2D Face Recognition

Part – 3

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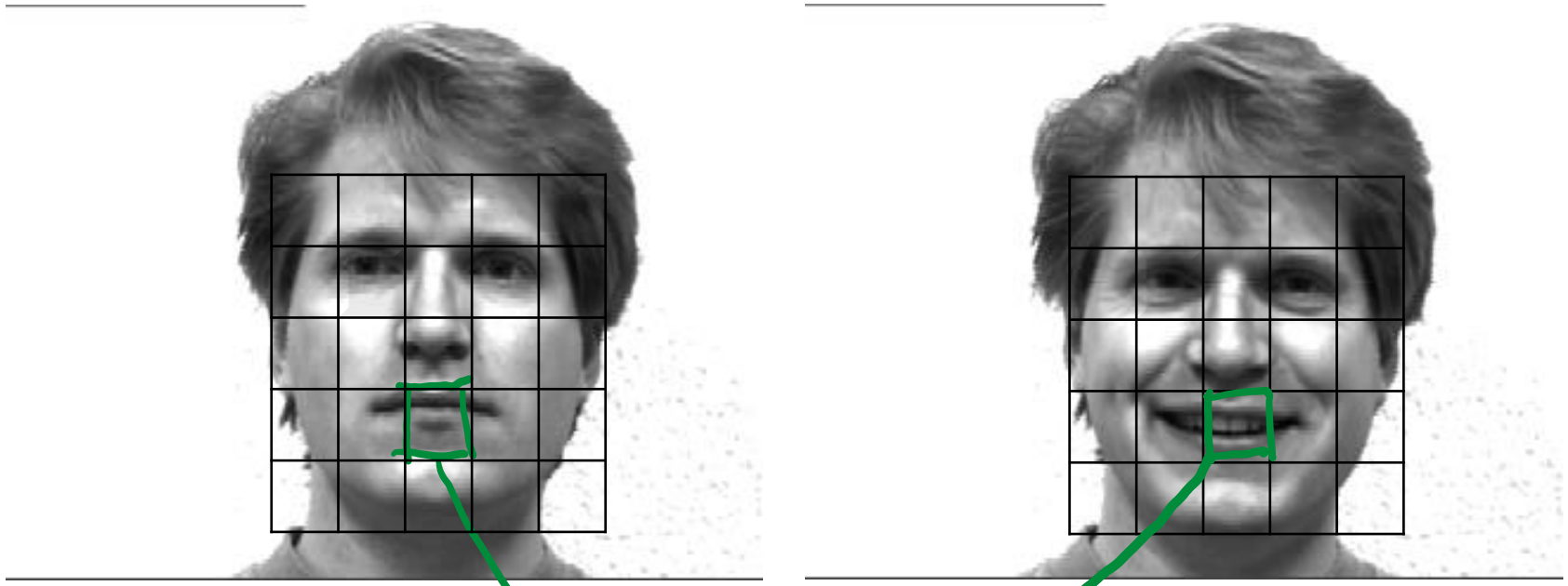
- Elastic Bunch Graph Matching Techniques (distortion invariant representation)



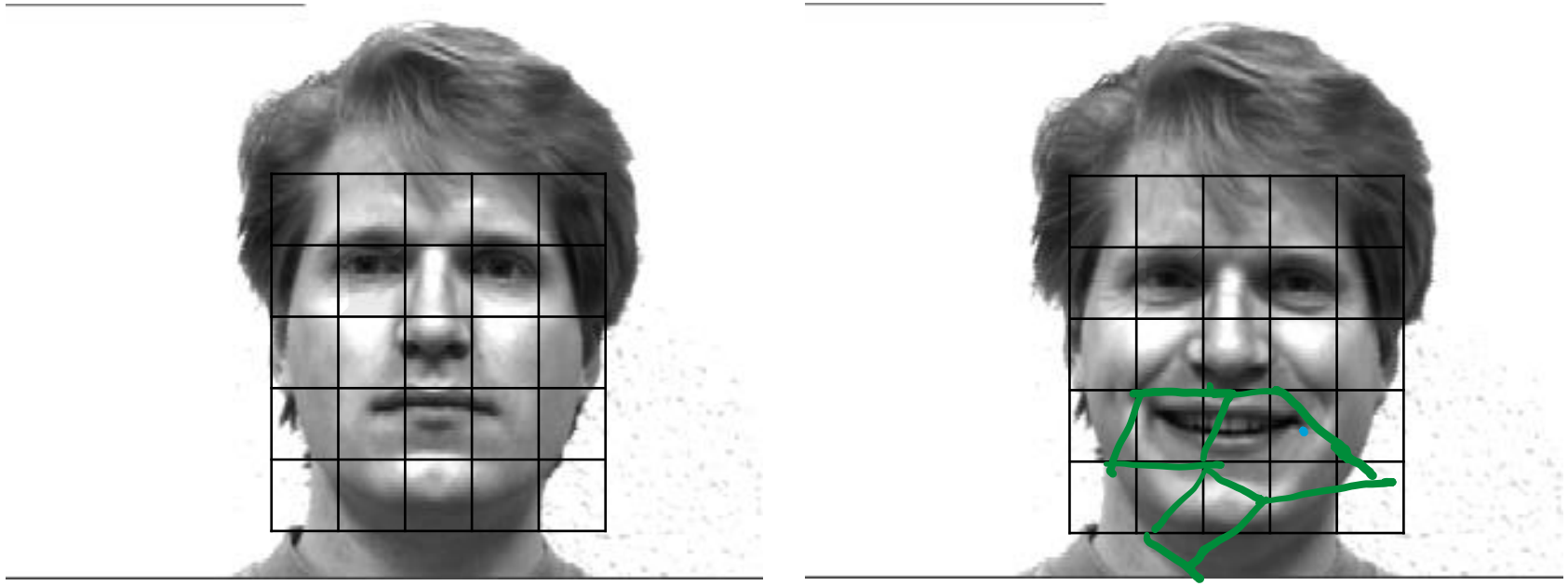
Grid of k nodes is superimposed on a face

And features are extracted from each grid

Will Features will be similar ??

Reference Image

Test Image



During Matching face, nodes are moved until features corresponding to new position matches with reference node features

Movement in the grid position

Procedure for Elastic Graph Matching

- Training stage
  - Grid with k nodes considered
  - Node position is indicated as x^l
  - At each node position, M feature values are extracted using 2D Gabor Filter bank

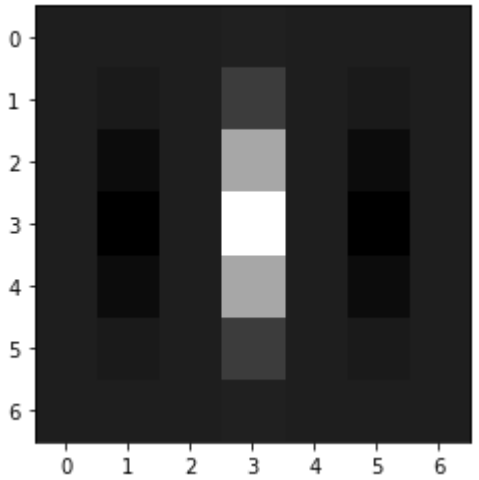
$$G_c[i,j] = Be^{-\frac{(i^2+j^2)}{2\sigma^2}} \cos(2\pi f(i\cos\theta + j\sin\theta))$$

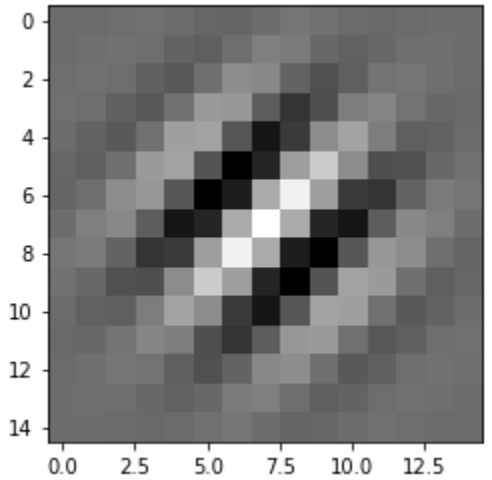
$$G_s[i,j] = Ce^{-\frac{(i^2+j^2)}{2\sigma^2}} \sin(2\pi f(i\cos\theta + j\sin\theta))$$

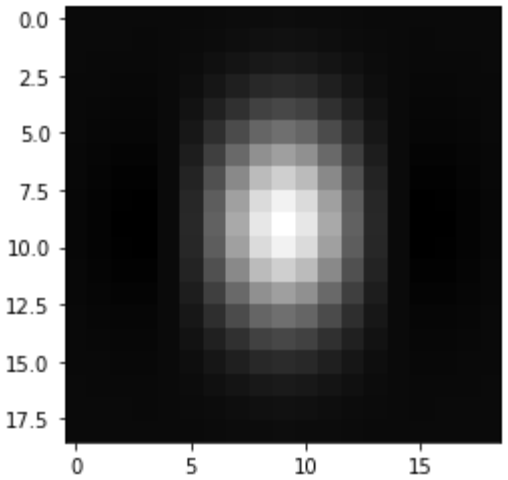
f *denotes frequency,* θ *denotes orientation,* σ *denotes the scale,* B *and* C *are normalizing factors*

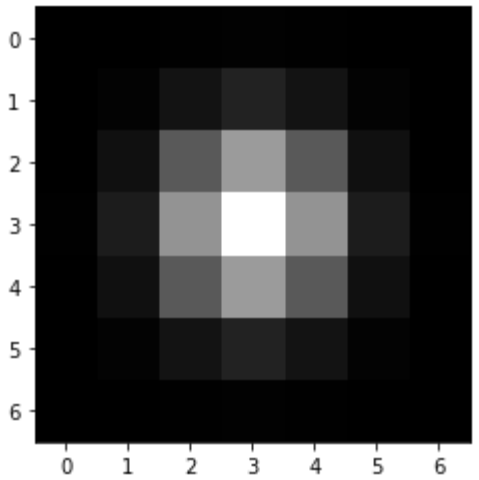
$$j(x^l) = [f_1(x^l), f_2(x^l) \cdots f_M(x^l)]$$

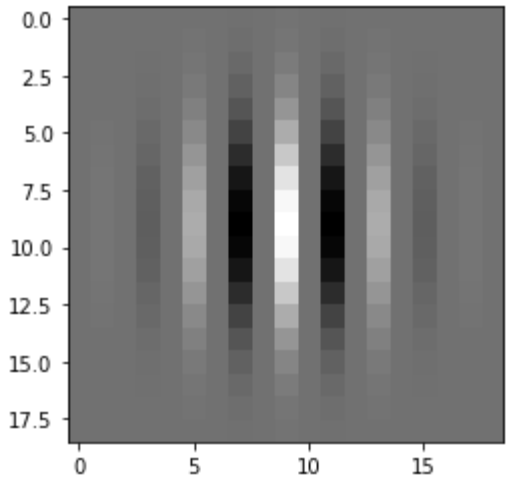
```
kernels = []
for theta in range(4):
    theta = theta / 4. * np.pi
    for sigma in (1, 3):
        for frequency in (0.05, 0.25):
            kernel = np.real(gabor_kernel(frequency, theta=theta,
                                          sigma_x=sigma, sigma_y=sigma))
            kernels.append(kernel)
```

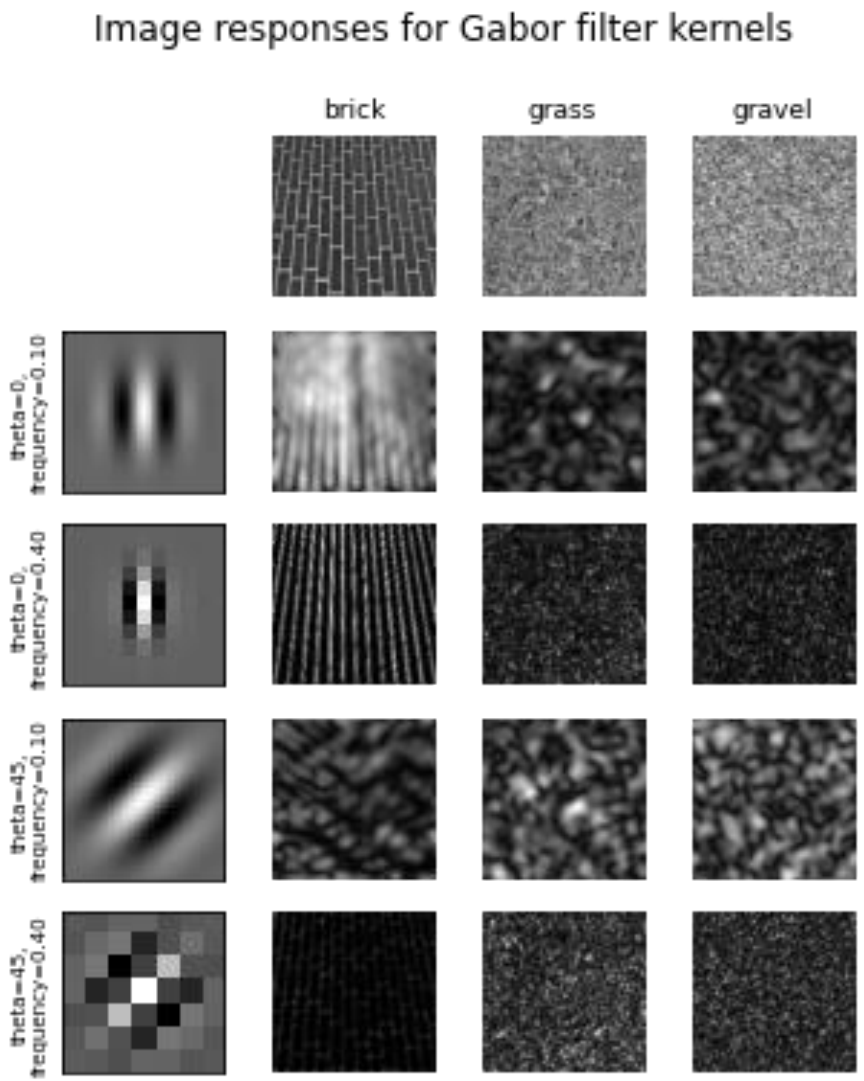












Reference: https://scikit-image.org/docs/dev/auto_examples/features_detection/plot_gabor.html

Procedure for Elastic Graph Matching

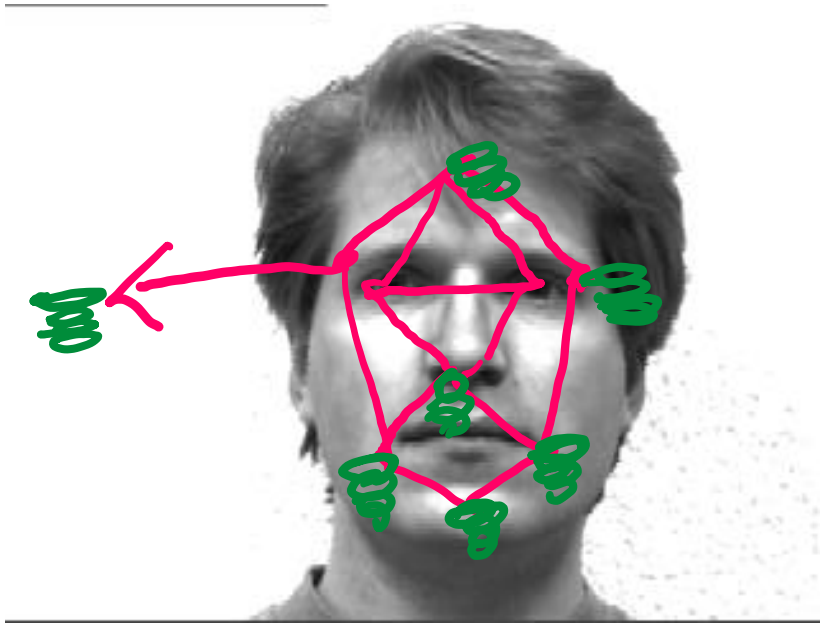
- Inference Stage (Test Image is presented)
  - Grid of k nodes are considered
  - Nodes are moved until the criterion reaches the minimum

$$C\left(x_t^l\right) = \sum_{l \in v} C_f\left(j\left(x_t^l\right), j\left(x_r^l\right)\right) + \lambda C_d\left(x_t^l, x_r^l\right)$$

  - $C_f\left(j\left(x_t^l\right), \left(x_r^l\right)\right) = \left\| j\left(x_t^l\right) - j\left(x_r^l\right) \right\|$ Euclidean distance between the feature vectors at x^l position
  - $C_d\left(x_t^l, x_r^l\right) = \sum_{\xi \in H(l)} \left(x_t^l - x_r^l\right) - \left(x_t^\xi - x_r^\xi\right)$ node movement with respect to the neighbouring nodes. λ will adjust grid deformation rigidity.

Elastic Bunch Graph Matching

- Node correspond to particular region in face. (eyes, nose and mouth)
- For each analyzed image , a Gabor feature is associated with each node.
  - Node -> bunch of feature vectors
  - Vectors may characterize open , closed eyes
- During inference stage, initial grid evolves through Elastic Graph Matching Technique Until the feature vector is close to those in the bunches of FBG (Face Bunch Graph)



Face Bunch Graph

Hybrid Face recognition Technique

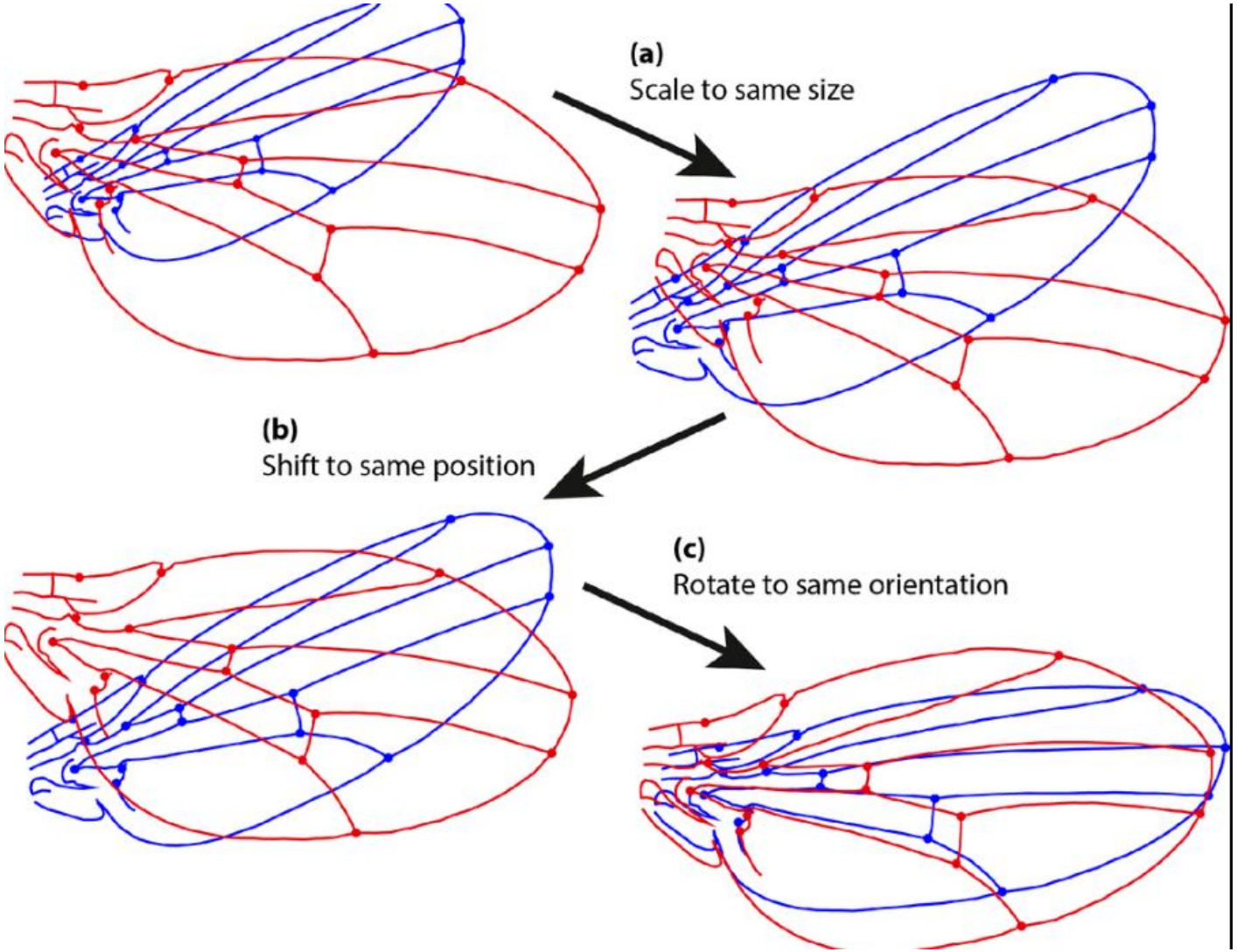
- Combination of Local and Global recognition approach
- Statistical shape model
  - Models a face image using set of coordinates that define the contour of a face
  - Using M face vectors corresponding to M face images, mean face shape is measured by aligning and averaging the shapes of considered face using **Procrustes method**

Procrustes Method

Translation

Rotation

Scale



Procrustes Method

1. Arbitrarily choose a reference shape (typically by selecting it among the available instances)
2. **Superimpose all instances to current reference shape(eliminating, translation, scale and rotation components)**
3. Compute the mean shape of the current set of superimposed shapes
4. If the Procrustes distance between mean and reference shape is above a threshold, set reference to mean shape and continue to step 2.

Active Shape Model

- Once all the images in the dataset are aligned, compact representation of the data points can be obtained using PCA

Each shape is represented by N points $x_i = \{x_{1i}x_{2i} \cdot x_{Ni}y_1{}_i y_{2i} \cdots y_{Ni}\}$

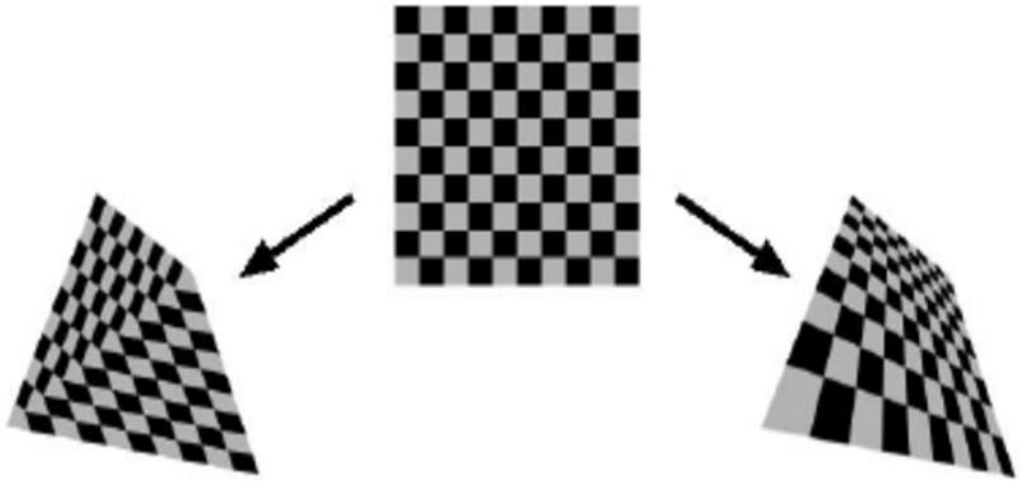
Reduced representation is

$$b_x = p^t(x_i - \bar{x})$$

Where p represents the set of eigen vectors

- In active shape model, alignment is carried out by iterative evolution of shape

  by varying parameters of b_x and parameters (x_t, y_t, θ, s)
- Active Shape Model uses only geometric information
- Statistical Texture model uses texture bounded by face shape and the alignment is carried out using piecewise affine warping



Factors that affect the performance of Face recognition systems and Potential Solutions

- Illumination
  - Lighting Variations
  - How to avoid? Obtain images in infrared domain
- Pose
  - Use of EBGM and Multiview systems can greatly solve the problem
- Occlusion
  - This problem is prevalent in video surveillance systems
- Facial Expression
  - Active shape and Texture Models
- Three dimensional Modelling
  - To characterize the depth information
- Spoofing
  - Fake fingerprints
  - Liveliness Detection (Texture Analysis , eye blinking detection)