

Neural Networks and Fuzzy Logic

BITS F312

TERM PROJECT

Title of the Paper Implemented:

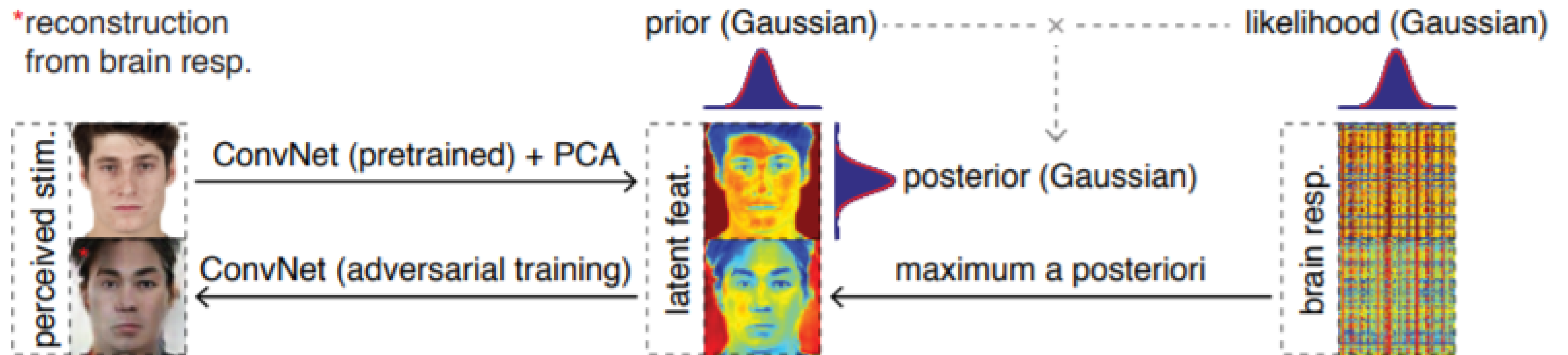
Reconstructing perceived faces from brain activations with deep adversarial neural decoding

Group 14:

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Miloni Mittal	2017A3PS0243P

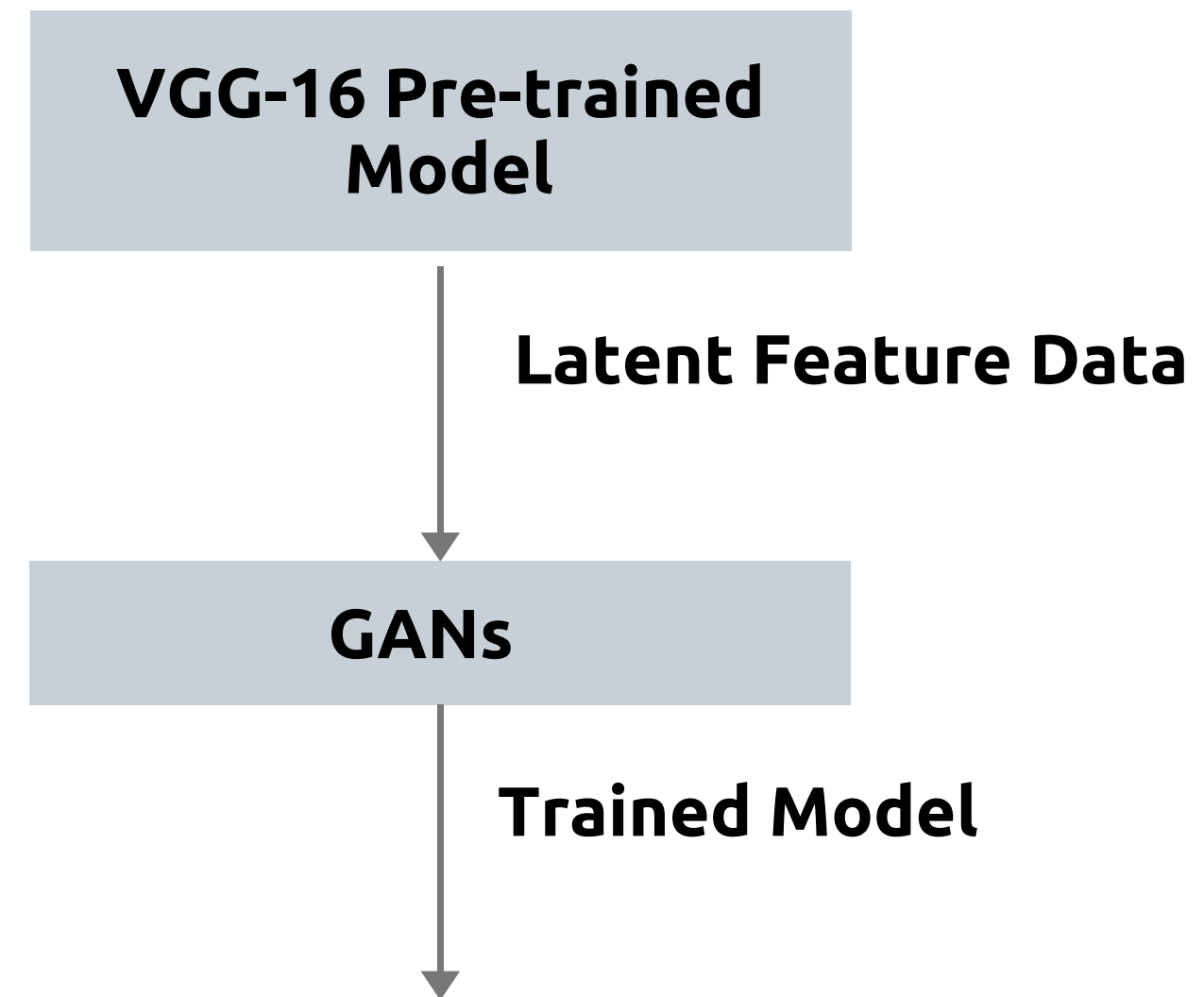
Aim

To reconstruct a perceived face using data on brain stimulus.

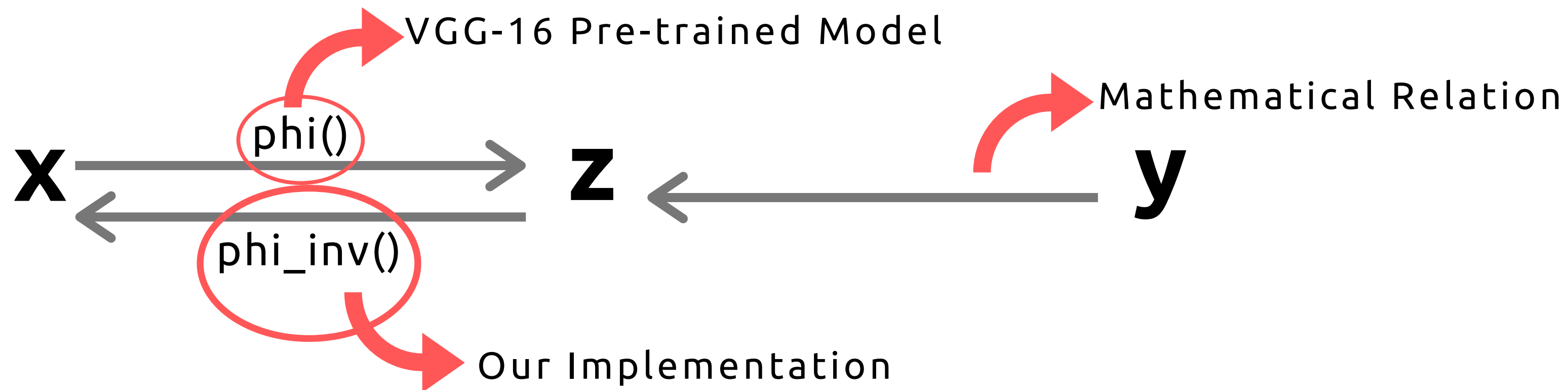


Introduction

- The paper aims to build a model which reconstructs the visual perceived face, given the brain activations.
- The brain response data is related to the face image via a latent feature model.
- The paper utilises two datasets: a fMRI dataset and the CelebA dataset.
- The mapping from face image to latent feature space is obtained with the help of a modified pre-trained VGG-16 model.
- The mapping between latent features and brain response is described using a probabilistic model.
- This latent feature data is then used to train the Generative Adversarial Network (GAN).



Representation of Variables



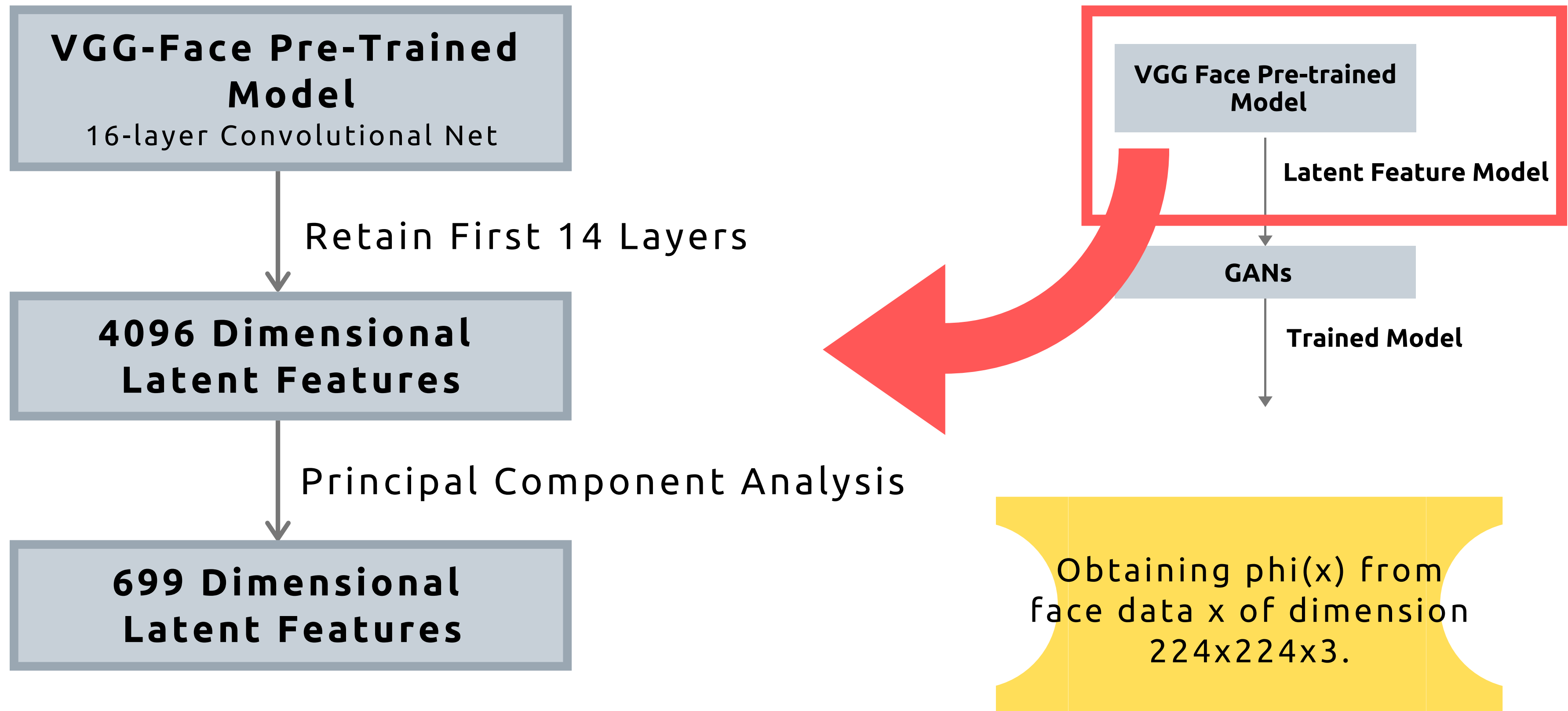
$$\mathbf{z} = ((\mathbf{B}\Sigma^{-1}\mathbf{B}^T + \mathbf{I})^{-1}\mathbf{B}\Sigma^{-1}\mathbf{y}) \quad (\text{Using concepts of Bayesian approach})$$

x= Stimulus

y= Brain Response (fMRI data)

z= Feature Space

Obtaining the Latent Feature Model from VGG-16



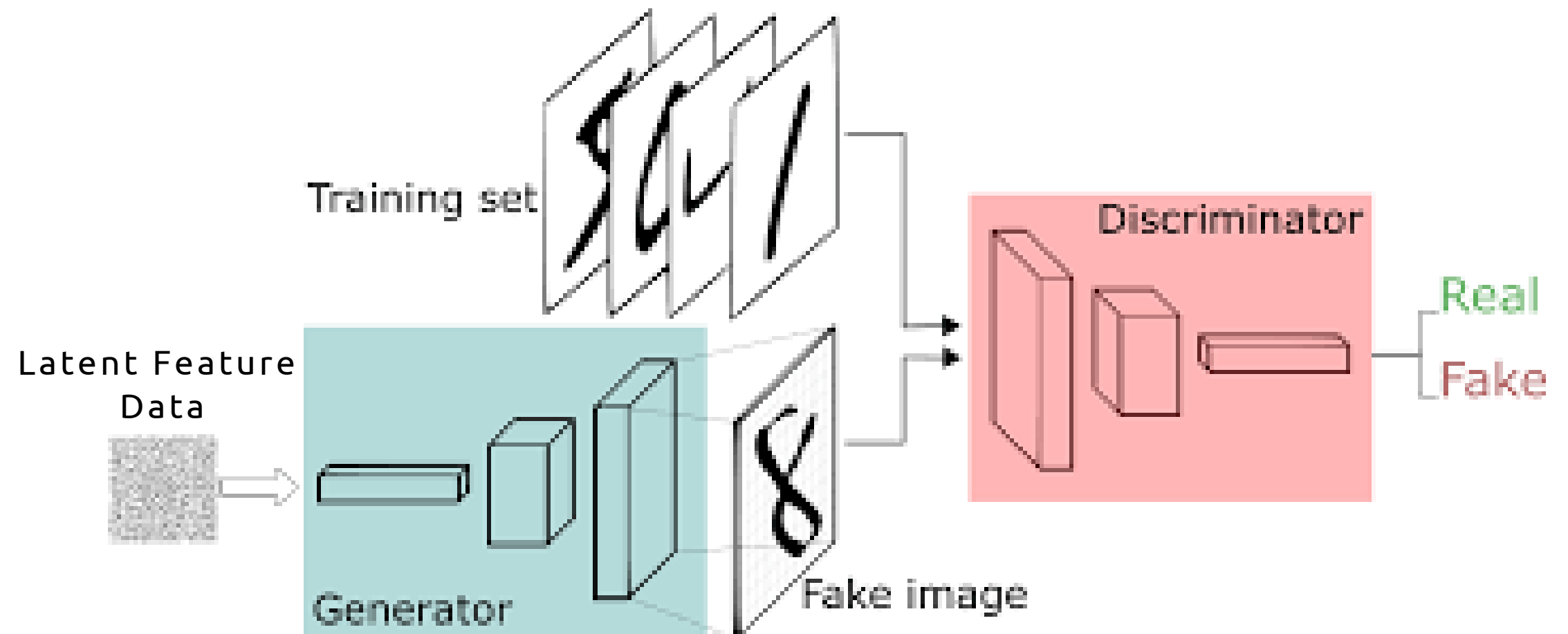
What are Generative Adversarial Networks (GANs)?

The generator and discriminator are adversaries whose main aim is to fool each other and in the process become masters at their purposes (generator- generating images as similar to the original and discriminators- differentiating between the original and fake images).

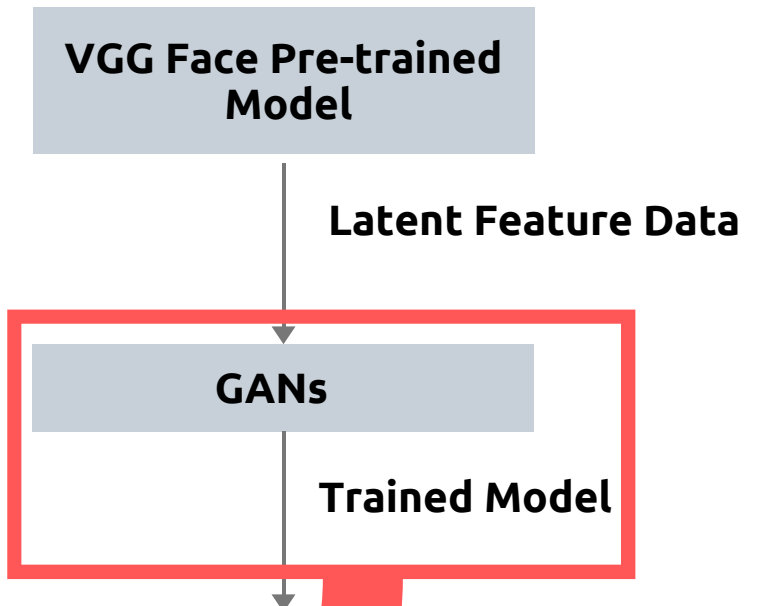
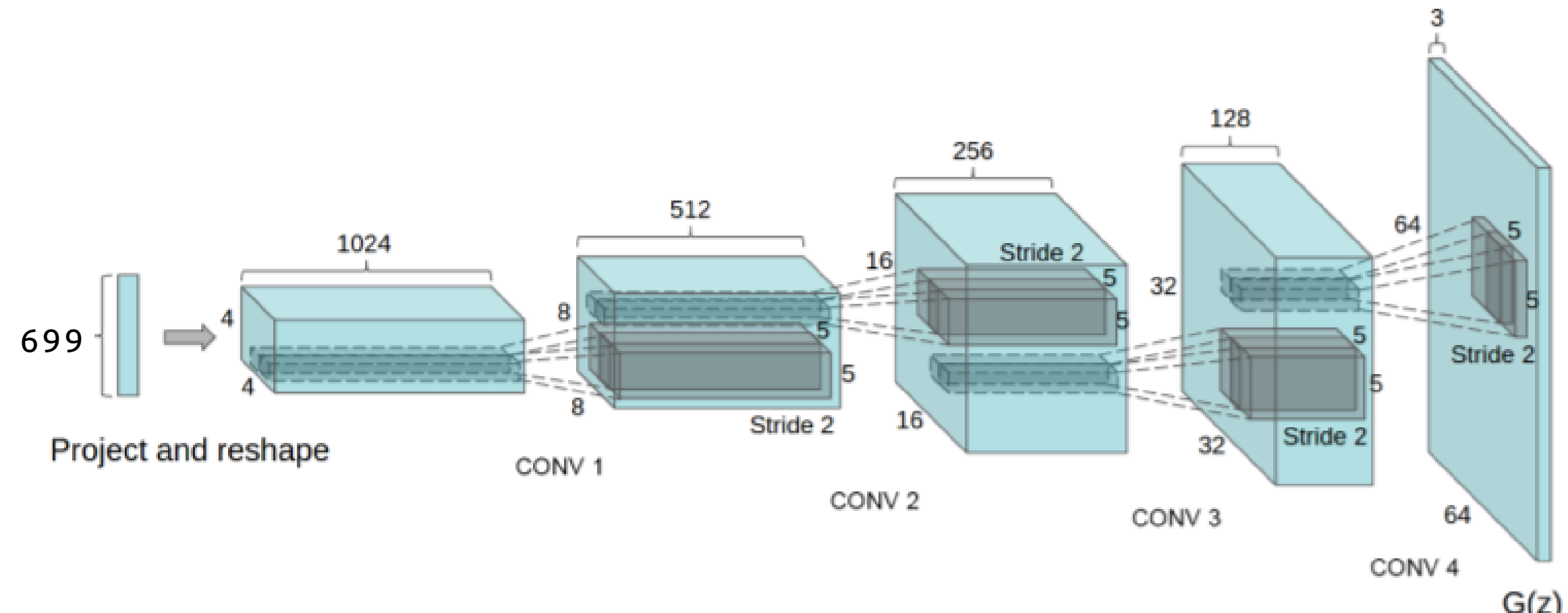
What are Generative Adversarial Networks (GANs)?

Our implementation of the GAN:

- The Generator is fed with Latent Feature Data and it attempts to reconstruct the original face image using it.
- The Discriminator is fed with actual images as well as images generated by the Generator and it differentiates between a fake image and an original image.



Generator Model

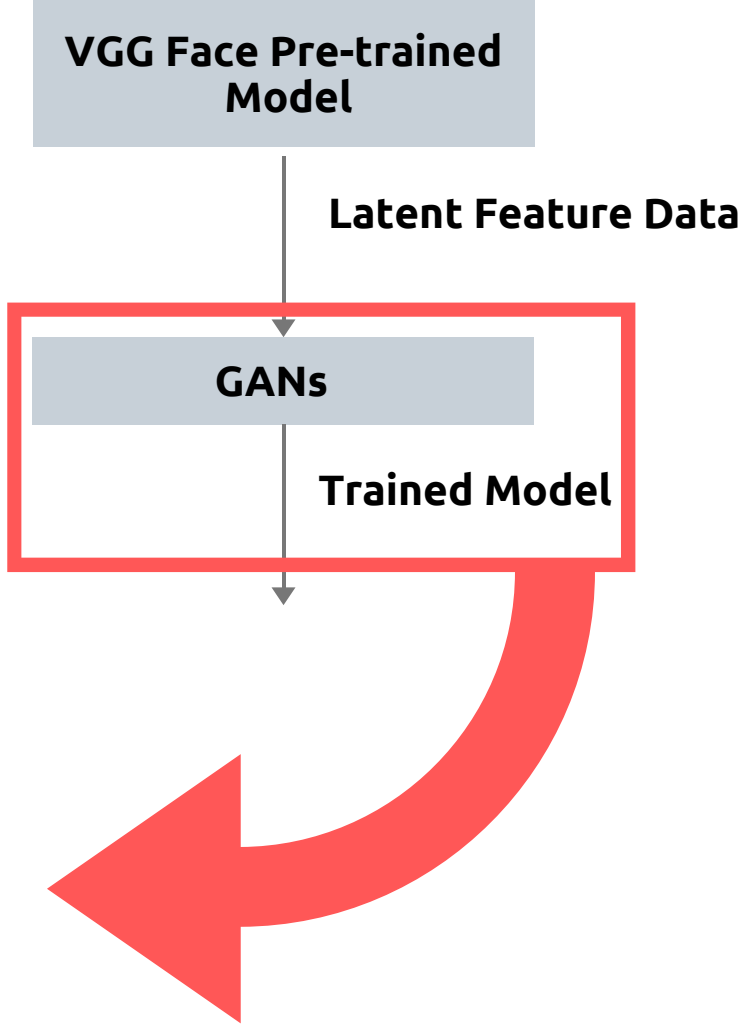


Layer Number	No. of Kernels	Stride	Padding	Comments
<u>i</u> th Layer	$2^{(10-i)}$	2x2	1x1	Batch normalization and rectified linear units
First Layer	2^9	1x1	No Padding	" "
Last Layer	3	2x2	1x1	No batch normalization and hyperbolic tangent units

Kernel Size 4x4

Discriminator Model

Layer Number	No. of Kernels	Stride	Padding	Comments
<u>i</u> th Layer	$2^{(5+i)}$	2x2	1x1	Batch normalization and rectified linear units
First Layer	2^6	2x2	1x1	No batch normalization
Last Layer	1	1x1	No padding	No batch normalization and a sigmoid unit



Kernel Size 4x4

Loss Functions

Generator Loss Function

$$L_{\text{gen}} = -\lambda_{\text{adv}} \underbrace{\mathbb{E} [\log(\psi(\phi^{-1}(\mathbf{z})))]}_{L_{\text{adv}}} + \lambda_{\text{fea}} \underbrace{\mathbb{E} [\|\xi(\mathbf{x}) - \xi(\phi^{-1}(\mathbf{z}))\|^2]}_{L_{\text{fea}}} + \lambda_{\text{sti}} \underbrace{\mathbb{E} [\|\mathbf{x} - \phi^{-1}(\mathbf{z})\|^2]}_{L_{\text{sti}}}$$

Discriminator Loss Function

$$L_{\text{dis}} = -\mathbb{E} [\log(\psi(\mathbf{x})) + \log(1 - \psi(\phi^{-1}(\mathbf{z})))]$$

Training and Testing

Due to computational limitations, we were forced to train the model over 20,000 images for 30 epochs.

The evaluation metrics were evaluated on 5000 images.

Performance Metrics

	Feature similarity	Pearson correlation coefficient	Structural similarity
S1	0.6546 ± 0.0220	0.6512 ± 0.0493	0.8365 ± 0.0239
S2	0.6465 ± 0.0222	0.6580 ± 0.0480	0.8325 ± 0.0229

Performance Metrics as obtained by Author

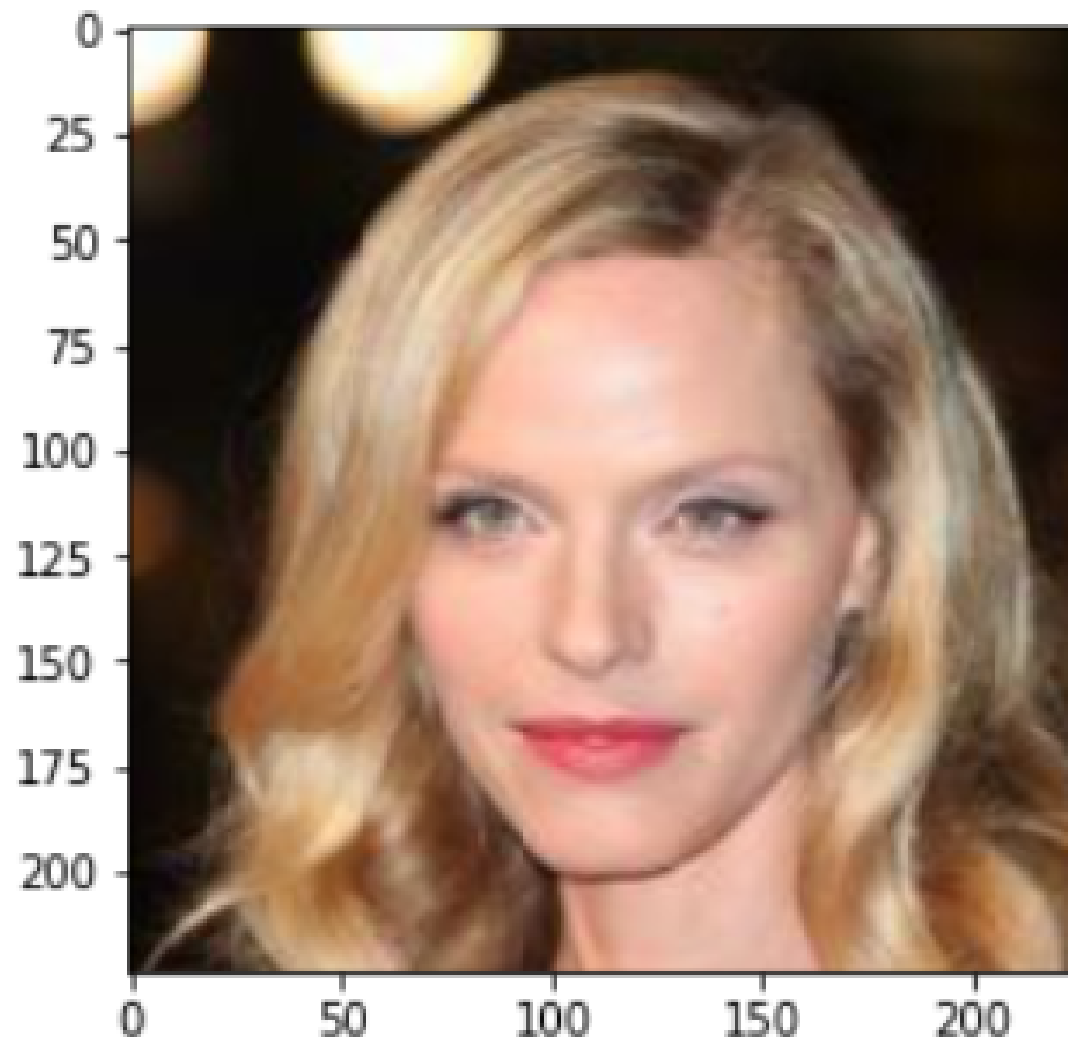
Structural Similarity: $0.28947963068882626 \pm 0.005695663162144385$

Pearson Correlation: $0.7751902192831039 \pm 0.015463066628726884$

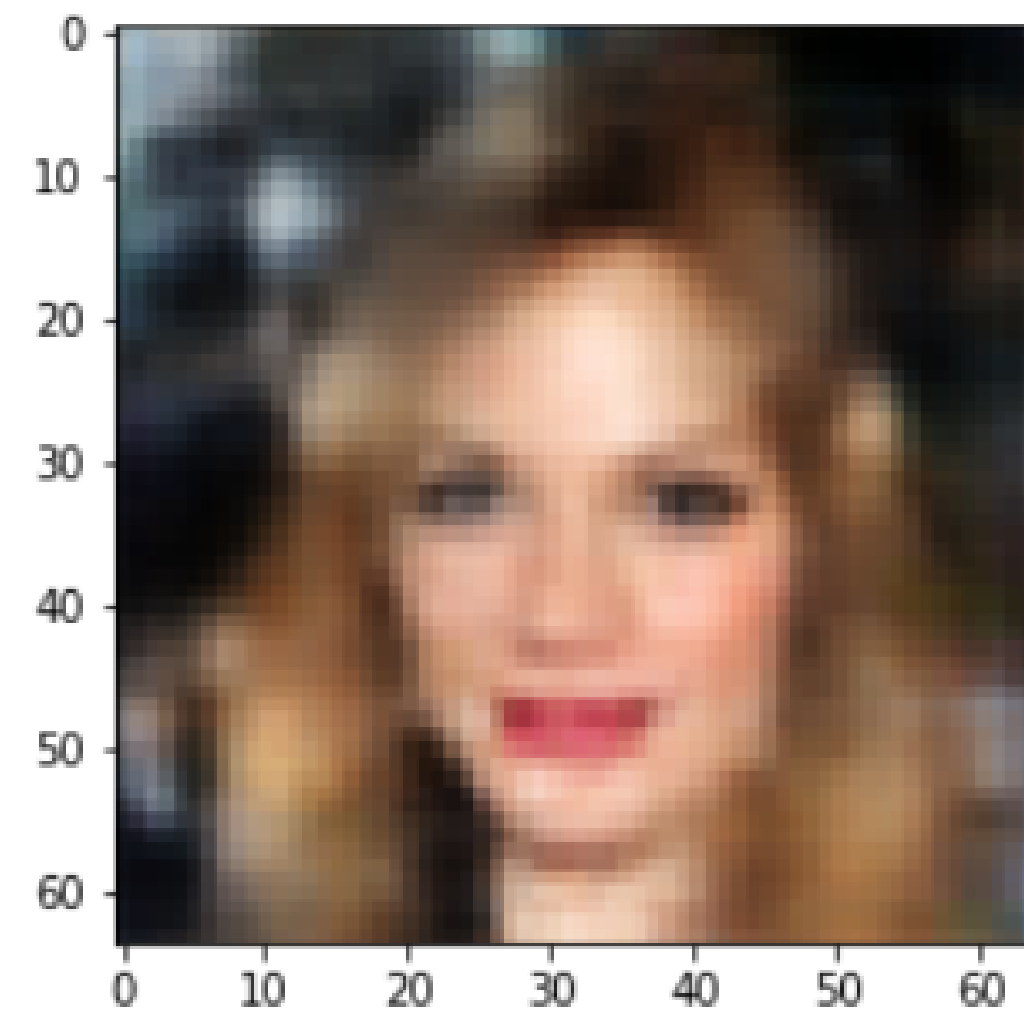
Euclidean Feature Similarity: $37.65902773539225 \pm 0.7089358121369557$

Performance Metrics as obtained by our Implementation

Results



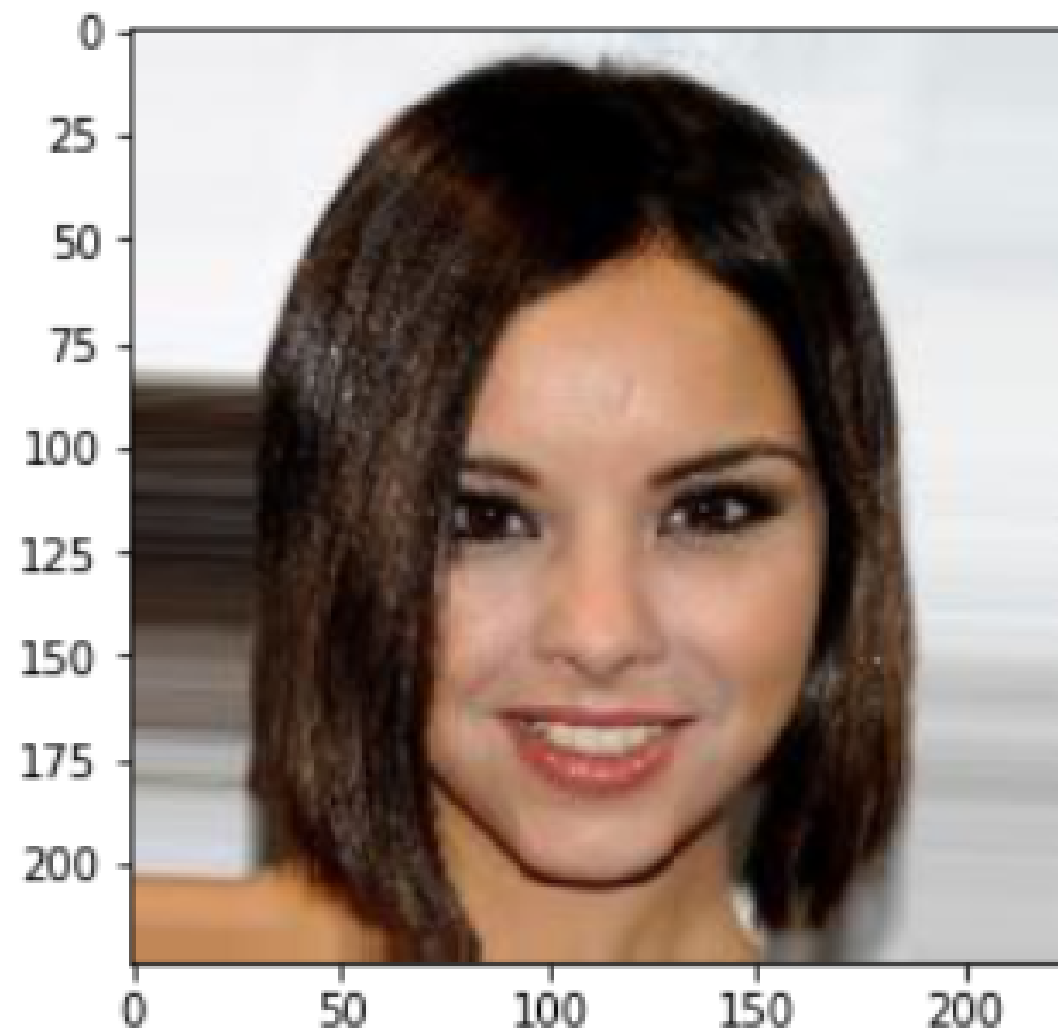
Original Image



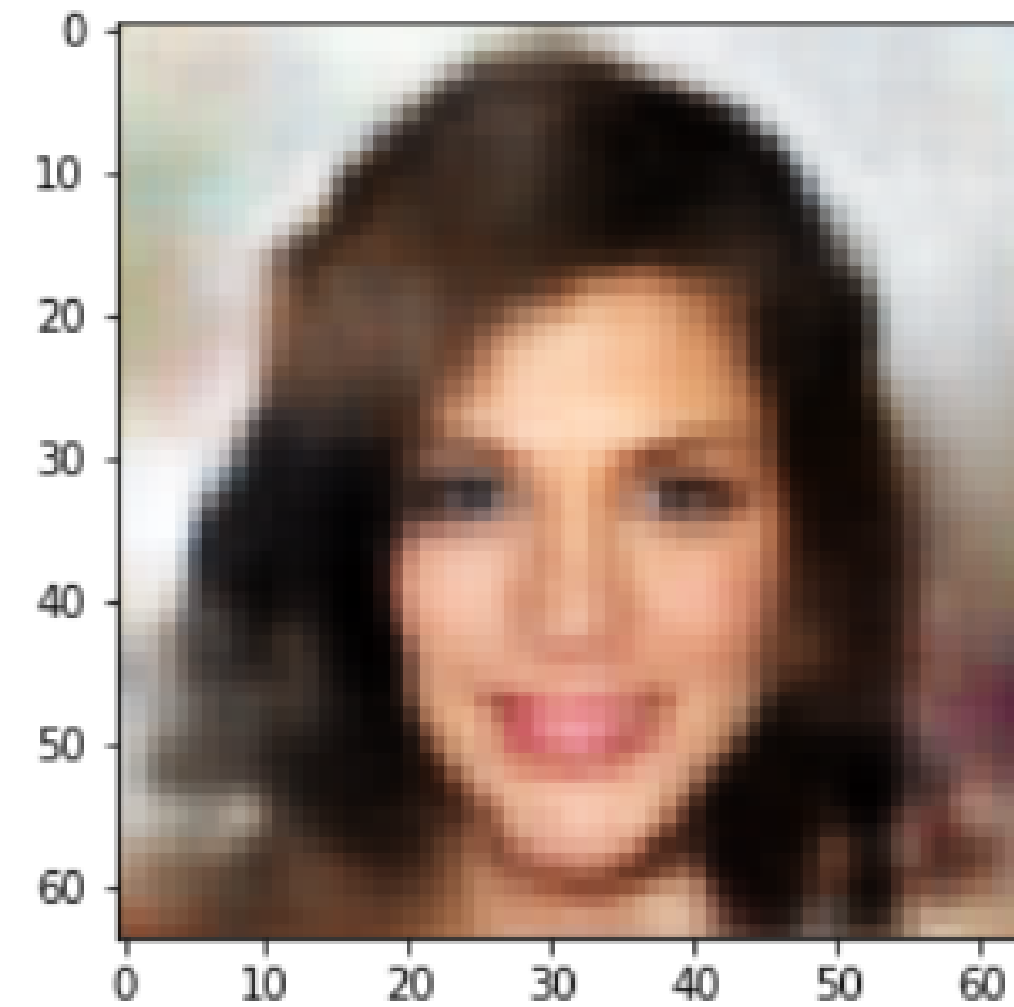
Generated Image



Results



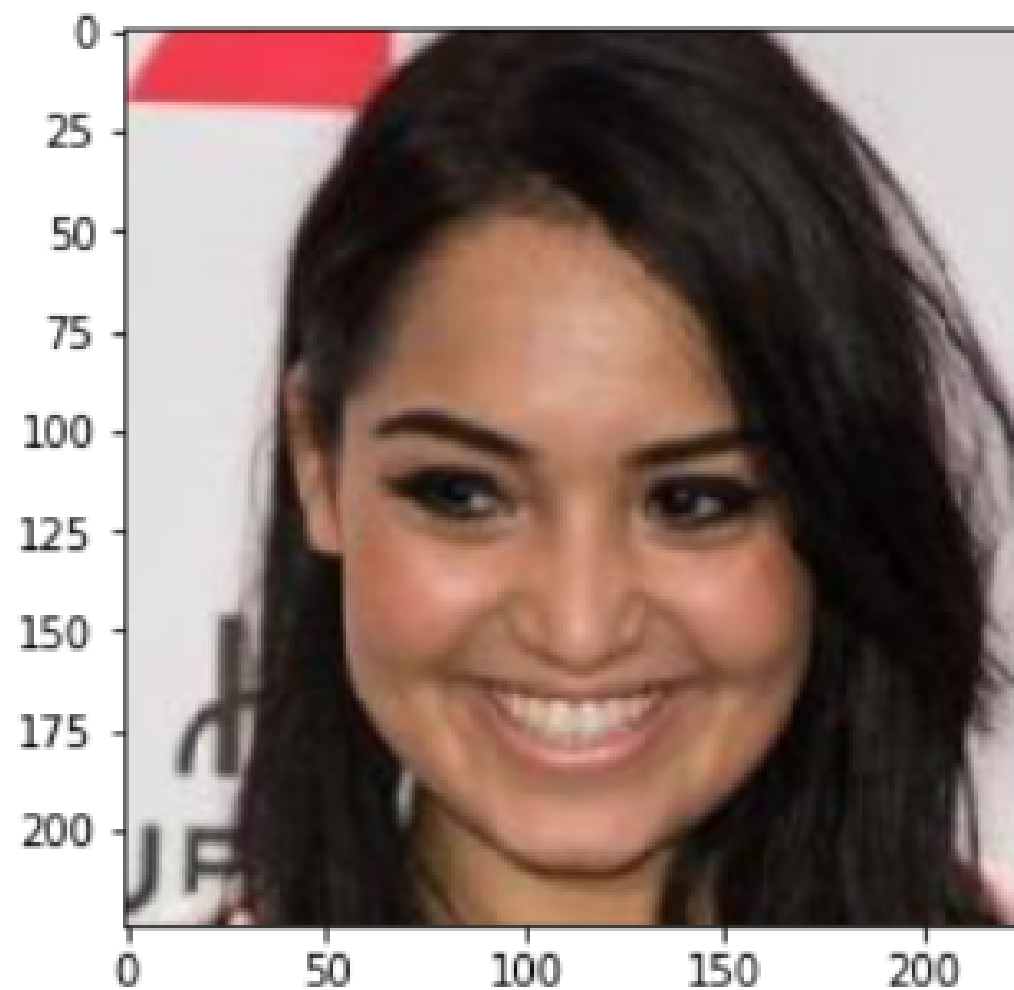
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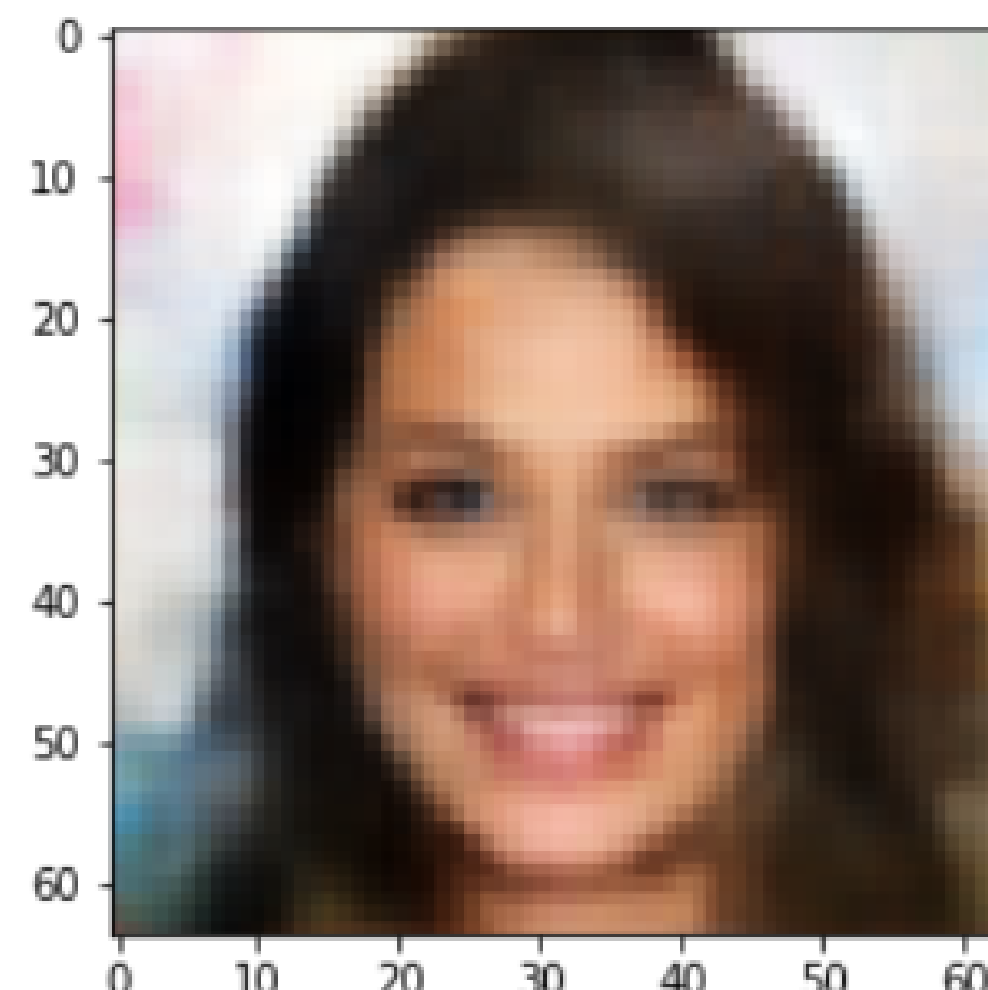
Generated Image



Results



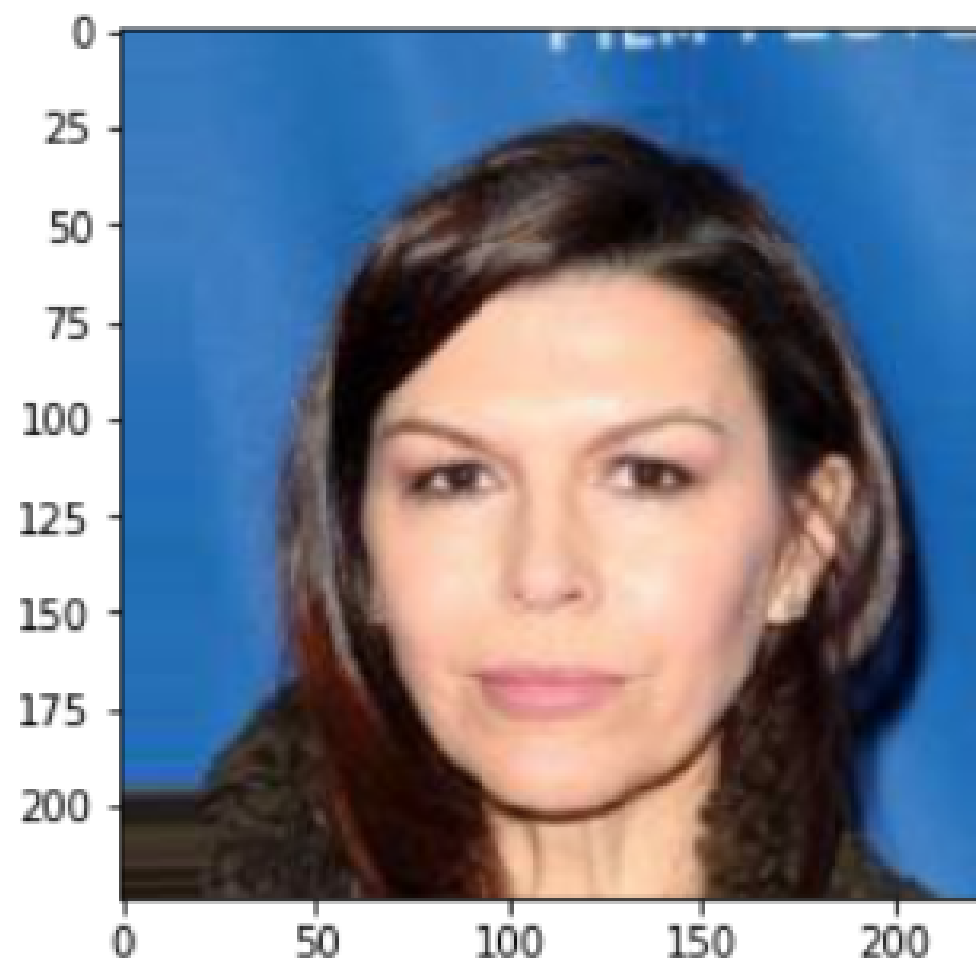
Original Image



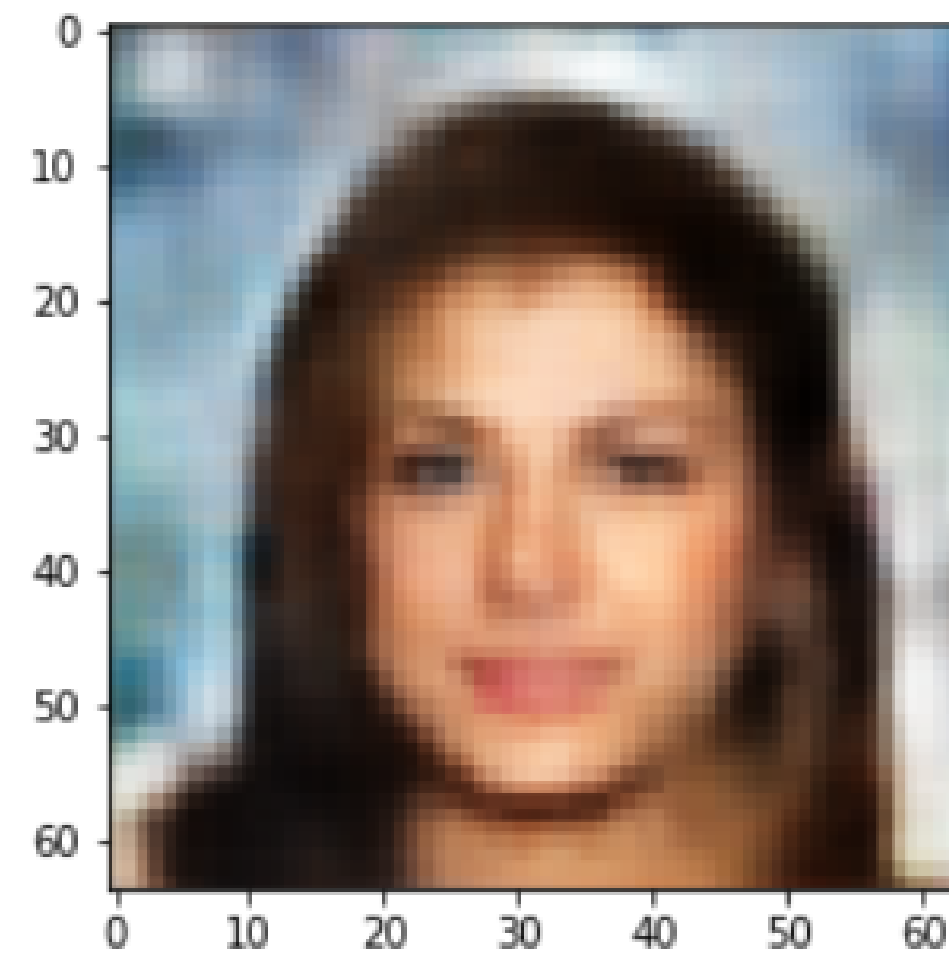
Generated Image



Results



Original Image



Generated Image





Thank You!