MAJOR PROJECT PART-I

FORENSIC FACE SKETCH GENERATION AND INTELLIGENT RECOGNITION SYSTEM

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Agenda

1. Introduction & Motivation
2. Abstract
3. Literature Survey
4. Existing & Proposed systems
5. Limitations of Existing System
6. Advantages of Proposed System

Introduction

- Forensic case studies highlight the critical role of **forensic science in solving crimes**, especially when traditional evidence like photos or videos is unavailable.
- According to a study by the FBI, forensic sketches based on eyewitness accounts led to suspect identification in **over 30%** of cases.
- A common issue with manual forensic sketching is the **subjectivity of artists.**
- While traditional forensic techniques rely heavily on human expertise, the rise of machine learning (ML) and artificial intelligence (AI) offers new possibilities.
- Automated systems can analyze large datasets, recognize patterns, and improve the accuracy of facial sketches significantly.

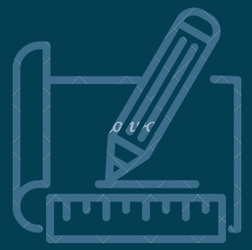
Motivation

Societal Impact

Advanced forensic face technologies can help solve cold cases, support victim identification, and assist in the fair administration of justice.

Need for Innovation

Enhancing accuracy in face generation and recognition can significantly improve forensic investigations, leading to quicker identification and potentially saving lives.



Current Challenges

Traditional methods of facial recognition struggle with low-quality images, partial faces, and variations in lighting, pose, and age.

Abstract

- **Objective:** To develop an integrated platform that modernizes forensic facial sketching using advanced technologies.

- **Technologies Used:**
  1. ***Machine Learning (ML) algorithms*** like Support Vector Machines (SVM) and Random Forest for recommending facial features during sketch creation.
  2. ***Deep Learning (DL) models*** such as Generative Adversarial Networks (GANs) and Identity-preserving Adversarial Networks (IPAMs)

- **Platform Development:** HTML, CSS, React.js for the frontend, and Node.js, MongoDB, Flask for the backend.

- **Functionality:**
  1. Users can create sketches through a drag-and-drop interface or upload hand-drawn sketches.
  2. The system matches the generated facial sketches to real-life images from a criminal database, aiding in easy identification of suspects.

- **Security:** The platform incorporates machine locking, two-step verification, and centralized server control to protect sensitive data.

- **Impact:** The system enhances the speed and accuracy of forensic facial recognition, improving the efficiency of criminal investigations.

Problem Statement

01

Existing Solution

- Manual sketching by forensic artists based on eyewitness descriptions.
- Artists interview witnesses to gather details about facial features.
- Hand-drawn sketches are created, which are then matched against criminal databases.
- Matching is often don manually or using basic image comparison tools.
- Relies heavily on eyewitness memory and the artist’s interpretation of the description.

02

Proposed Solution

- Automated sketch creation using a drag-and-drop interface that suggests facial features via ML algorithms.
- Eyewitnesses or investigators can select facial features from a pre-trained ML model to construct a composite sketch.
- Employs FEGGAN for high-fidelity sketch synthesis and IPAM for maintaining identity consistency.
- They are used to match the sketches with real-life images from criminal databases.
- The system provides real-time sketch generation and automated matching, improving the workflow.

Literature Survey Paper-1

S. No.	Paper Title	Source	Keywords	Problem Domain	Methods Used	Datasets Used	Evaluation Metrics	Future Work
1.	Domain Alignment Embedding Network for Sketch Face Recognition	IEEE Access December 2020	Sketch face recognition, feature embedding network, deep metric learning, small sample problem.	Sketch-based Face Recognition	Domain Alignment Embedding Network	S1. UoM-SGFSv2 - set A S2. UoM-SGFSv2 - set B S3. PRIP-VSGC	**Rank-1:** 1. S1 - 68.53% 2. S2 - 74% **Rank-10:** 1. S1 - 92.4% 2. S2 - 95.2% 3. S3 - 63.2% **Rank-50:** 1. S1 - 97.47% 2. S2 - 99.07%	- **Diverse Sketch Styles:** Enhance model robustness by incorporating various artistic and cartoon sketch styles. - **Cross-Demographic Recognition:** Improve recognition accuracy across different ethnicities, age groups, and genders. - **Real-Time Implementation:** Optimize DAEN for deployment in real-time applications, like surveillance systems and mobile apps.

Literature Survey Paper-2

S. No.	Paper Title	Source	Keywords	Problem Domain	Methods Used	Datasets Used	Evaluation Metrics	Future Work
2.	An Identity-Preserved Model for Face Sketch-Photo Synthesis	IEEE Xplore: IEEE SIGNAL PROCESSING LETTERS, VOL. 2 March 2024	Face sketch-photo synthesis, generative adversarial networks, image generation, image-to-image translation	Face Synthesis, Image to image translation	a U-Net generator with two discriminators, optimized by leaky ReLU and Adam, alongside identity-verifying models (ResNet-50 and LightCNN-29v2)	1. CUFS - Chinese University of Hong Kong Face Sketch Database - 606 faes 2. CUFSF - CUHK Face Sketch FERET - 1194 images	**Rank-1:** 1.CUFS : ResNet-50- 0.8 LightCNN-29v2 - 0.78 2. CUFSF: ResNet-50- 0.737 LightCNN-29v2- 0.701 **VR@FAR=0.1%:** 1. CUFS: ResNet-50 - 0.58 LightCNN-29v2 - 0.48 2. CUFSF: ResNet-50-0.608 LightCNN-29v2- 0.598	- **Handling diverse sketch styles:** Adapt model to various sketch types. - **Cross-Racial and Age-inclusive models:** Broaden demographic coverage and inclusivity. - **Real-time synthesis and recognition:** Enable instant face matching from sketches. - **Integration with other modalities:** Combine with infrared or thermal imaging. - **Synthetic Data Generation for Low-Resource contexts:** Create data for underrepresented populations

Literature Survey Paper-3

S.No.	Paper Title	Source	Keywords	Problem Domain	Methods Used	Datasets Used	Evaluation Metrics	Future Work
3.	Dual-View Normalization for Face Recognition	IEEE Access August 2020	Face recognition, face normalization, face synthesis.	Face Recognition	Dual-View Normalization with Light-CNN and ArcFace as Feature Extractors	1. Multi-PIE - 75,000 images of 337 people 2. CASIA-WebFace - 494,414 images of 10,575 people 3. IJB-A - 5396 images and 20,412 video frames of 500 subjects 4. IJB-C - 3134 still images and 117542 frames from natural scene video of 3531 different individuals	**VR@FAR=0.1:** 1. IJB-A: Light-CNN: 95.7 ArcFace: 97,2 2. IJB-C: Light-CNN: 92.4 ArcFace: 96.5 **VR@FAR=0.01** 1. IJB-A: Light CNN: 91.3 ArcFace: 94.2 2. IJB-C: Light-CNN: 87.96 ArcFace: 92.76 **Identification @Rank-1:** 1. IJB-A: Light-CNN: 96.8 ArcFace: 97.4 **@Rank-5:** 1. IJB-A: Light-CNN: 98.7 ArcFace: 98.8	**- Attribute-Based Normalization:** Use unsupervised clustering to tailor normalization. - **Multi-View Expansion:** Incorporate more views beyond dual poses. - **Self-Supervised Learning:** Improve generalization using unlabeled data

Literature Survey Paper-4

S.No.	Paper Title	Source	Keywords	Problem Domain	Methods Used	Datasets Used	Evaluation Metrics	Future Work
4.	Forensic Face Sketch Recognition based on Pre-selected facial regions	IEEE 12th International Conference on Control System, Computing and Engineering (ICCSCE) October, 2022	Forensic, Face sketch, recognition, histogram of gradient, facial region	Face Recognition	Histogram of Gradient with utilizing a pre-selected facial region of both sketches and the photos using Adobe Photoshop CS6 to remove the occlusion on the sketch dataset and photo dataset.	1. PRIP-HDC	**Accuracy @Rank-1**: 6.38% (Existing- 2.13%)	Use deep learning models (e.g., GANs or U-Nets) to automatically detect occlusions and inpaint missing facial areas, providing cleaner inputs for recognition models, thus imporving accuracy

Literature Survey Paper-5

S.No.	Paper Title	Source	Keywords	Problem Domain	Methods Used	Datasets Used	Evaluation Metrics	Future Work
5.	A New Framework for Matching Forensic Composite Sketches With Digital Images	IEEE Xplore: International Journal of Digital Crime and Forensics, Volume 13, Issue 5, Sept-Oct,2021	Convolution Neural Network (CNN), Dropout, E-PRIP Dataset, Exponential Linear Unit, Face Sketch Recognition, Leaky Rectified Linear Unit, Sigmoid, Swish Activation Function	Forensic Composite Face Sketch Matching with Digital Images	Swish Activation Function with 6 layer CNN	1. E-PRIP dataset (123 composite sketches and its respective digital images) 2.Composite Sketch with Age Variation dataset collected from IIIT, Delhi (3529 sketches and digital images from 150 individuals)	**Accuracy:** 1. E-PRIP - 78.26% 2. CSA - 69.57% **Precision:** 1. E-PRIP - 63.64% 2. CSA - 54.55% **Recall (TPR):** 1. E-PRIP - 87.50% 2. CSA - 75% **F1-score:** 1. E-PRIP - 73.68% 2. CSA - 63.16% **FPR:** 1. E-PRIP - 0.2667 2. CSA - 0.3333	- **Experiment with Lightweight CNN Models:** Test multiple compact CNN architectures to improve efficiency. - **Combine Datasets:** Merge additional datasets to increase image count, enhancing model performance. - **Test on Larger Datasets:** Increase dataset size to improve deep network performance. - **Advanced Neural Networks:** Explore using more sophisticated neural network models for training on larger datasets to enhance sketch and digital image matching accuracy

Limitations of Existing System

1. Subjectivity: Relies heavily on the artist’s interpretation, leading to variability in sketch quality and accuracy.
2. Time-Consuming: The manual sketching process is lengthy, delaying investigations and suspect identification.
3. Inaccuracy: Eyewitness memories can be unreliable, resulting in sketches that may not accurately represent the suspect's appearance.
4. Limited Matching Capability: Current systems often lack effective tools for matching sketches to images in criminal databases, reducing the likelihood of successful identification.
5. Skill Dependency: The effectiveness of the sketching process depends on the artist’s experience and skill level, leading to inconsistencies.
6. Non-Frontal Image Issues: Existing methods struggle to accurately represent suspects who are not viewed head-on, making profile sketches challenging.
7. Inadequate Technological Integration: Many current systems do not leverage modern technologies, such as machine learning and computer vision, which could enhance accuracy and efficiency.

Advantages of Proposed System

1. Increased Efficiency: Automates the sketching process, significantly reducing the time required to generate a facial composite.
2. Improved Accuracy: Utilizes machine learning algorithms to suggest facial features, enhancing the precision of sketches based on eyewitness descriptions.
3. User-Friendly Interface: The drag-and-drop feature allows users, including non-experts, to easily create sketches without extensive training.
4. Real-Time Matching: Quickly matches generated sketches to real-life images from criminal databases, facilitating faster suspect identification.
5. Scalability: Built on cloud infrastructure, allowing for easy scaling to accommodate large datasets and user loads.
6. Enhanced Data Security: Implements robust security measures, including machine locking and two-step verification, to protect sensitive data.
7. Reduction of Human Error: Minimizes subjective biases and inaccuracies associated with manual sketching by relying on algorithms and standardized processes.

Limitations of Previous Works

- GAN-style model, which are very good at domain gap reduction (accuracy up to 85% but need a lot of computation.
- Identity-preserving methods, for example, feature decoupling with LightCNN, achieve very high accuracy ~90 per cent) by emphasising the preservation of identity characteristics, but at the computational cost.
- Normalisation methods such as dual-discriminator U-Net manage the variation in sketch quality well, but suffer a loss in performance when there are extreme stylistic departures.
- Super-resolution and graph-regularized models provide flexibility in the low-resolution setting, and identity-aware networks reach accuracy of 85 per cent or more on such inputs.
- Hybrid models and IHDA work well in real-world situations but need huge amounts of data to handle a variety of situations.
- No system available with a combination of Face Sketch Construction and Recognition

Proposed Methodology

Dual-Module System:
Addresses limitations of current methods to improve sketch construction and recognition.

Face Sketch Construction Module:

1. Use Auto-ML Embedded models for facial feature recommendations
2. Assists forensic artists in translating witness descriptions into accurate sketches

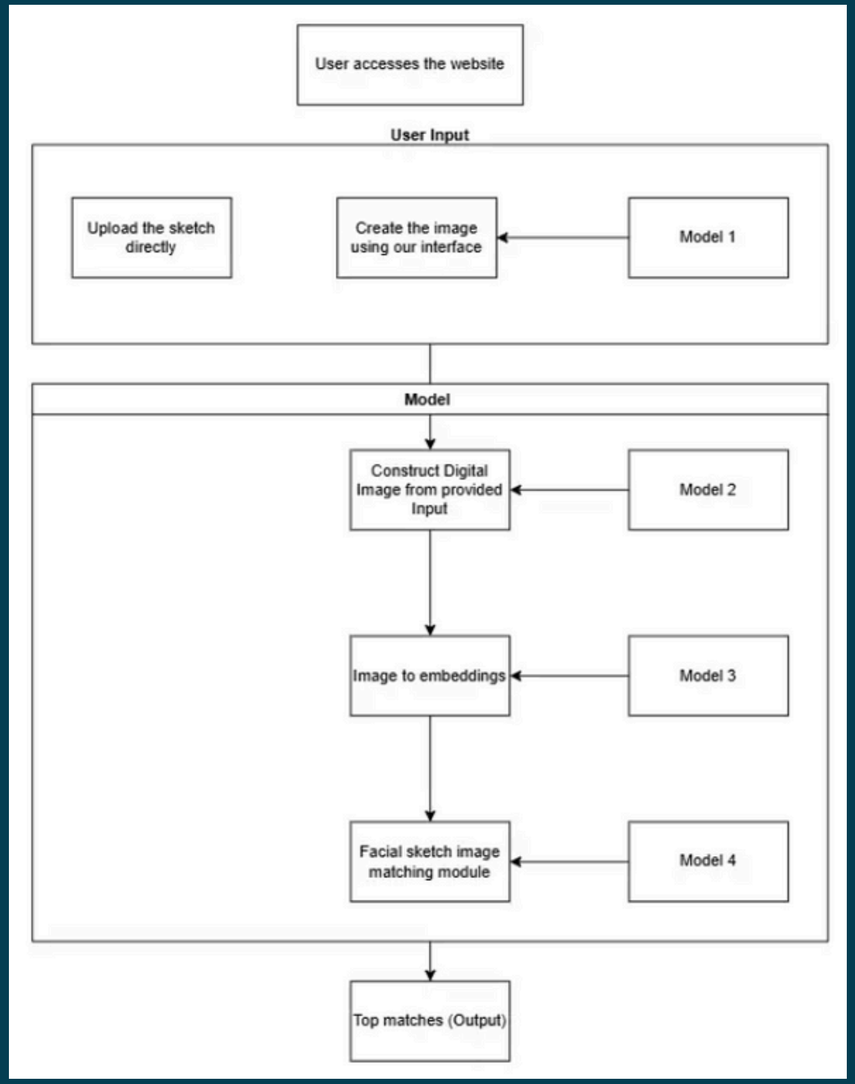
Recognition Module:

1. Hybrid Approach: Uses FEGGAN for high-fidelity sketch synthesis and IPAM for identity consistency
2. Converts sketches to digital formats for recognition
3. Leverages ArcFace with ResNet for enhanced feature embedding and accurate matching with real-life image database

Expected Key Advantages:

Adaptability: Dynamic sketch creation based on selected features
Accuracy: Enhanced matching precision
Efficiency: Optimized processing for practical forensic applications

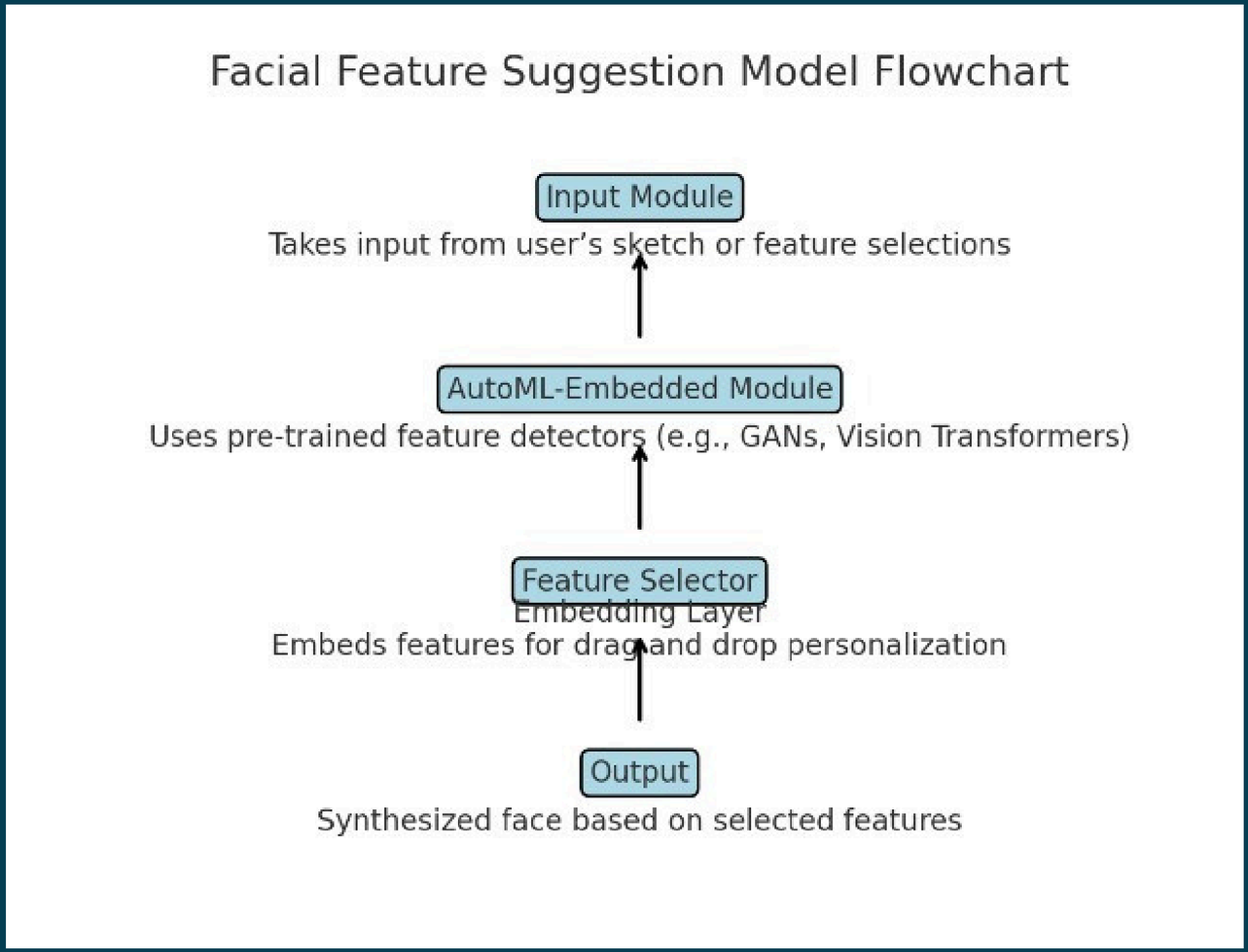
Proposed Flow



Model Architectures

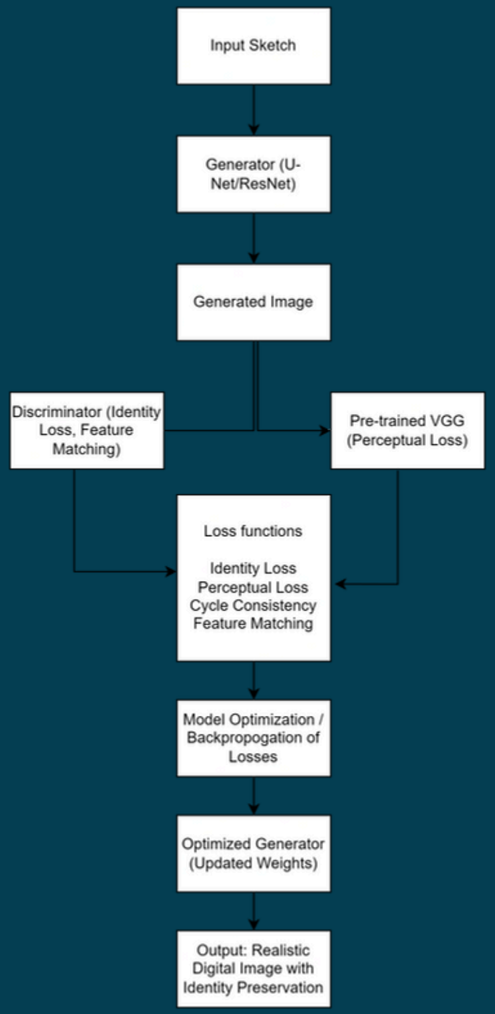
Model-1

(For facial feature recommendations)

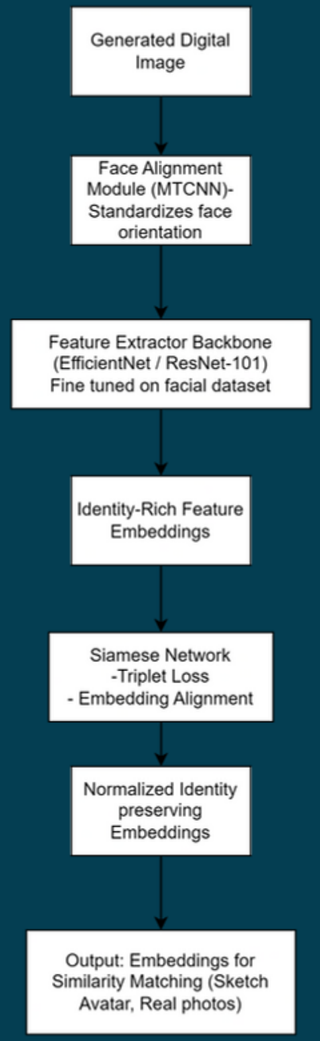


Model Architectures

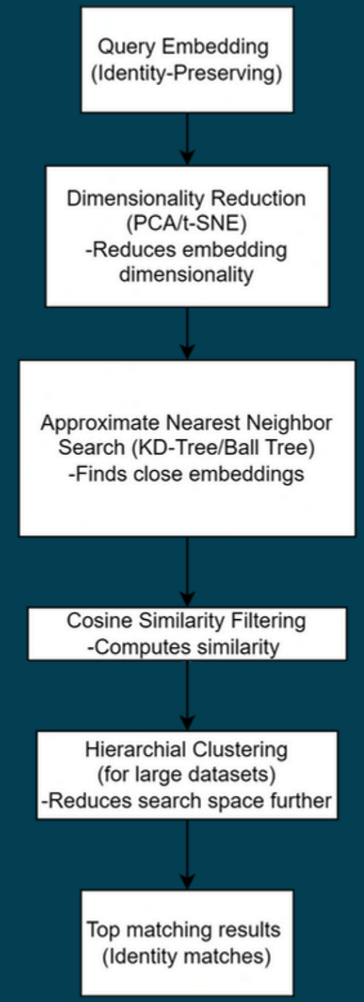
Model-2
(For converting sketch to digital image)



Model-3
(For converting digital image to embeddings)



Model-4
(For matching input to database)



Datasets

CUFS Dataset (Link)

CUHK Face Sketch database (CUFS) is for research on face sketch synthesis and face sketch recognition. It includes 188 faces from the Chinese University of Hong Kong (CUHK) student database, 123 faces from the AR database, and 295 faces from the XM2VTS database. There are 606 faces in total. For each face, there is a sketch drawn by an artist based on a photo taken in a frontal pose, under normal lighting condition, and with a neutral expression.

CUFSF Dataset (Link)

The CUHK Face Sketch FERET (CUFSF) is a dataset for research on face sketch synthesis and face sketch recognition. It contains two types of face images: photo and sketch. Total 1,194 images (one image per subject) were collected with lighting variations from the FERET dataset. For each subject, a sketch is drawn with shape exaggeration.

Datasets

FERET Dataset (Link)

The Facial Recognition Technology (FERET) dataset is a widely used database in facial recognition research. It includes a diverse set of facial images captured under various lighting conditions, expressions, and angles. The dataset is valuable for training and evaluating facial recognition algorithms, particularly in handling variations in facial appearance.

LFW Dataset (Link)

The Labelled Faces in Wild (LFW) dataset contains over 13,000 labeled images of faces collected from the web. It is developed by researchers from University of Masachussets. The images feature a wide range of poses, expressions, and lighting conditions, making it a valuable resource for studying unconstrained face recognition.

Conclusion

- **Problems**: Subjectivity, time-intensive, inaccurate sketches, limited matching, skill dependency, non-frontal image challenges, and poor tech integration.

- **Survey Findings**: Existing methods (GANs, ResNets) enhance recognition but lack integration, scalability, and efficiency.

- **Proposed Solution**: Dual-module system with:
  - **Sketch Construction**: Auto-ML for feature recommendations.
  - **Recognition**: FEGGAN + IPAM for matching sketches to databases.

- **Benefits**: Faster, more accurate, adaptable, scalable, and unified platform for efficient suspect identification.

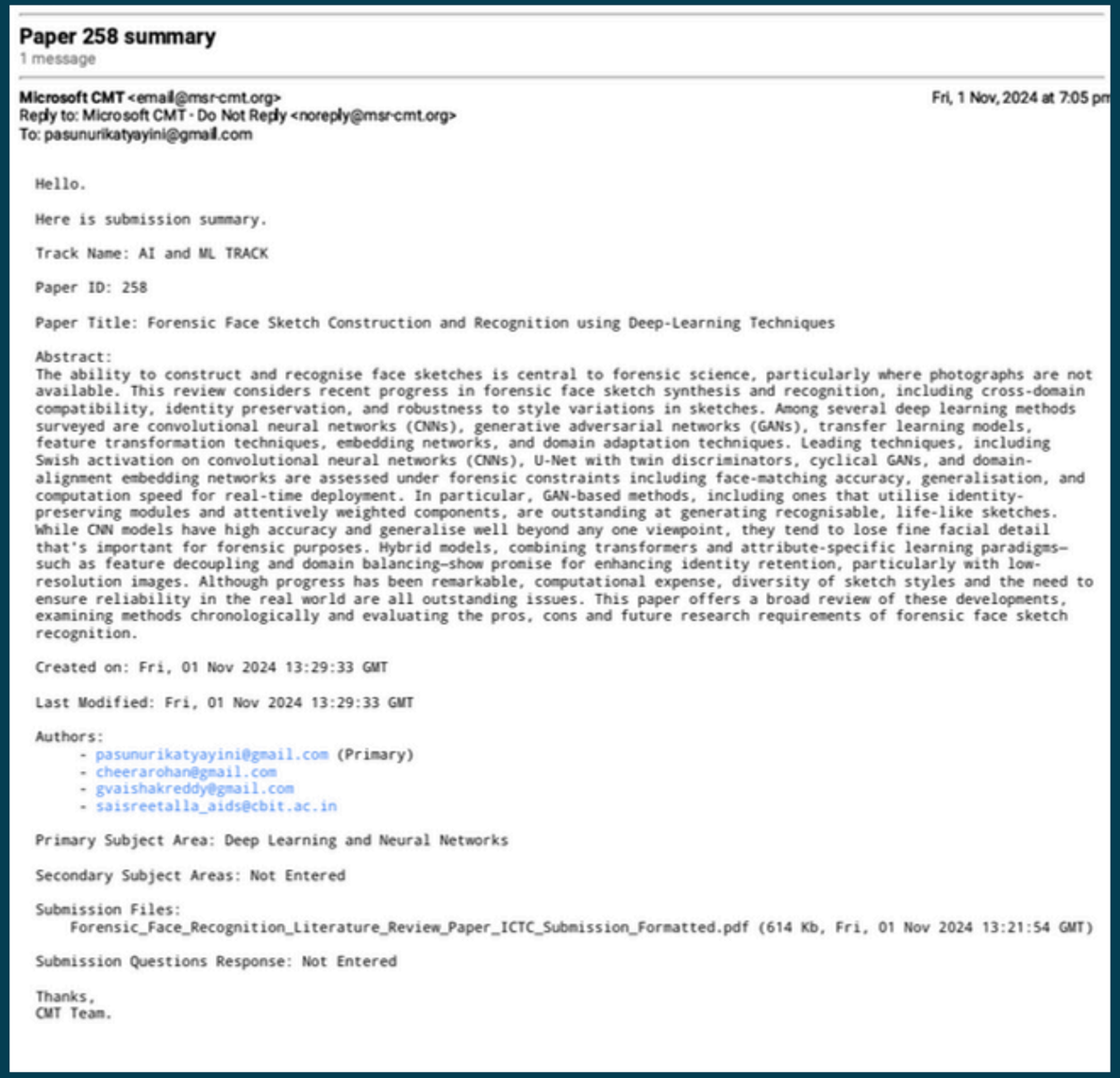
Paper Publication (Proof for Communication)

Conference Name: International Conference on Innovative Computing Technologies, CBIT

Date of Submission: 1st Nov, 2024

Expected Date of Acceptance: 25th Nov, 2024

Expected Date of Conference: 13th - 14th Dec, 2024



Paper 258 summary
1 message

Microsoft CMT <email@msr-cmt.org> Fri, 1 Nov, 2024 at 7:05 pm
Reply to: Microsoft CMT - Do Not Reply <noreply@msr-cmt.org>
To: pasunurikatyayini@gmail.com

Hello.

Here is submission summary.

Track Name: AI and ML TRACK

Paper ID: 258

Paper Title: Forensic Face Sketch Construction and Recognition using Deep-Learning Techniques

Abstract:
The ability to construct and recognise face sketches is central to forensic science, particularly where photographs are not available. This review considers recent progress in forensic face sketch synthesis and recognition, including cross-domain compatibility, identity preservation, and robustness to style variations in sketches. Among several deep learning methods surveyed are convolutional neural networks (CNNs), generative adversarial networks (GANs), transfer learning models, feature transformation techniques, embedding networks, and domain adaptation techniques. Leading techniques, including Swish activation on convolutional neural networks (CNNs), U-Net with twin discriminators, cyclical GANs, and domain-alignment embedding networks are assessed under forensic constraints including face-matching accuracy, generalisation, and computation speed for real-time deployment. In particular, GAN-based methods, including ones that utilise identity-preserving modules and attentively weighted components, are outstanding at generating recognisable, life-like sketches. While CNN models have high accuracy and generalise well beyond any one viewpoint, they tend to lose fine facial detail that's important for forensic purposes. Hybrid models, combining transformers and attribute-specific learning paradigms—such as feature decoupling and domain balancing—show promise for enhancing identity retention, particularly with low-resolution images. Although progress has been remarkable, computational expense, diversity of sketch styles and the need to ensure reliability in the real world are all outstanding issues. This paper offers a broad review of these developments, examining methods chronologically and evaluating the pros, cons and future research requirements of forensic face sketch recognition.

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Forensic_Face_Recognition_Literature_Review_Paper_ICTC_Submission_Formatted.pdf (614 Kb, Fri, 01 Nov 2024 13:21:54 GMT)

Submission Questions Response: Not Entered

Thanks,
CMT Team.

Thank you!