,B,C))
3. Let Jlast(I,A,B,C)=J(I,A,B,C) Until We Find The Best One
4. Tumble: A Random Number Vector Is Generated \( \Delta(I) \in \mathbb{R}^d \) With Each Element Lies In[-1,1]
5. Take A Chemotactic Step As Follows:
   \( \Theta^i(A+1,B,C)=\Theta^i(A,B,C)+S(I) \Delta(I) \) (Sqrt(\( \Delta^2(I) \) \Delta(I))
6. Calculate J(I,A+1,B,C) Using
   \( J(I,A+1,B,C)=J(I,A,B,C)+Jcc((\Theta(A+1,B,C), P(A+1,B,C))
7. Swim:
   A. Let G=0 (Swim Length Counter)
   B. While G<Zs Repeat
   C. Let G=G+1
8. Go To Next Bacterium I=I+1, I:=T
Step 5: If A<Zc, Repeat Step 4 As The Bacteria Life Is Not Over
Step 6: Reproduction:
1. For The Given B And C, And For Each I=1,2,...,T Let
   \( J^\text{health}=\sum_{j=1,2,...,Zr+1} J(I,A,B,C) \)
2. The Tr Bacteria With The Highest Jhealth Values Die And Tr Best Bacteria Split Into Two.
Step 7: If B<Zr Go To Step 3 Till The Reproduction Steps Are Over.
Step 8: Elimination-Dispersal: For I=1,2,...,T With Probability Ped, Eliminate And Disperse Each Bacterium I Till C<Zed.

V. PRINCIPAL COMPONENT ANALYSIS

It Is A Method Of Analysing Arrangement In Data, And Expressing The Information In Such A Way As To Focus Their Resemblance And Difference [18]. PCA Converts The Set Of Observations Of Correlated Variables Into A Set Of Values Of Linearly Uncorrelated Variables By Using Orthogonal Transformation. These Set Of Values Are Called Principal Components. It Is One Of The Simplest Techniques Of Analysis That Uses Eigen Values And Eigen Vectors. It Can Be Thought Of As A Technique To Explain The Internal Structure Of The Data Set Or Features In A Way That Makes It Easier To Solve The Issue Or The Problem. It Describes How Much Data Is Varying. It Is Mostly Used For Reducing Dimension Of The Image So That The Required Information Is Obtained And Extra Information Can Be Discarded. The Aim Is To Select A Good Quantity Of Images In Order To Have The Best Understanding Of Problem With The Minimum Database. Below Are The Steps Which Are Followed In PCA.

Step 1: First Create The Data Set Or Feature Set Or Feature Vector.
Step 2: Mean Is Calculated For The Vectors.
Step 3: Mean Is Subtracted From Each Value.
Step 4: Co-Variance Is Calculated Of The Results Of Step 3. A Co-Variance Matrix Is Obtained.
Step 5: Form The Above Covariance Matrix, Eigenvalues And Eigen Vectors Are Calculated.
Step 6: Eigen Values And The Eigen Vectors Are The Principal Components.

VI. IMPLEMENTATION

**Step 1: Data Collection:** In This Multimodal Biometric Fusion Data Is Collected From The UCI Machine Learning Repository Site. First Dataset Contains Face Images And Second One Contains Finger Print Images.

**Step 2: Conversion:** The Multi Model Biometric System Needs To Convert The Original To Gray Scale Image. This System Works On Gray Scale Images.

**Step 3: Feature Extraction In Fingerprint:** Mostly, Local Ridge Features Are Used For Identification Systems Based On Fingerprints. These Local Ridge Features Are Called Minutiae. Here, In This Proposed System Minutiae Points Are Extracted From Fingerprints. Minutiae Points Are Extracted Using Binary And Thinned Image. First, Binary Image Is Extracted From Gray Scale Image And Then Resultant Binary Image Is Processed To Have A Thinned Image. From That Thinned Image, Minutiae Points Are Extracted. These Will Be Used For Matching.

**Step 4: Feature Extraction In PCA (Principle Component Analysis):** Principal Component Analysis Algorithm Is Used To Extract Features From Face Images. This Algorithm Can Be Used For Dimension Reduction, Data Analysis And Feature Extraction. It Defines The Eigen Values And Eigen Vectors.

**Step 5: Feature Selection Using BFOA Algorithm:** Large Number Of Features Are Extracted In The Previous Steps (Step 3 and Step 4). Such A Large Feature Set Adds To Cost So It Is Beneficial To Optimize The Feature Set. By Optimising It, We Mean To Select Some Of The Features Which Are More Prominent Among Them And Use Them In Next Steps For Identification. For That Purpose We Use BFOA I.E. Bacterial Foraging Optimization Algorithm. The Whole Step By Step Information Of The Working Of It Is Explained In Previous Chapters.

**Figure 2: Proposed Flow Chart**
**Step 6: Fusion:** Fusion Of Multiple Biometric Traits Is Required For Multi-Biometric Authentication System. This Gives More Accurate Results In Recognition Of A Person. Here, Weighted Sum Rule Based Technique Is Used For Fusion. Fusion Is Basically Done To Get A Single Vector Or A Scalar Number From Different Feature Sets Of The Different Modalities. It Is Performed While Training As Well As Testing Phases.

**Step 7: Multi-Layer Neural Network:** In This Classification Method, MLNN Is Used To Train The Features And Test The Features. There Are Three Layers Apparently Exist In MLNN Namely Input Layer, Hidden Layer And Output Layer. Except For The Input Features Each Feature Is A Neuron That Uses A Non-Linear Activation Function Using Sigmoid Method. MLNN Uses A Supervised Method For Training And For Testing Method, Simulation Model Is Used To Analyse The Similar Features. The Result Comes Out To Be True Identity /Match Exists Or An Imposter Or Not A Match. According To Which Access Can Be Granted Or Denied.

**Step 8: Compute Performance Parameters:**
- False Acceptance Rate (FAR): It Defines How Many Users Are Falsely Accepted As True Identities. It Is The Measurement For Selection Of Imposters As Genuine Persons.
- Genuine Acceptance Rate (GAR): It Is The Opposite Of FRR. It Defines The Accuracy Of The System Or It Gives The Probability Of Selecting A Genuine User As A Genuine One.
  \[ \text{GAR} = 1 \text{- FRR} \].

**VII. DATABASE DESCRIPTION**

**Face Dataset:** Face Images Files Are In PGM Format. The Size Of Individual Face Image Is 92*112 Pixels With 256 Gray Level Per Pixel. The Images Are Defined In 40 Directories, Which Have Names Of The Form XV, Where X Indicates The Subject Number. Each Subject Has 10 Images Having Different Expressions, Poses Etc. Each Of These 10 Dissimilar Images Are Defined By Y [19].

![Figure 3: Face Images](image)

**Fingerprint Dataset:** Fingerprint Images Are Taken From CASIA Unique Finger Impression Picture Database. It Has 20000 Images For 500 Subjects Or Individuals. Every Individual Contributes For 40 Images Of His Fingers. Each Image Is Taken By Putting Different Levels Of Pressure On The Sensor. Each Image Is Of Size 328*356 [20].

![Figure 4: Fingerprint Images](image)

**VIII. CONCLUSION AND FUTURE SCOPE**

**Conclusion:** In The Conclusion, Multi-Modal Biometric System Is Compared To Uni-Modal Biometrics. It Is Now In-Use For Few Applications. It Has Implemented A Multi-Modal Biometric System Based On PCA (Principle Component Analysis) And Minutiae Algorithm With MLNN Classification And BFOA Methods That
Will Use The Facial And Fingerprint For Verification Of The Person. In This Work, Bacteria Foraging Optimization Method Is Used To Select The Feature Based On The Extracted Features. It Is The Intension Of This Research Technique To Calculate The Fusion. In This Research Work, PCA (Principle Component Analysis) And Minutiae Algorithm Are Used For Feature Extraction Using Facial Images And Fingerprint Images Respectively. Principle Component Analysis Can Be Used For Reducing Dimensions, Data Analysis And Feature Extraction. Fingerprint Images Features Are Extracted From Fingerprint Images Using Minutiae Algorithm. Optimization Is Done Through BFOA (Bacteria Foraging Optimization) That Evaluates Feature Vector Of The Features With Reduced Dimensions. The Different Texture Features Of Facial And Fingerprint Are Extracted. Weighted sunFusion Method Is Used To Connect These Uni-Modal Features. It Could Conclude That The Fusion Produces Better Identification Consequences When Compared With Single Modalities. The Performance Study Using Database Might Be Performed And Calculate The Performance Parameters Like GAR, FAR And FRR. In This Proposed Work, GAR Or Accuracy Is 99%. False Rejection Rate Is 1%. False Acceptance Rate Is 1.3%.

**Future Scope:** This Work Can Be Extended With Other Biometric Identifiers. Other Biometrics Like Iris Can Also Be Added To It With Already Existed Biometrics. This Can Be Used As A Part Of Other Systems Too Like For Security Purpose. Other Algorithms Can Be Used To Improve Its Performance.

**REFERENCES**


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