Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 4, No. 4, April : 2024

SKETCH-TO-FACE GENERATION FOR POLICE INVESTIGATION

PRAJWAL GAIKWAD AISSMS Institute of Information Technology, Sangamvadi, Pune, Maharashtra, India prajwal.gaikwad@aissmsioit.org
SWAYAMSIDDHA MANE DESHMUKH AISSMS Institute of Information Technology, Sangamvadi, Pune, Maharashtra, India swayamsiddha.manedeshmukh@gmail.com
PRASANNA BHILEGAONKAR AISSMS Institute of Information Technology, Sangamvadi, Pune, Maharashtra, India bhilegaonkarprasanna12@gmail.com
SAKSHI DUBILE AISSMS Institute of Information Technology, Sangamvadi, Pune, Maharashtra, India sakdubile934@gmail.com
LUCY FERNANDES AISSMS Institute of Information Technology, Sangamvadi, Pune, Maharashtra, India lucyf1404@gmail.com

Abstract—
In order to overcome the drawbacks of conventional techniques, the "Sketch-to-Face Generation for Investigation" presents a revolutionary method that uses Generative Adversarial Networks (GANs) to transform hand-drawn sketches into realistic facial images. GANs, trained to interpret facial expressions, produce accurate images, enhance trustworthiness, and integrate with criminal databases for effective cross-referencing in identifying suspects. This combination promises increased investigation efficiency by redefining suspect identification.

Motivated by the need for increased precision, the technology adjusts to various platforms and makes sure that it works with the current research frameworks. The solutions are designed using advanced tools like database integration, deep learning frameworks, and advanced image processing algorithms for scalability, reliability, and user-friendliness. Responsible AI practices are emphasized by ethical considerations, which also highlight privacy and legal requirements for ethical implementation.

Keywords—
Sketch-to-face generation, Generative Adversarial Networks (GANs), suspect identification, image verification, criminal databases, investigation efficiency, CNN, HOG, feature detection.

I. INTRODUCTION

Accurately converting hand-drawn sketches into realistic facial images is a significant challenge in the field of criminal investigations. Conventional techniques frequently struggle to capture minute details, which reduces the effectiveness of identifying suspects.

A. How it Works:

Using cutting-edge Generative Adversarial Networks is the key to this revolutionary strategy. These networks meticulously learn to decode complex facial expressions, features, and proportions to produce visually accurate outputs that closely resemble real people. By deviating from traditional procedures, suspects based on hand-drawn sketches will be more accurately and thoroughly represented.

B. Need:

− Improved Suspect Recognition:

Hand-drawn sketches are frequently used in traditional suspect identification techniques, but they may not be accurate enough to capture subtle facial features. By generating more realistic and detailed facial images, sketch-to-face generation using cutting edge technologies can significantly improve the accuracy of suspect identification.

− Overcoming Sketches Limitations:

Though they are priceless, hand-drawn sketches may not always be able to capture minute details. To ensure a more thorough and dependable identification process, it is necessary to bridge the gap between crude sketches and realistic facial representations, which calls for a sophisticated sketch-to-face generation.

− Achievement in Research:

Realistic faces are produced more quickly by combining sophisticated image processing methods with Generative Adversarial Networks (GANs). By giving law enforcement better tools for identifying suspects, this efficiency can speed up investigations and ultimately lead to a quicker resolution of cases.

− Minimizing Positive Outliers:

Sketch-to-face generation systems can reduce false positives by utilizing sophisticated image verification techniques. In order to minimize the possibility of incorrect identifications, law enforcement resources must be directed toward precise matches, which depends on the accuracy of the generated facial images.

− Accessibility and Adaptability:

Sketch-to-face generation technology's adaptability within current investigative frameworks is ensured by its versatility across multiple platforms. Because of its ease of use, law enforcement professionals of all technical backgrounds can utilize it, democratizing advanced identification tools for general use.

II. MOTIVATION

The necessity to modernize and strengthen established techniques of suspect identification is the driving force behind the creation and application of sketch-to-face generation for police investigations. Although they have been used for a long time in criminal investigations, hand-drawn sketches frequently lack the fine facial details needed for precise identifications. With the introduction of Generative Adversarial Networks (GANs), there is now a way to overcome these constraints and create extremely realistic and detailed facial images from simple sketches.

The need to improve investigation efficiency, which will allow law enforcement to expedite the identification process and promptly handle criminal cases, is what motivates this transformative approach. In addition to trying to address the intrinsic flaws in conventional techniques, the technology also tries to lower the possibility of false positives, guaranteeing that resources are allocated to legitimate matches. Furthermore, the identification process is made more reliable by the incorporation of sophisticated image verification techniques and the smooth integration with criminal databases, which increases trust in the produced facial images.

The objective is to enhance suspect identification by integrating advanced technology with the demands of law enforcement. This will provide a powerful instrument that has the potential to greatly improve the precision, efficiency, and overall effectiveness of criminal investigations. The ultimate goal is to improve community welfare and public safety by carefully integrating cutting-edge technologies into the criminal justice system.

III. RELATED WORK

A. Existing Systems & their Impact:

Most of the current suspect identification systems [21] are based on conventional techniques, such as creating facial composites and manually interpreting hand-drawn sketches. Unfortunately, these techniques have severe limitations when it comes to capturing fine facial details, which makes suspect identification less accurate. The lack of fidelity in composite sketches frequently results in potential mismatches and erroneous identifications. This has a significant effect on the investigation process as a whole and may cause resources to be diverted from reliable leads. Subspace learning-based approaches, sparse representation-based approaches, and Bayesian inference-based approaches. This are the initial approaches before GAN which are not so good in terms of accuracy [10].

In addition, depending solely on manual interpretation can be laborious and susceptible to the prejudices and constraints of human observation. Because of this, the current systems might not be able to meet the growing needs of law enforcement for accurate and quick suspect identification [1][15]. These constraints highlight the critical need for novel approaches, like "Sketch-to-Face Generation for Police

Investigation," to transform and improve the efficiency of suspect identification procedures. The incorporation of cutting-edge technologies seeks to lessen these effects by offering a facial synthesis and identification method that is more precise, effective, and dependable [18][20].

A three-channel CNN architecture with triplet loss were used in the existing systems [18][14]. Though Experimental results showed that the proposed method outperformed existing approaches still it lacked the accuracy due to limited datasets of sketches available. Some of the limitations where Intra-class variations posed a challenge for face sketch recognition. Slow convergence occurred without a hard triplet sample selection strategy. The existing systems focused on matching software-generated sketches to face photographs using a very deep convolutional neural network and transfer learning [20].

B. GAN-Based Image Generation:

The main goal of previous work on Generative Adversarial Networks (GANs) [14], for image synthesis has been to produce realistic images from a variety of inputs. The "Sketch-to-Face Generation for Police Investigation" focuses on converting hand-drawn sketches into intricate facial images for law enforcement purposes, as opposed to the more general uses of GANs [9]. While visual fidelity and diversity are the general goals of GANs, this project focuses on the particular difficulties of identifying suspects by deciphering complex facial features, expressions, and proportions from crude sketches, meeting the particular requirements of criminal investigations [4]. High quality images can be also generated using different variants and researches in GAN such as Multi-Hierarchies GAN with local region module, mask module, and fusion module. Proposed method will be able to generate high-quality and expressive clear face sketch images. We can apply it to a variety of styles and different races [5][9]. Proposed algorithms achieved state-of-the-art performance in face sketch synthesis. Generated sketches have less noise, fewer artifacts, more details, and realistic textures. Blur and artifacts in generated face sketches. More shape exaggerations, age, and illumination variations in certain databases [9].

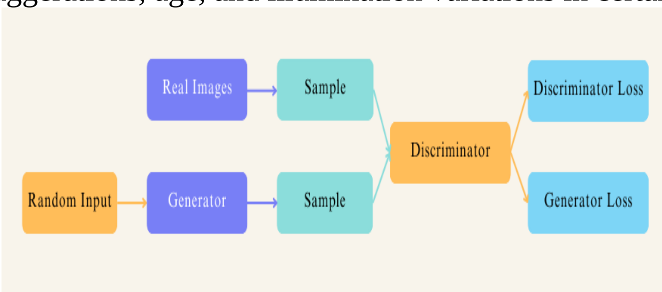

Fig. GAN Model

C. Image Verification Techniques:

Prior studies on image verification methods have mostly focused on using sophisticated algorithms to evaluate the integrity of images. On the other hand, the "Sketch-to-Face Generation for Police Investigation" project uses image verification methods that are especially designed to guarantee the accuracy of the generated faces. In the context of suspect identification, these techniques are particularly important for reducing the possibility of false positives [12]. By tackling the particular difficulties involved in facial synthesis from hand-drawn sketches, the project seeks to improve the general accuracy and dependability of the generated visuals within the law enforcement domain [18]. Convolutional neural networks (CNN) have been successful in image recognition. CNN with more convolution hidden layers have more powerful feature extraction abilities. The focus is on the recognition of image localization and classification. In the future, CNN will be applied to more complex images and scenarios. Conventional method of narrowing down potential perpetrators is time-consuming and may decrease accuracy. Automatic photo retrieval system can speed up selection process without sacrificing accuracy. The proposed method outperforms state-of-the-art methods in face sketch image retrieval. The method is capable of improving retrieval rate accuracy, especially at rank-1[6][18].

D. General Conclusion to Literature survey:

[1] Dr. S. Nikkath Bushra, K. Uma Maheswari [22], The paper discusses the use of Deep Convolutional Generative Adversarial Network (DCGAN) for converting forensic sketches into real photos. This technique is helpful in crime investigations and facial recognition systems. This research presents a novel artificial intelligence method that leverages Deep Convolutional Generative Adversarial Networks (DCGAN) to transform forensic sketches into realistic, high-resolution face photographs. This will help law enforcement quickly produce accurate suspect photos from partial or incomplete sketches. With this discovery, criminal identification processes will be more accurate and efficient, with important ramifications for forensics, law enforcement, and security systems.

[2] Samsul Setumin, Muhamad Faris, Che Aminu din, Azmin Suandi, [12], Law enforcement's standard strategy for identifying possible criminals. A technique for automatically retrieving photos can expedite the selection process without compromising precision. It is necessary to create a forensic sketch based on eyewitness descriptions. Methods of matching sketches and photos are suggested to enhance performance. There are primarily two methods: intermodality and intramodality. Prior to matching, the intra-modality technique generates a pseudo-sketch or pseudo-photo. The intermodality method eschews the conversion or synthesis step. Two methods for feature extraction are available: handcrafted features and deep learning features. MLBP with LFDA and SIFT descriptor are used for local feature extraction. Proposed CCA strategy for fusing HOG and GW characteristics. A second matching piece and a Patch of Interest (PoI) are included in the suggested strategy.

[3] Zhongwei Zhang,[4][20], Introduces and highlights the principles, applications, and future research directions for GAN. Covers typical GAN versions proposed by researchers. Gives artificial intelligence a fresh lease of life. Offers a novel algorithm framework for unsupervised learning. Addresses the problem of gradient vanishing in GAN training. It examines gradient disappearance and mode collapse in GAN training. Typical GAN improvement models are examined, along with their benefits, drawbacks, application scenarios, and execution costs. It displays the application results generated by GAN in the areas of data production, super-resolution imaging, and style conversion imaging. The paper talks about GAN's future research goals and existing problems.

[4] Christian Galea, Reuben Farrugia,[21], An overview of facial photo-sketch recognition algorithms that have been published in the literature. Summary of the face recognition models based on deep learning that have been put into use. Utilization of facial photo-sketch recognition using a deep convolutional neural network. Applying transfer learning to a facial photo recognition model that has already been trained. Synthesis of images and sketches using a 3D morphable model for training data augmentation. Expansion of the UoM-SGFS database to accommodate twice as many participants. Comprehensive assessment of well-liked and cutting-edge composite sketch identification techniques. Present-day techniques' performance with big galleries and software-generated sketches is inadequate. Restricted access to neural network data for training that is available to the public. Current techniques are not intended for face composite sketches created by software. Insufficient knowledge of the assessment of well-known and innovative algorithms.

[5] Ganesh Patil, R Banyal,[18], The study examines various deep-learning techniques for picture recognition. The application of convolutional neural networks (CNN) to image recognition is covered. More convolutional hidden layers in a CNN result in more effective feature extraction. CNN has made great strides in image identification. The application of deep learning to the recognition of medical photos and seeds is mentioned in the study.

[6] Kangning Du, Huaqiang Zhou, Lin Cao, Anan Guo, Tao Wang,[5], There are two types of face sketch synthesis techniques now in use: model-driven and data-driven. Methods based on GAN synthesis are examples of model-driven techniques. advocated utilizing a Multi-Hierarchies GAN framework to synthesize facial sketches. Produced crisp, expressive, and high-quality facial sketch images. High-level features and textural features were extracted using a face feature extractor.

[7] Feng Liu, [9], Examining techniques for exemplar-based sketch synthesis. Techniques for generating dense sketch outputs using GANs are discussed. An explanation of how the method uses attention mechanisms. Eight state-of-the-art techniques are surpassed by MAGAN in both statistical

and visual evaluations. The numerical assessments consist of SSIM, FSIM, and LPIPS. The suggested technique effectively reduces errors and blur in created face sketches. The proposed MAGAN performs better in face sketch synthesis. Realistic textures, better details, fewer artifacts, and less noise are all present in generated sketches. Future research will concentrate on photosynthesis from sketches and applying the technique to natural faces.

[8] Jalan, Harsh Jaykumar,[10], Sketch Cop, Identikit, E-FIT, and Evo Fit were analyzed. Forensic sketch artists utilize a program called Sketch Cop. A computer-based technique called E-FIT is used to create facial composites. Evo Fit creates composite sketches by holistically processing faces. Current systems need human interaction as well as flaws. PG-GAN and StyleGAN were used to generate human pictures. When compared with PG-GAN, StyleGAN produced images that were better defined. TL-GAN modified StyleGAN's latent-space input to change the output images. The capacity to precisely alter facial traits is provided by TL-GAN. In the generated images, aging characteristics including wrinkles and bleached hair were noted.

[9] J. Zhao, X. Xie, L. Wang, M. Cao, and M. Zhang,[6], An adversarial model is recommended for generating high-quality face photographs from sketching. Improved feature-level loss to create a greater degree of similarity between synthetic and real-world images. Outperformed cutting-edge techniques in terms of SSIM for the sketch-to-photo conversion. Higher precision of sketch-based face identification utilizing a gallery set of synthetic images. Upcoming projects will look into pre-training techniques and create composite images from difficult forensic sketches.

IV. IMPLEMENTATION

A. Basic System Architecture:

The system architecture for sketch-to-image synthesis using a Generative Adversarial Network (GAN) in the context of criminal investigation typically involves several components. Here's a basic outline:

− Data Collection and Preprocessing:

Gather a dataset containing pairs of criminal sketches and corresponding images. Preprocess the data by standardizing image sizes, normalizing pixel values, and augmenting the dataset for diversity.

− Generator and Discriminator Networks:

Design the generator and discriminator networks based on a GAN architecture. You can use convolutional layers for both networks. The generator takes in a sketch and generates a corresponding image, while the discriminator assesses the realism of the generated images.

− Conditional Input Handling:

Implement a mechanism to handle conditional input, where the sketch serves as a condition for image generation. This might involve concatenating or merging the sketch information with the input to the generator.

− Loss Functions:

Define appropriate loss functions for training the GAN. Commonly used losses include adversarial loss (encouraging realistic image generation) and perceptual loss (ensuring similarity to real images). You may also incorporate auxiliary losses to guide the synthesis based on specific features.

− Training Pipeline:

Set up the training pipeline, which involves iteratively feeding sketches and real images into the GAN, updating the generator and discriminator parameters to improve performance. Use techniques like gradient descent to optimize the model.

− Hyperparameter Tuning:

Fine-tune hyperparameters such as learning rates, batch sizes, and the architecture of the generator and discriminator to achieve optimal results. This may involve experimentation and validation on a separate dataset.

− Evaluation Metrics:

Implement metrics to evaluate the performance of the model. Common metrics include Fréchet Inception Distance (FID) or Inception Score to measure the quality and diversity of generated images.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 4, No. 4, April : 2024

− GPU Acceleration:
Utilize GPU resources for faster training, especially considering the computational demands of GANs.
− Post-Processing:
Integrate any necessary post-processing steps to enhance the quality of generated images. This might include techniques to smooth or refine the output.
− Integration with Criminal Investigation Tools:
Ensure seamless integration with existing criminal investigation tools and workflows. This may involve collaboration with forensic experts and the incorporation of additional domain-specific information.
− Ethical Considerations:
Address ethical considerations, ensuring compliance with privacy and data protection regulations. Implement measures to prevent biases in the generated images.
− User Interface (Optional):
Develop a user interface for investigators to input sketches, view generated images, and provide feedback. This can enhance usability and facilitate the practical application of the system.
Following represents the basic system architecture of the sketch to face transformation:

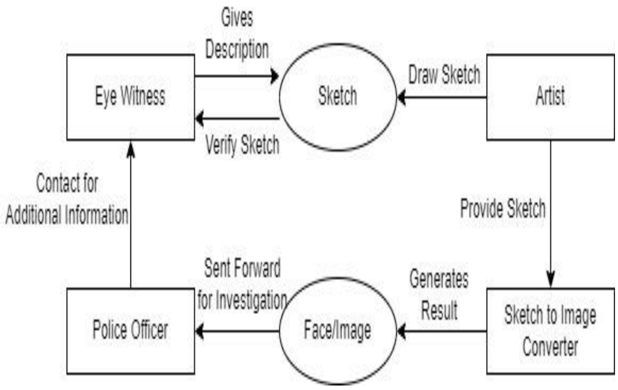

Fig. System Architecture

B. **Technology & Tools:**
− Conditional Cycle-GAN:
The proposed method for face sketch-to-photo transformation utilizes a novel conditional Cycle-GAN, which combines the advantages of Cycle-GAN and conditional GANs to generate realistic face photos from sketches. A conditional Cycle-GAN improves face identification accuracy by generating realistic face photos from sketches, which can be used as a replacement for face sketches in face identification systems.
− Convolutional Neural Networks (CNN):
The method employs a pre-trained face classification network to extract features from the synthesized and ground truth photos for the face feature loss calculation.
It utilizes the TensorFlow framework for implementing the proposed model.
Python is used as the programming language for developing the model. The project employs the Keras library, which is built on top of TensorFlow, for building and training the deep learning model. Histogram of Oriented Gradients (HOG) algorithm for face detection. Deep neural network for generating face encodings. Cosine distance metric for comparing the encodings of an input face with the encodings in the database. CUHK database for evaluating the proposed method. The paper uses the Scikit-learn library for performing data preprocessing and feature extraction tasks. The authors employ the OpenCV library for image processing and manipulation tasks. The paper utilizes the Pandas library for data analysis and manipulation. The authors use the Matplotlib library for data visualization and plotting. It employs the NumPy library for numerical computations and array manipulation.
C. **Datasets:**
− CUHK dataset:
The proposed method is evaluated using hand-drawn sketch-photo pairings from the CUHK dataset.

− Celeb A HQ dataset:
The Celeb A HQ dataset is used to construct sketch-photo pairs for evaluation purposes.

D. **Algorithms & Concepts:**

The Generative Adversarial Network (GAN) uses convolutional neural network layers for face sketch-to-photo translation. The method is evaluated using the CUHK dataset, consisting of 188 hand-drawn sketch-photo pairings. The HOG algorithm is used for face detection, with the network tuned to match encodings of the same person.

These algorithms and concepts are employed to develop an automated sketch-based face recognition method for criminal investigation. The HOG algorithm is used to detect faces from sketches, and deep neural networks are used to generate face encodings. The network is trained to ensure that encodings of the same person are similar and encodings of different persons are dissimilar. The cosine distance metric is then used to compare the encodings and retrieve the closest match from the database. The proposed method is evaluated on the CUHK database and demonstrates accurate performance

The results of the experiments demonstrate that the proposed approach can generate visually realistic images with rich texture information and features, which can be beneficial for law enforcement agencies in tracking and arresting criminals.

V. FUTURE SCOPE

Generative Adversarial Networks (GANs) are expected to be improved as technology advances, resulting in even more precise and intricate facial synthesis. Real-time apps might take center stage, enabling law enforcement to quickly create and confirm facial images while conducting ongoing investigations. Working together with foreign law enforcement organizations could increase the system's reach, enabling cross-border data exchange and enhancing the ability to solve crimes worldwide. Furthermore, studies could look into incorporating different sketch styles to improve the system's flexibility. In the ever-changing world of police investigations, continued advancements in privacy protection and ethical issues will be essential to guaranteeing the ethical and legal use of this technology. Sketch-to-face generation has enormous potential for future innovation and optimization, which will strengthen its position.

VI. CONCLUSION

To sum up, the "Sketch-to-Face Generation for Police Investigation" represents a revolutionary development in the field of law enforcement technology. Suspect identification problems can be fully resolved by combining database cross-referencing, image verification, and Generative Adversarial Networks (GANs). This novel method not only increases the effectiveness of the investigation but also has the ability to completely alter accepted procedures in criminal investigations. The system's adaptability, efficiency gains, and ethical considerations highlight its importance as a potent tool for law enforcement, pointing to a future in which suspect identification will be significantly accurate and quick, enhancing community safety and justice.

VII. ACKNOWLEDGEMENT

We extend our gratitude to the collective efforts of all team members involved in the ongoing development of the "Sketch-to-Face Generation for Police Investigation" project. Their dedication and collaboration contribute significantly to the advancement of this innovative initiative.

VIII. REFERENCES

[1] Akram A., Wang N., Li J. Gao X. (2018). A comparative study on face sketch synthesis. IEEE Access, 6, 37084–37093.https://doi.org/10.1109/ACCESS.2018.2852709.

[2] X. Zhang and W. Dahu, “Application of artificial intelligence algorithms in image processing,” J. Vis. Commun. Image Represent., vol. 61, no. March, pp. 42–49, 2019, doi: 10.1016/j.jvcir.2019.03.004.

[3] H. Huang, P. S. Yu, and C. Wang, “An Introduction to Image Synthesis with Generative Adversarial Nets,” arXiv, pp. 1–17,2018

[4] Zhang, Z. (2020). Research Progress on Generative Adversarial Network with its Applications. *Zhang, Z. (2020). Research Progress on Generative Adversarial Network With its Applications. 2020 IEEE* https://doi.org/10.1109/itoec49072.2020.91416 .

[5] Du, Kangning , et al. "MHGAN: Multi-Hierarchies Generative Adversarial Network for High-Quality Face Sketch Synthesis." *IEEE*, vol. 8, 2019, https://doi.org/10.1109/ACCESS.2020.3041284.

[6] J. Zhao, X. Xie, L. Wang, M. Cao, and M. Zhang, “Generating Photographic Faces From the Sketch Guided by Attribute Using GAN,” IEEE Access, vol. 7, pp. 23844–23851, 2019, doi:10.1109/ACCESS.2019.2899466.

[7] M. Zhang, N. Wang, Y. Li, and X. Gao, ‘‘Bionic face sketch generator,’’ IEEE Trans. Cybern., vol. 50, no. 6, pp. 2701–2714, Jun. 2020.

[8] A. Mishra and S. Vishwakarma, ”Analysis of TF-IDF Model and its Variant for Zhang, H., She, P., Liu, Y., Gan, J., Cao, X., Foroosh, H. (2019). Learning Structural Representations via Dynamic Object Landmarks Discovery for Sketch Recognition and Retrieval. IEEE Transactions on Image Processing, 28(9), 4486–4499. doi:10.1109/tip.2019.2910398

[9] ZHENG, J., WU, Y., SONG, W., XU, R., & LIU, F. (2018). Multi-Scale Feature Channel Attention Generative Adversarial Network for Face Sketch Synthesis. IEEE, 8, 146754-146769. https://doi.org/10.1109/ACCESS.2020.3015312.

[10] Jalan, Harsh Jaykumar; Maurya, Gautam; Corda, Canute; Dsouza, Sunny; Pan chal, Dakshata (2020). [IEEE 2020 3rd International Conference on Communication System, Computing and IT Applications (CSCITA) - Mumbai, India (2020.4.3-2020.4.4)] 2020 3rd International Conference on Communication System, Computing and IT Applications (CSCITA) - Suspect Face Generation., 73 78. doi:10.1109/CSCITA47329.2020.9137812

[11] M. Zhang, R. Wang, X. Gao, J. Li, and D. Tao, ‘‘Dual-transfer face sketch–photo synthesis,’’ IEEE Trans. Image Process., vol. 28, no. 2, pp. 642–657,Feb. 2019.

[12] SETUMIN, S., WU, Y., & FARIS CHE AMINUDIN, M. (2020). Canonical Correlation Analysis Feature Fusion with Patch of Interest: A Dynamic Local Feature Matching for Face Sketch Image Retrieval. *IEEE*, *8*, 137342-137355. https://doi.org/10.1109/ACCESS.2020.3009744

[13] Pan, Zhaoqing; Yu, Weijie; Yi, Xiaokai; Khan, Asifullah; Yuan, Feng; Zheng, Yuhui (2019). Recent Progress on Generative Adversarial Networks (GANs): A Survey. IEEE Access, 1–1. doi:10.1109/ACCESS.2019.2905015

[14] Wang, T.-C., Liu, M.-Y., Zhu, J.-Y., Tao, A., Kautz, J., Catanzaro, B. (2018). High-Resolution Image Synthesis and Semantic Manipulation with Conditional GANs. 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition. doi:10.1109/cvpr.2018.00917

[15] A. Saini, T. Gupta, R. Kumar, A. K. Gupta, M. Panwar, and A. Mittal, “Image based Indian monument recognition using convoluted neural networks,” 2017 Int. Conf. Big Data, IoT Data Sci. BID 2017, vol. 2018–Janua, pp. 138–142, 2018.

[16] Weiguo Wan, Hyo Jong Lee (2019). Genarative adversarial multi-task learning for face sketch synthesis and recognition 978-1-5386-6249-6/31.00.2019 IEEE

[17] G. G., Patil, and Banyal R. K. "Techniques of Deep Learning for Image Recognition." 2019 5th International Conference for Convergence in Technology (I2CT) Pune, India.Mar29-31, 2019,https://doi.org/10.1109/I2CT45611.2019.9033628.

[18] Wan, W., Gao, Y. & Lee, H.J. Transfer deep feature learning for face sketch recognition. *Neural Comput & Applic* **31**,9175–9184,(2019). https://doi.org/10.1007/s00521-019-04242-5

[19] Zhongwei Zhang (2020). Research Progress on Generative Adversarial Network with its Applications, IEEE 5th Information Technology and Mechatronics Engineering Conference (ITOEC 2020)

[20] Galea, C., & Farrugia, R. A. (2018). Matching Software-Generated Sketches to Face Photos with a Very Deep CNN, Morphed Faces, and Transfer Learning. *IEEE*, *16*(6), 1421-1431. https://doi.org/10.1109/TIFS.2017.2788002

[21] S. Nikkath Bushra and K. Uma Maheswari, "Crime Investigation using DCGAN by Forensic Sketch-to-Face Transformation (STF)- A Review," *2021 5th International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, India, 2021, pp. 1343-1348, doi: 10.1109/ICCMC51019.2021.9418417.