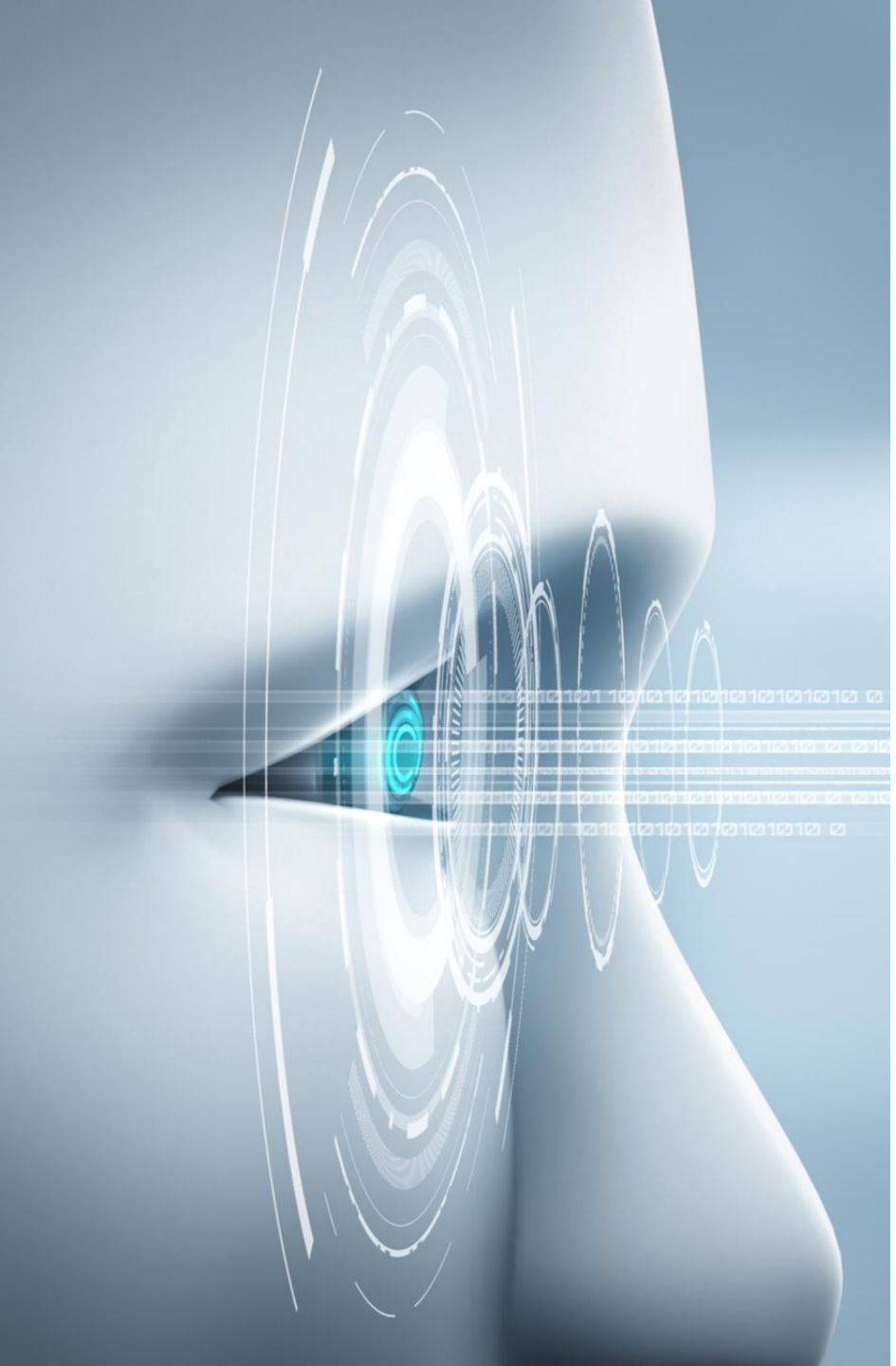


# Computer Vision Applications

BY QUADEER SHAIKH

# About me

**Work Experience**

- Risk Analyst
  - Morgan Stanley (Jan 2023 – Present)
- Data Science Intern
  - AkzoNobel Coatings International B.V. Netherlands (Feb 2022 – Dec 2022)
- Data Science Intern
  - EzeRx Health Tech Pvt. Ltd. (Jan 2022 – July 2022)
- Associate Engineer
  - Tata Communications Ltd. (July 2019 – Aug 2020)
- Network Automation and Analysis Engineer Intern
  - Cisco (June 2018 – July 2018)

**Education**

- M.Tech – Artificial Intelligence
  - NMIMS (2021 - 2023, currently pursuing)
- B.E. – Computer Engineering
  - Mumbai University (2015 - 2019)

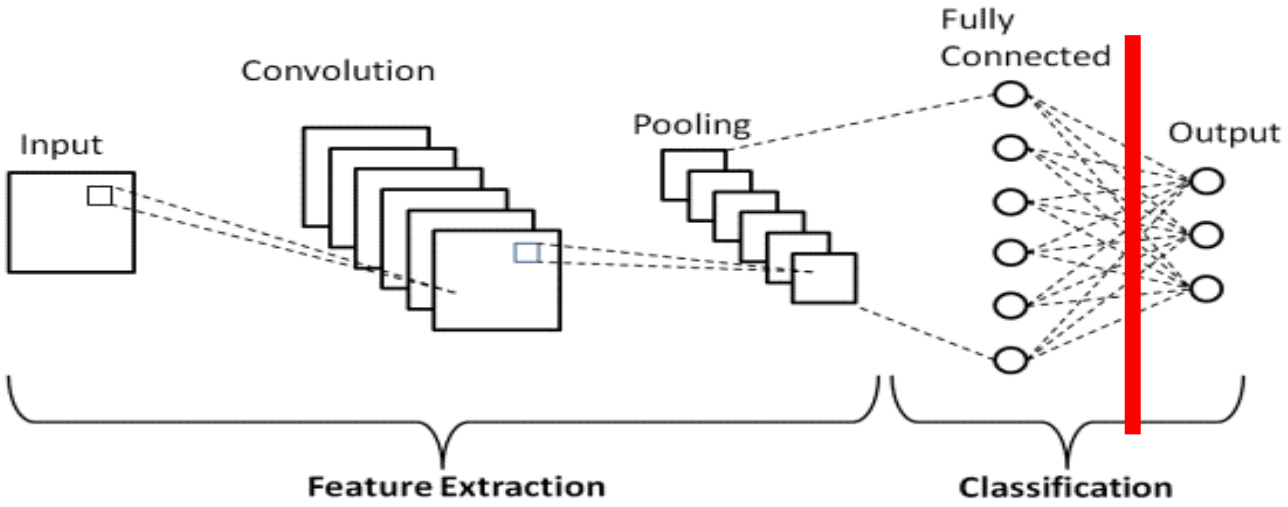
# Visual Embeddings and One Shot Learning

# Visual Embeddings

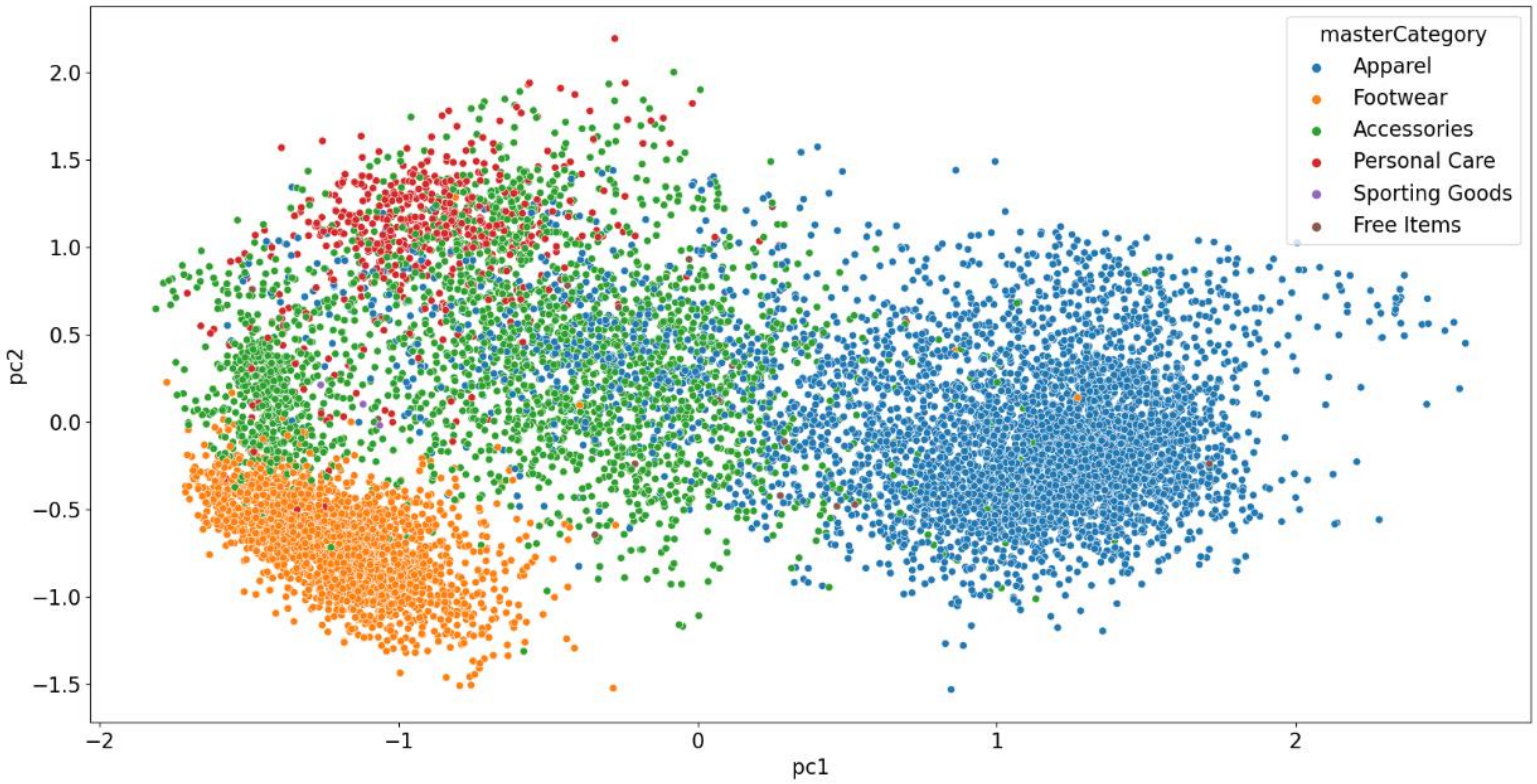
What are image embeddings? An image embedding is **a lower-dimensional representation of the image**. In other words, it is a dense vector representation of the image which can be used for different computer vision tasks. E.g. Classification

Usually is the output of the layer before the final layer (last fully connected layer)

This way, comparisons between images can be performed by measuring their pairwise distances in this embedding space.

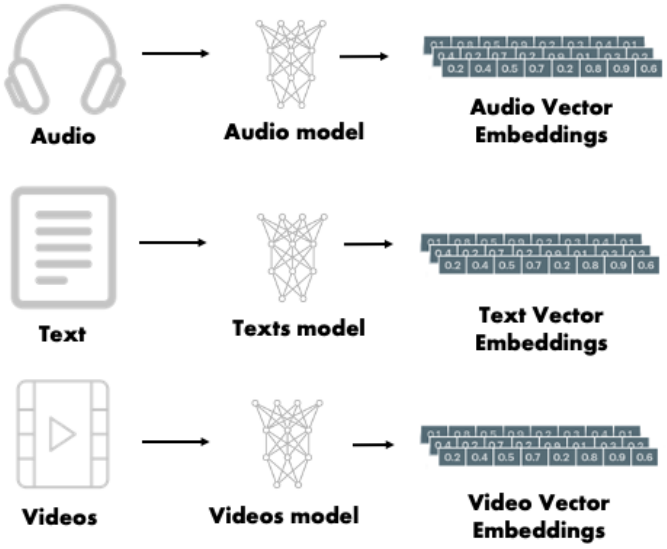


# Visual Embeddings: Projected in 2D using Dimensionality Reduction



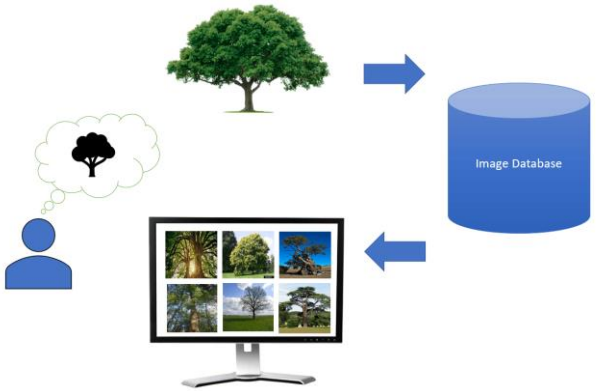
# Embeddings: Formal Definition

An embedding is a vector space, typically of lower dimension than the input space, which preserves relative dissimilarity (in the input space). The terms vector space and embedding space are used interchangeably. Embeddings can be extracted for any kind of data form.



# Applications of Visual Embeddings

1. Image Recommendation Systems
2. Reverse Image Search Engines
3. Face Recognition
4. Object Re-Identification





# Reverse Image Search/Image Recommendation Approach

1. Extract visual embeddings using a pretrained network
2. Store the vector embeddings in a database
3. Provide input image -> calculate visual vector embedding
4. Calculate distance between input image embeddings and all the image embeddings in the database
5. Display the k-Nearest Neighbours based on the distance calculated

**Note:** In the examples shown, k = 5

Subjective metrics such as hit-rate and A/B tests are used to evaluate the success of these tasks

# Face Recognition

# One Shot Learning: Face Recognition

One-shot learning is an **object categorization problem**, found mostly in **computer vision**. Whereas most **machine learning**-based object categorization algorithms require training on hundreds or thousands of examples, one-shot learning aims to classify objects from one, or only a few, examples. The term **few-shot learning** is also used for these problems, especially when more than one example is needed.

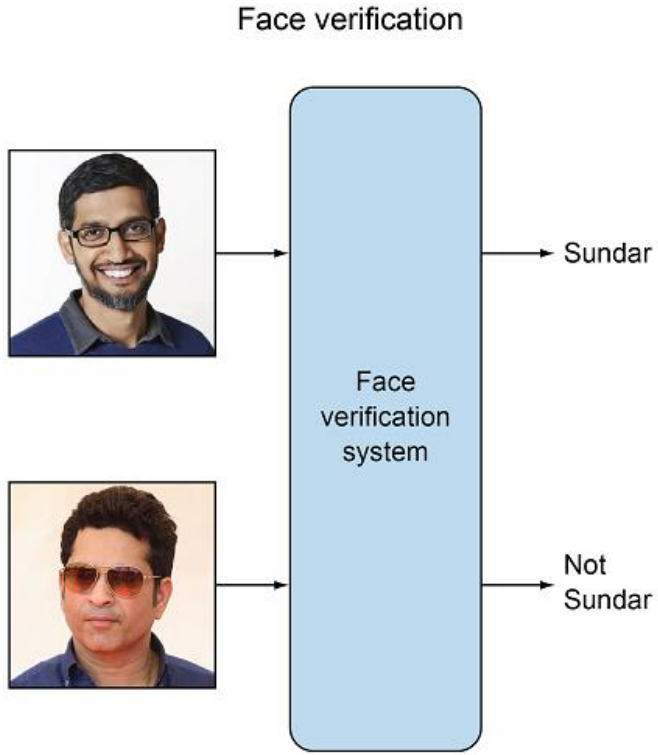
Tasks like signature or face verification require the recognition of objects or faces. Deep learning algorithms typically require a lot of training data for these recognition based tasks. But, for a setup like face recognition we do not possess a large variety of photos for each person.

# Face Recognition: Modes

1. **Face Identification:** One-to-many matches that compare a query face image against all the template images in the database to determine the identity of the query face
   - Person A's image is compared with all the other people images present in the database
   - One to Many comparison
2. **Face Verification:** One-to-one match that compares a query face image against a template face image whose identity is being claimed.
   - Person A's image is saved in the database, Person A's new input image is compared with the existing image in the database
   - One to one comparison

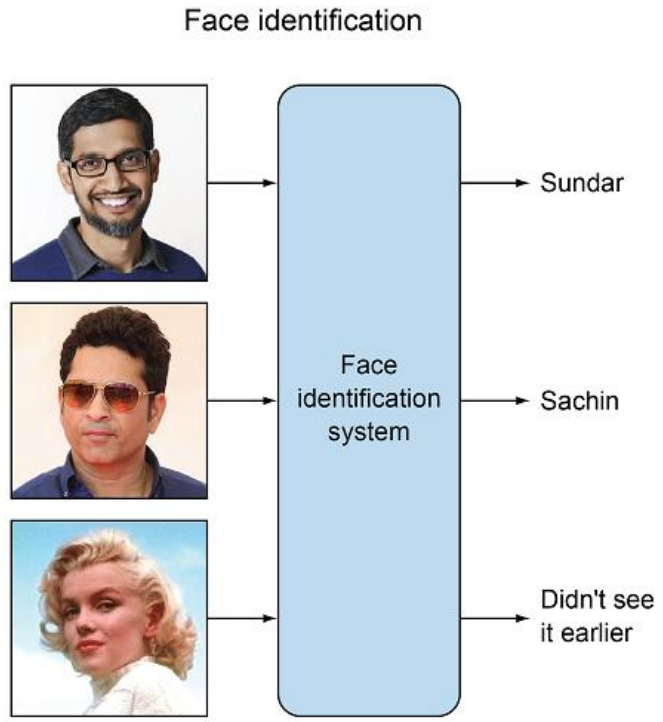
# Face Verification

1. Face image embeddings of users stored in a database
2. User provides and input image, saying he is person A
3. Distance = L2(User's face embeddings, Person A's face embeddings)
4. If Distance < Distance threshold
   - The person is verified as person A
5. Else:
   - It is not person A



# Face Identification

1. Face image embeddings of all users stored in a database
2. Person of interest identified
3. Person's face embeddings calculated
4. Distance = L2(person's face embeddings, face embeddings in DB)
5. Find the person id from the database with lowest distance
6. If distance < distance thresh
   - Person is person id with the lowest distance
7. Else
   - Person's image is not present in the database



# Face Recognition

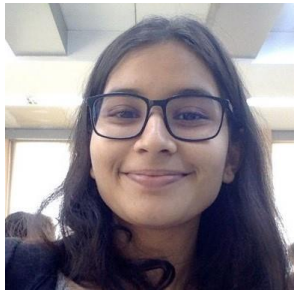
1. Face Detection
   - Haar Cascades
   - Object Detection based models – MTCNN – Covered in Object Detection
   - Mediapipe – To be covered in next lecture
2. Face Alignment
3. Embedding Extraction
4. Face Identification/Verification

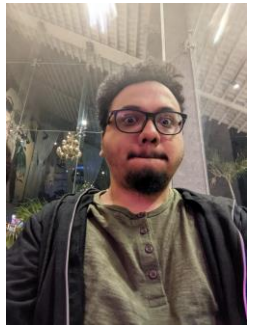
# Face Detection: RoI

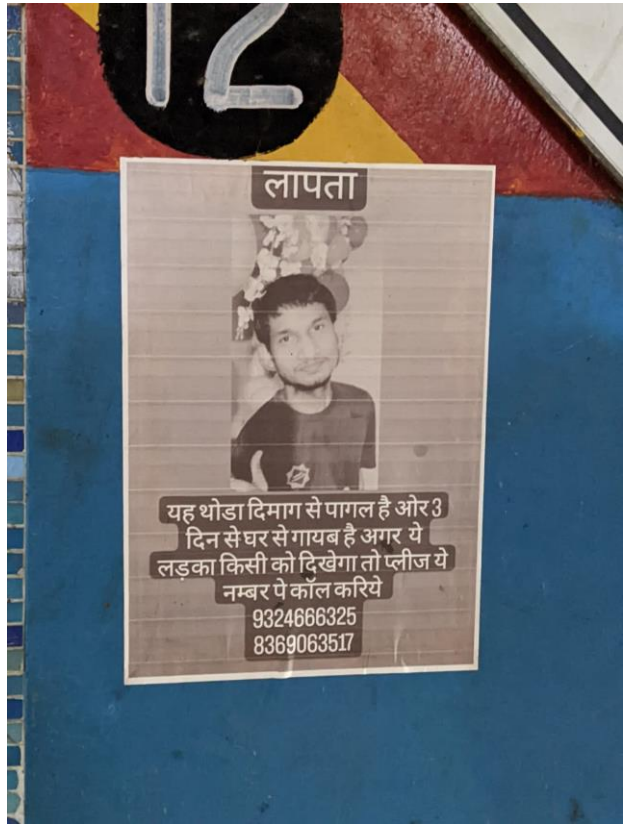





# Face Detection: Full Images

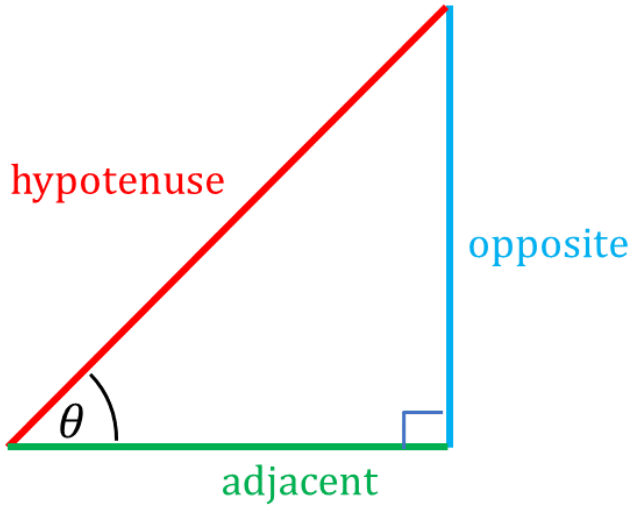






# Face Alignment: 2D Alignment

Some math.....




$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

# Face Alignment: 2D Alignment

Some math.....

# Face Alignment: 2D Alignment

Some math.....

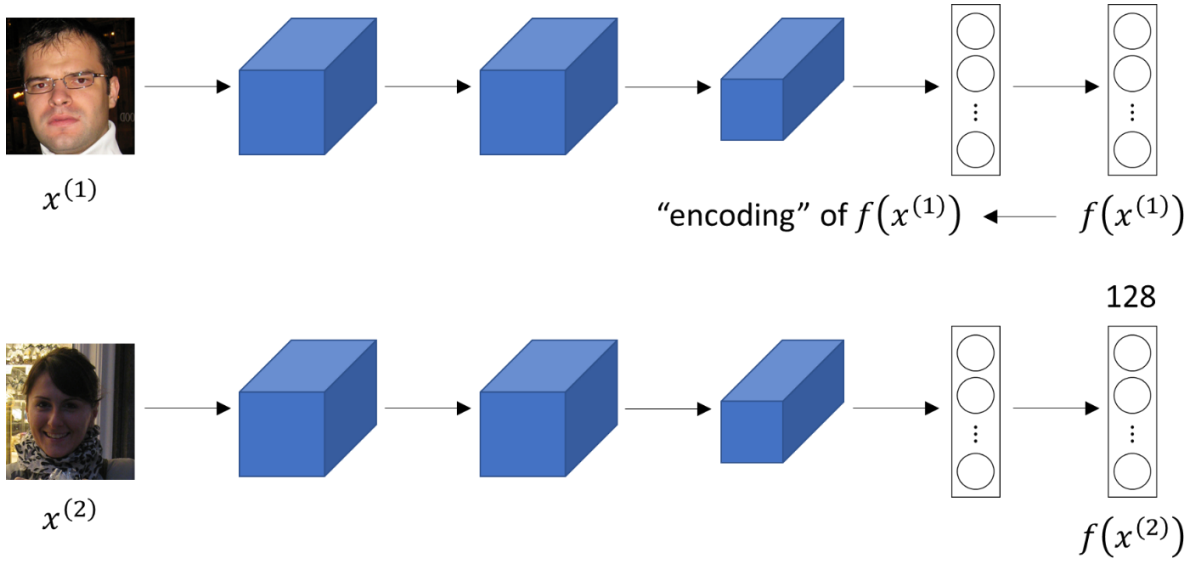
# Embedding Extraction and Face Recognition

What kind of network should we train for this one shot learning/few shot learning task ?

1. A model from scratch ?
2. A pretrained model ?

# Siamese Network

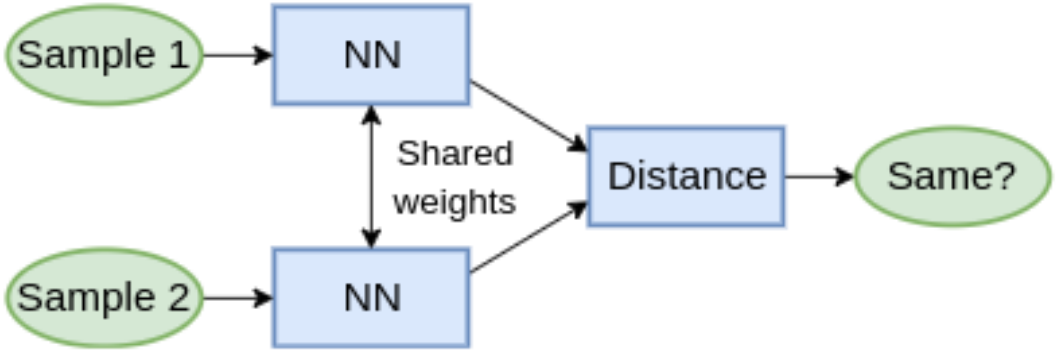
A **Siamese neural network** (sometimes called a **twin neural network**) is an artificial neural network that uses the same weights while working in tandem on two different inputs to compute comparable output vectors.



# Siamese Network: L1/L2 Distance and Classification

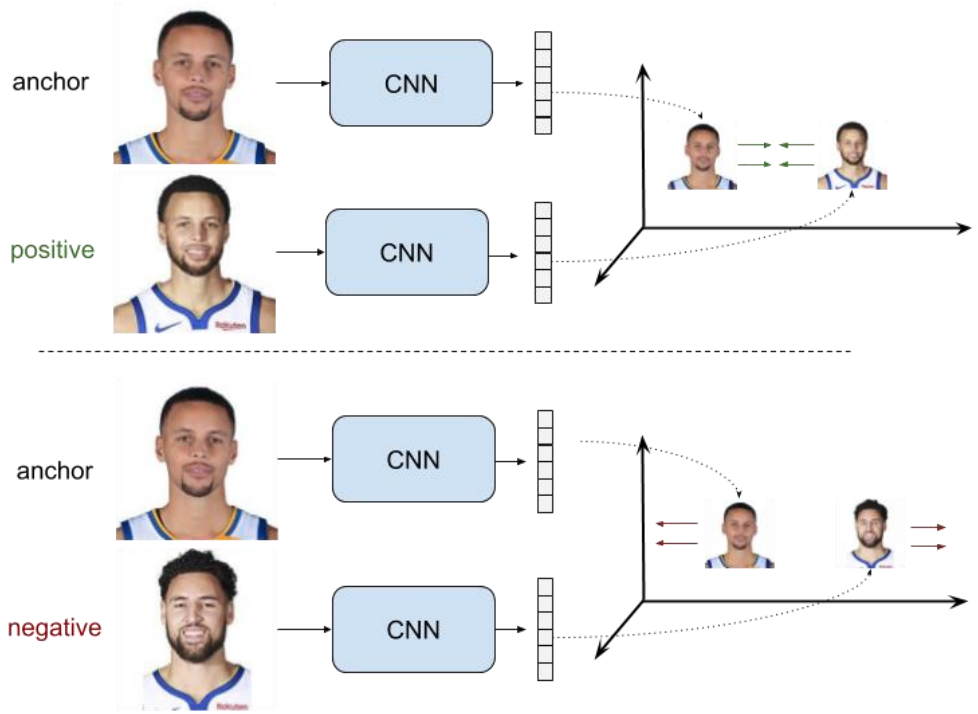
Calculate the distance between the feature vectors

Pass this distance vector to the classification layer

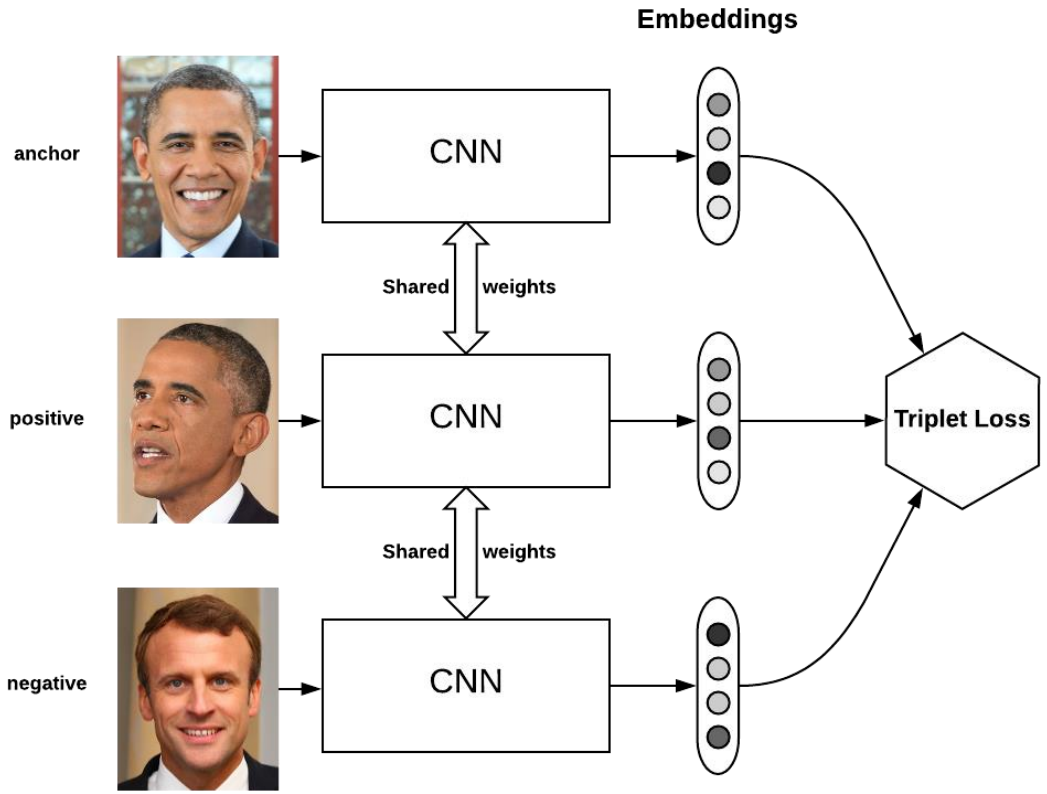


# Siamese Network: Custom Loss

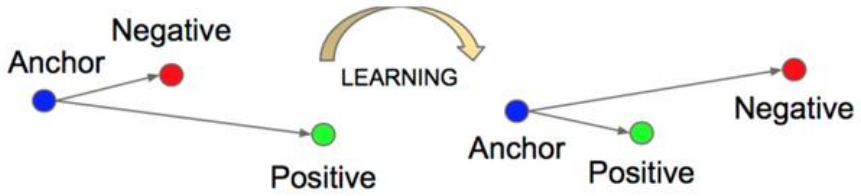
1. Contrastive Loss
2. **Triplet Loss**



# Siamese Network: Triplet Loss




$$\mathcal{L} = max(d(a,p) - d(a,n) + margin, 0)$$

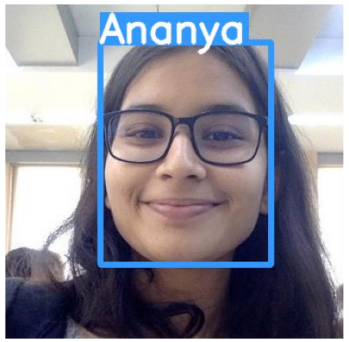


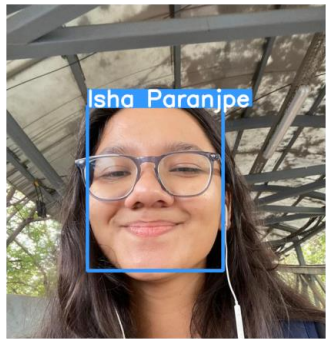
# Important Aspects of Face Recognition Systems

1. Fairness
2. Transparency
3. Accountability
4. Non-discrimination
5. Notice and Consent
6. Lawful Surveillance

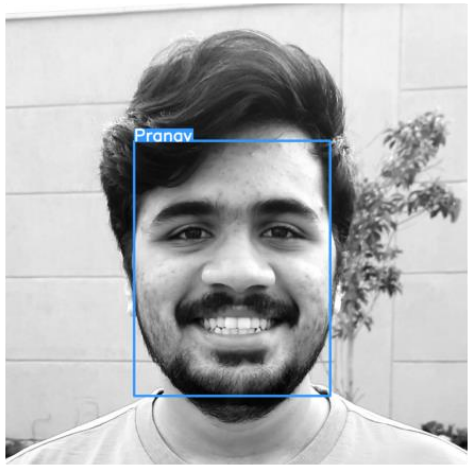
# Applications of Face recognition

1. Auto Tagging on social media platforms
2. Authentication via Face Verification
3. Missing Person Identification







# *Thank you*

For any queries drop an email at: quadeershaikh15.8@gmail.com