DSE-312: Computer Vision

Assignment

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- **Department:** Data Science and Engineering

In [3]:
```
import numpy as np
import cv2
import matplotlib.pyplot as plt
import os
import pandas as pd
```

Session 1

Ans 1: Pseudocode of SIFT Descriptor

Following steps are involved in the SIFT algorithm:-

1. Scale-space peak selection: Potential location for finding features.
2. Keypoint Localization: Accurately locating the feature keypoints.
3. Orientation Assignment: Assigning orientation to keypoints.
4. Keypoint descriptor: Describing the keypoints as a high dimensional vector.
5. Keypoint Matching

Scale-Space peak Selction: for an image IMG,

- Produce Scale sapce of IMG by Convolution of Gaussian kernel(Blurring) at different scales with the input image.
- Scale-space is separated into octaves and the number of octaves and scale depends on the size of the original image.
- Within the Octave: for an image IMG:
```
* images are progressively blurred using the Gaussian Blur operator.
* Compute DoG of Each Image.
```
- Calculate Laplacian of Gaussian approximations.

KeyPoint Localization:

- For low contrast features, check their intensities.
- If the intensity at this extrema is less than a threshold value (0.03 as per the paper), it is rejected
- DoG has a higher response for edges, so edges should not be removed.
- From Hessiam matrix H
- Compute Principal Curvature Using Hessian Matrix.

Orientation Assignment: (to assign an orientation to each keypoint to make it rotation invariance)

- Take neighborhood around the keypoint location depending upon the scale
- Calculate Gradient magnitute and Direction in that neighborhood.
- Create orientation histogram with 36 bins covering 360 degress.
- Take highest peak in the histogram i.e above 80% and calculate the orientation(keypoints with same location and scale, but of different directions is created)

Keypoint descriptor:

- Take 16x16 window around the keypoint. Divide it into 16 sub_blocks of 4x4 size.
- For each sub_block, create 8 bin orientation histogram
- Rotate the image
- Subtract the keypoint Orientation from each orientation.
- Threshold the Number that are big to achieve the illumination independence.
- Normalize the feature Vector.

Keypoint Matching:

- Identify the nearest neighbors between two images and match them.
- For case:
  - if second closest match is very near to the first:
    - calculate ratio of closest-distance to second-closest distance
    - if ratio > 0.8:
      - reject the images

Uses of SIFT Descriptor:

- The SIFT descriptor with its associated matching methods can be used for establishing point matches between different views of a 3-D object or a scene.
- SIFT can robustly identify objects even among clutter and under partial occlusion, because the SIFT feature descriptor is invariant to uniform scaling, orientation, illumination changes, and partially invariant to affine distortion.

Applications of SIFT Descriptor:

1. Object recognition using SIFT features
2. Robot localization and mapping
3. Panorama stitching
4. 3D scene modeling, recognition and tracking
5. 3D SIFT-like descriptors for human action recognition
6. Analyzing the Human Brain in 3D Magnetic Resonance Images

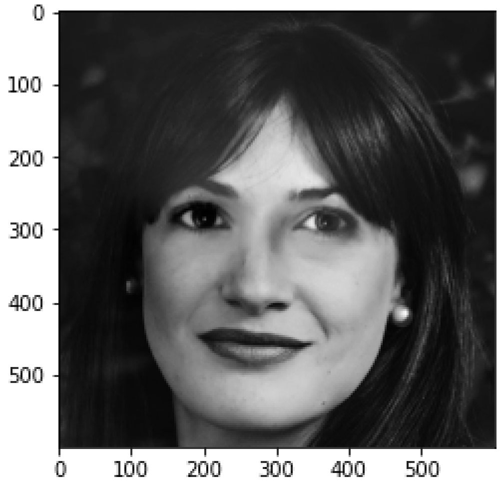
Ans 2: Viola-Jones Algorithm

In [2]:

```
# Loading the image
image = cv2.imread("archive\\real_and_fake_face\\training_fake\\easy_5_1100.jpg")
```

```python
# Converting image to grayscale
img = cv2.cvtColor(image,cv2.COLOR_RGB2GRAY)

# visualizing the image
plt.imshow(img, 'gray')
```

Out[2]: <matplotlib.image.AxesImage at 0x28cc6ddfac0>



In [3]:

```python
# Loading the required haar-cascade xml classifier file
face_cascade = cv2.CascadeClassifier('haarcascade_frontalface_alt.xml')

# Applying the face detection method on the grayscale image
detected_faces = face_cascade.detectMultiScale(img)
```

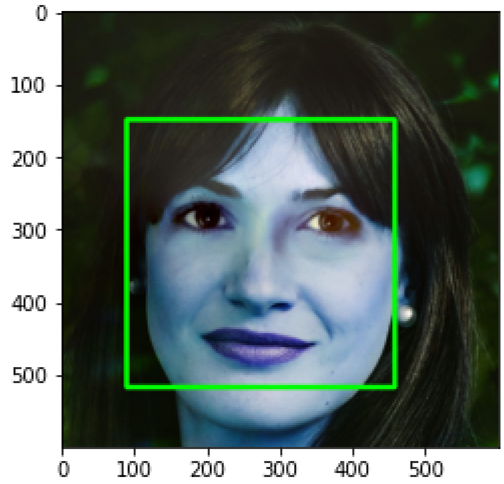
In [4]:

```python
# Iterating through rectangles of detected faces
for (column, row, width, height) in detected_faces:
    cv2.rectangle(image,
                  (column, row),
                  (column + width, row + height),
                  (0, 255, 0), 5)
```

In [5]:

```python
# Detection of the face
plt.imshow(image, 'gray')
```

Out[5]: <matplotlib.image.AxesImage at 0x28cce7bfbb0>



Steps of Viola-Jones Algorithm

• Scaling:

- Scale the detector (rather than the images)
- Features can easily be evaluated at any scale
- Scale by factors of 1.25

• Location:

- Move detector around the image (e.g., 1 pixel increments)

• Final Detections

- A real face may result in multiple nearby detections
- Post-process detected sub-windows to combine overlapping detections into a single detection

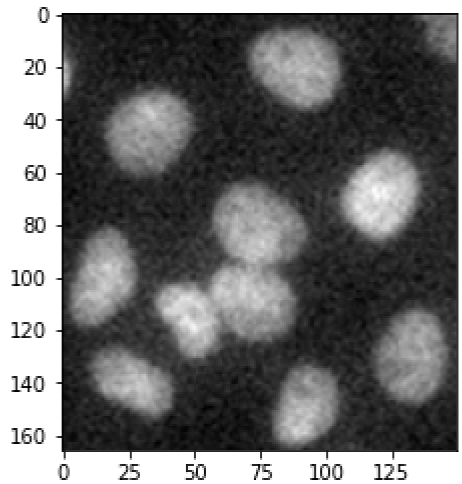
Ans 3: Separating Objects using Clustering

In [6]:

```
# Loading the image
original_image = cv2.imread("tounching_grayscale.png")

# Converting image to grayscale
img = cv2.cvtColor(original_image,cv2.COLOR_BGR2GRAY)

# visualizing the image
plt.imshow(img, 'gray')
```

Out[6]:

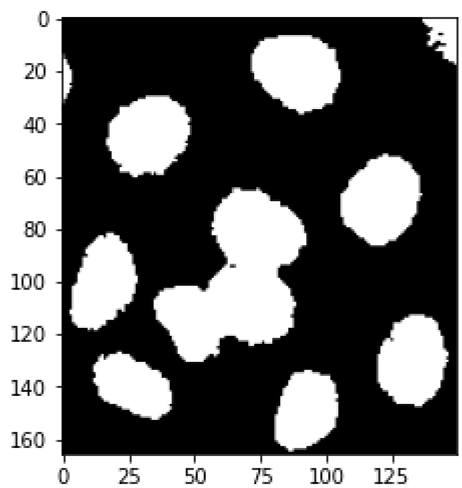
```
<matplotlib.image.AxesImage at 0x28cce915be0>
```



In [7]:

```
# convertig the image into binary image
ret, thresh = cv2.threshold(img,0,255, cv2.THRESH_BINARY + cv2.THRESH_OTSU)
plt.imshow(thresh, cmap = 'gray')
```

Out[7]: <matplotlib.image.AxesImage at 0x28cce987e20>



In [8]:

```
# noise removal using morphology
kernel = np.ones((3,3),np.uint8)
opening = cv2.morphologyEx(thresh,cv2.MORPH_OPEN, kernel, iterations = 2)
```

In [9]:

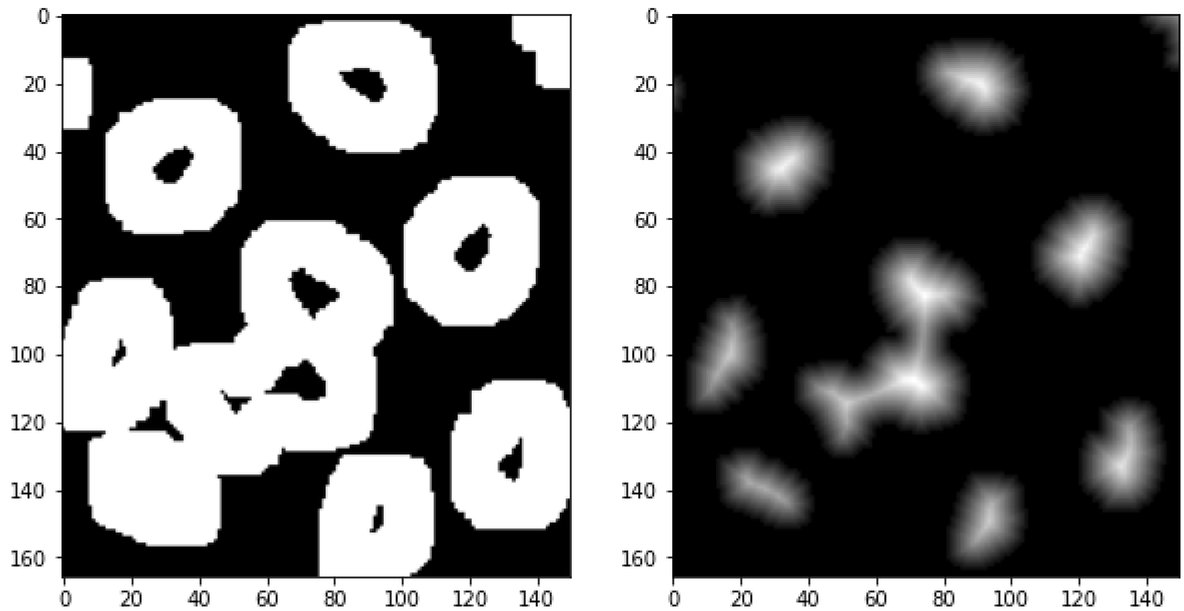
```
# sure background area
sure_bg = cv2.dilate(opening, kernel, iterations=5)

# Finding sure foreground area
dist_transform = cv2.distanceTransform(opening, cv2.DIST_L2, 5)
ret, sure_fg = cv2.threshold(dist_transform, 0.7*dist_transform.max(), 255, 0)

# Finding unknown region
sure_fg = np.uint8(sure_fg)
unknown = cv2.subtract(sure_bg, sure_fg)
```

In [10]:

```
plt.figure(figsize=(10, 10))
```

```python
# visualizing the unknown region
plt.subplot(121)
plt.imshow(unknown, cmap = 'gray')

# visualizing the transformed image
plt.subplot(122)
plt.imshow(dist_transform, cmap = 'gray')
```

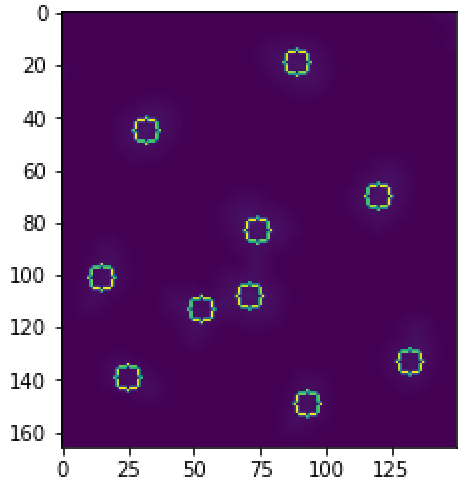
Out[10]: <matplotlib.image.AxesImage at 0x28ccea061f0>



In [11]:

```python
# forming separate clusters from the touching objects
from sklearn.cluster import KMeans
from skimage.feature import peak_local_max
local_max_location = peak_local_max(dist_transform, min_distance=1)
kmeans = KMeans(n_clusters=10)
kmeans.fit(local_max_location)
local_max_location = kmeans.cluster_centers_.copy()
local_max_location = local_max_location.astype(int)
local_max_location.shape
dist_transform_copy = dist_transform.copy()
for i in range(local_max_location.shape[0]):
    cv2.circle( dist_transform_copy, (local_max_location[i][1],local_max_location[i][0]

# visualizing the clusters
plt.imshow(dist_transform_copy)
```

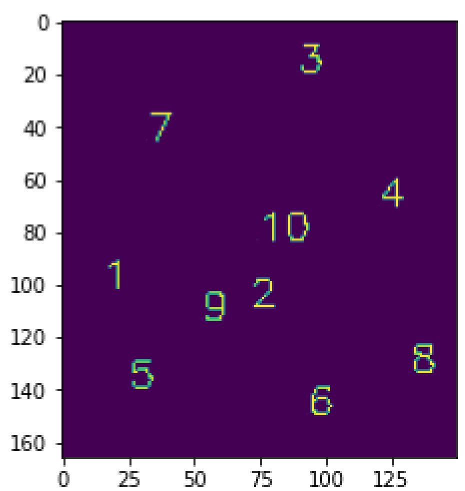
Out[11]: <matplotlib.image.AxesImage at 0x28ce1535af0>



In [12]:

```
# counting the number of clusters
markers = np.zeros_like(dist_transform)
labels = np.arange(kmeans.n_clusters)
markers[local_max_location[:,0],local_max_location[:,1]] = labels + 1
markers = markers.astype(int)
markers_copy = markers.copy()
index_non_zero_markers = np.argwhere(markers != 0)
markers_copy = markers_copy.astype(np.uint8)
index_non_zero_markers
font = cv2.FONT_HERSHEY_SIMPLEX
for i in range(index_non_zero_markers.shape[0]):
    string_text = str(markers[index_non_zero_markers[i][0] ,index_non_zero_markers[i][1
    cv2.putText( markers_copy, string_text, (index_non_zero_markers[i][1], index_non_ze
plt.imshow(markers_copy)
```

Out[12]: <matplotlib.image.AxesImage at 0x28ce15b6250>



The touching objects are separated and there are 10 clusters obtained.

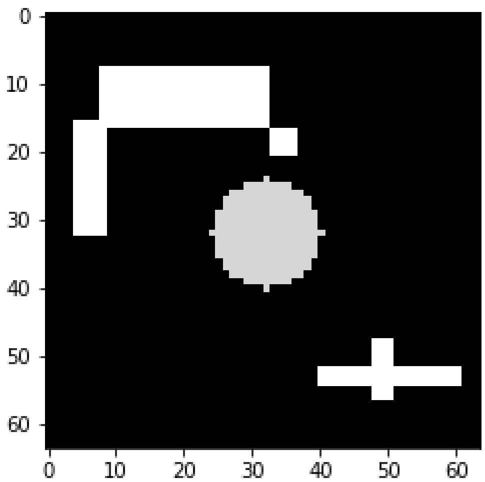
Ans 4: Eccentricity and Bounding Box

In [13]:

```
# Loading the image
original_image = cv2.imread("shapes.png")

# making the copy of the original image
```

```
image = original_image.copy()

# Converting image to grayscale
img = cv2.cvtColor(original_image,cv2.COLOR_BGR2GRAY)

# visualizing the image
plt.imshow(img, 'gray')
```

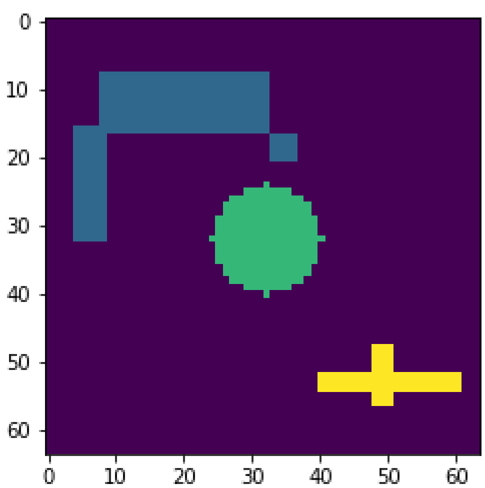
Out[13]: <matplotlib.image.AxesImage at 0x28ce161d760>



In [14]:

```
# marking the regions in the given image
from skimage.measure import label, regionprops, regionprops_table
label_im = label(img)
regions = regionprops(label_im)
plt.imshow(label_im)
```

Out[14]: <matplotlib.image.AxesImage at 0x28cc6f01b80>



In [15]:

```
# obtaining the values of eccentricity and bounding box of each shape
pd.DataFrame(regionprops_table(label_im, img, properties = ['eccentricity', 'bbox']))
```

Out[15]:

	eccentricity	bbox-0	bbox-1	bbox-2	bbox-3
0	0.866945	8	4	33	37

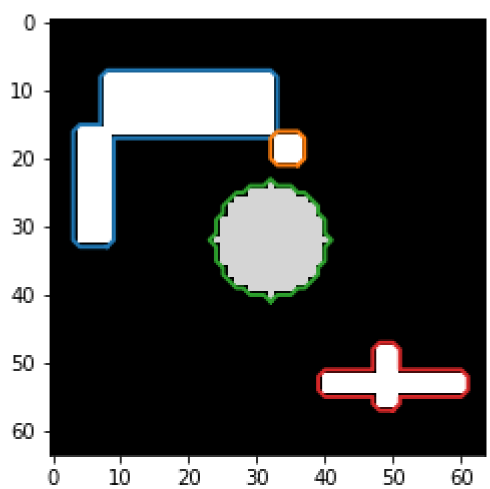
	eccentricity	bbox-0	bbox-1	bbox-2	bbox-3
1	0.000000	24	24	41	41
2	0.948645	48	40	57	61

In [16]:

```
from skimage.measure import find_contours
from skimage.io import imread
import matplotlib.pyplot as plt
from skimage.color import rgb2gray
```

In [17]:

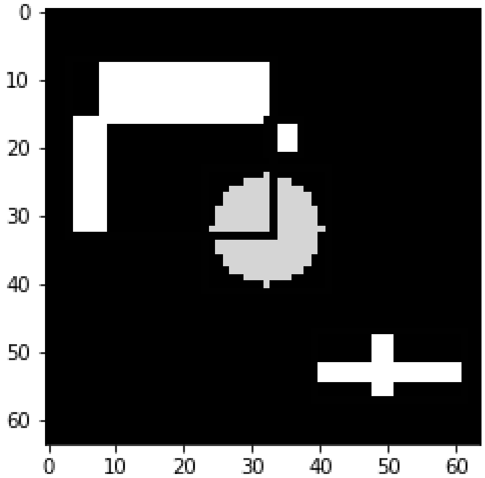
```
# visualizing the countours
contours = find_contours(img, 0.8)

fig, ax = plt.subplots()
ax.imshow(img, interpolation='nearest', cmap=plt.cm.gray)

for n, contour in enumerate(contours):
    ax.plot(contours[n][:, 1], contours[n][:, 0], linewidth=2)

plt.show()
```



In [18]:

```
from skimage.draw import polygon_perimeter

bounding_boxes = []

for contour in contours:
    Xmin = np.min(contour[:,0])
    Xmax = np.max(contour[:,0])
    Ymin = np.min(contour[:,1])
    Ymax = np.max(contour[:,1])

    bounding_boxes.append([Xmin, Xmax, Ymin, Ymax])


with_boxes  = np.copy(img)

for box in bounding_boxes:

    r = [box[0],box[1],box[1],box[0], box[0]]
```

```
    c = [box[3],box[3],box[2],box[2], box[3]]
    rr, cc = polygon_perimeter(r, c, with_boxes.shape)
    with_boxes[rr, cc] = 1                                   #set color white

plt.imshow(with_boxes, interpolation='nearest', cmap=plt.cm.gray)
plt.show()
```

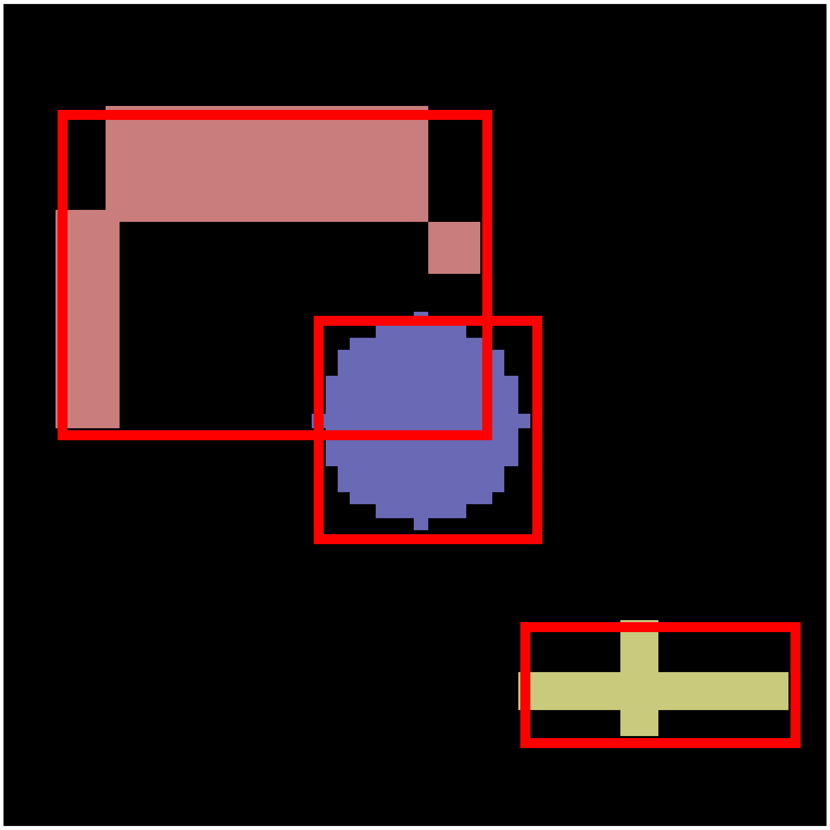


In [19]:

```
import matplotlib.patches as mpatches
from skimage.filters import threshold_otsu
from skimage.segmentation import clear_border
from skimage.measure import label, regionprops
from skimage.morphology import closing, square
from skimage.color import label2rgb
```

In [20]:

```
# label image regions
label_image = label(img)

# to make the background transparent, pass the value of `bg_label` and leave `bg_color`
image_label_overlay = label2rgb(label_image, image=img, bg_label=0)

fig, ax = plt.subplots(figsize=(10, 6))
ax.imshow(image_label_overlay)

for region in regionprops(label_image):
    # take regions with large enough areas
    if region.area >= 50:
        # draw rectangle around segmented coins
        minr, minc, maxr, maxc = region.bbox
        rect = mpatches.Rectangle((minc, minr), maxc - minc, maxr - minr,
                                  fill=False, edgecolor='red', linewidth=5)
        ax.add_patch(rect)

ax.set_axis_off()
plt.tight_layout()
plt.show()
```



Bounding Box around every object is shown in the above image.

Ans 5: Local Feature Matching

Process of Harris Corner Detection Algorithm

1. Take the grayscale of the original image
2. Apply a Gaussian filter to smooth out any noise
3. Apply Sobel operator to find the x and y gradient values for every pixel in the grayscale image
4. For each pixel p in the grayscale image, consider a 3×3 window around it and compute the corner strength function. Call this its Harris value.
5. Find all pixels that exceed a certain threshold and are the local maxima within a certain window (to prevent redundant dupes of features)
6. For each pixel that meets the criteria in 5, compute a feature descriptor.

Process of ORB Descriptor

1. Run each test against all training patches.
2. Order the tests by their distance from a mean of 0.5, forming the vector T.
3. Greedy search:
   - Put the first test into the result vector R and remove it from T.
   - Take the next test from T, and compare it against all tests in R. If its absolute correlation is greater than a threshold, discard it; else add it to R.
   - Repeat the previous step until there are 256 tests in R. If there are fewer than 256, raise the threshold and try again

In [124…

```
# Loading the two different views of Monument image
image_view1 = cv2.imread('Monument_View1.jpg')
image_view2 = cv2.imread('Monument_View2.jpg')

# Converting the images into grayscale images
gray_1 = cv2.cvtColor(image_view1, cv2.COLOR_BGR2GRAY)
gray_1 = np.float32(gray_1)
gray_2 = cv2.cvtColor(image_view2, cv2.COLOR_BGR2GRAY)
gray_2 = np.float32(gray_2)
```

In [125…

```
# Harris Corner Detection Method
corner_1 = cv2.cornerHarris(gray_1, 2, 5, 0.07)

# Result is dilated for marking the corners
corner_1 = cv2.dilate(corner_1, None)

har_view1 = cv2.imread('Monument_View1.jpg')
# Threshold for an optimal value
har_view1[corner_1 > 0.01 * corner_1.max()] = [0, 0, 255]
```

In [126…

```
gray_1 = gray_1.astype(np.uint8)

# Initiate ORB detector
orb = cv2.ORB_create()

# finding the keypoints and descriptors with ORB
keypoints_orb_1, descriptors_1 = orb.detectAndCompute(gray_1, None)
orb_view1 = cv2.drawKeypoints(gray_1, keypoints_orb_1, None)
```

In [131…

```
# Visualization of 1st view of monument image
plt.figure(figsize = (50, 50))

# Plotting the original image
plt.subplot(1,3,1)
plt.imshow(image_view1)
plt.title('Original image', fontsize = 50)

# Plotting the Harris Corner detected image
plt.subplot(1,3,2)
plt.imshow(har_view1)
plt.title('Harris Corner detection', fontsize = 50)

# Plotting the ORB descriptor
plt.subplot(1,3,3)
plt.imshow(orb_view1)
plt.title('ORB descriptor', fontsize = 50)
plt.show()
```

In [128…

```
# Harris Corner Detection Method
corner_2 = cv2.cornerHarris(gray_2, 2, 5, 0.07)

# Result is dilated for marking the corners
corner_2 = cv2.dilate(corner_2, None)

har_view2 = cv2.imread('Monument_View2.jpg')
# Threshold for an optimal value
har_view2[corner_2 > 0.01 * corner_2.max()]=[0, 0, 255]
```

In [129…

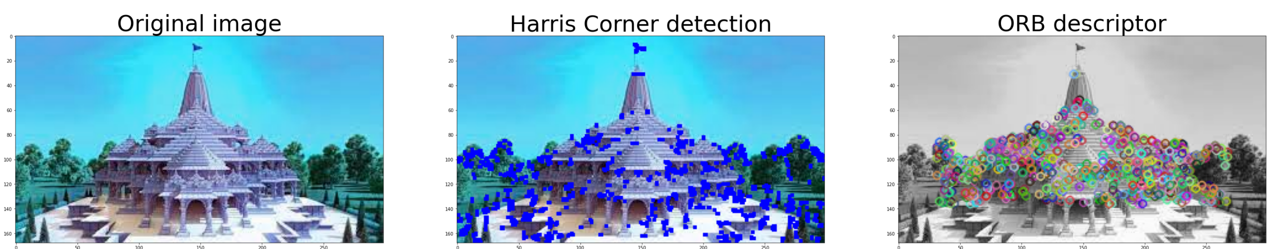
```
gray_2 = gray_2.astype(np.uint8)

# Initiate ORB detector
orb = cv2.ORB_create(nfeatures=1500)

# find the keypoints and descriptors with ORB
keypoints_orb_2, descriptors_2 = orb.detectAndCompute(gray_2, None)
orb_view2 = cv2.drawKeypoints(gray_2, keypoints_orb_2, None)
```

In [132…

```
# Visualization of 2nd view of monument image
plt.figure(figsize = (50, 50))

# Plotting the original image
plt.subplot(1,3,1)
plt.imshow(image_view2)
plt.title('Original image', fontsize = 50)

# Plotting the Harris Corner detected image
plt.subplot(1,3,2)
plt.imshow(har_view2)
plt.title('Harris Corner detection', fontsize = 50)

# Plotting the ORB descriptor
plt.subplot(1,3,3)
plt.imshow(orb_view2)
plt.title('ORB descriptor', fontsize = 50)
```

Out[132…

```
Text(0.5, 1.0, 'ORB descriptor')
```



In [133…

```
desc1 = np.float32(descriptors_1)
desc2 = np.float32(descriptors_2)
```

In [134…

```
# Implementing FLANN feature matching
FLANN_INDEX_KDTREE = 0
index_params = dict(algorithm = FLANN_INDEX_KDTREE, trees = 5)
search_params = dict(checks = 50)
flann = cv2.FlannBasedMatcher(index_params, search_params)
matches = flann.knnMatch(desc1, desc2, k=2)
```

In [135…

```
good = []
for m, n in matches:
    if m.distance < 2*n.distance:
        good.append(m)
```

In [136…

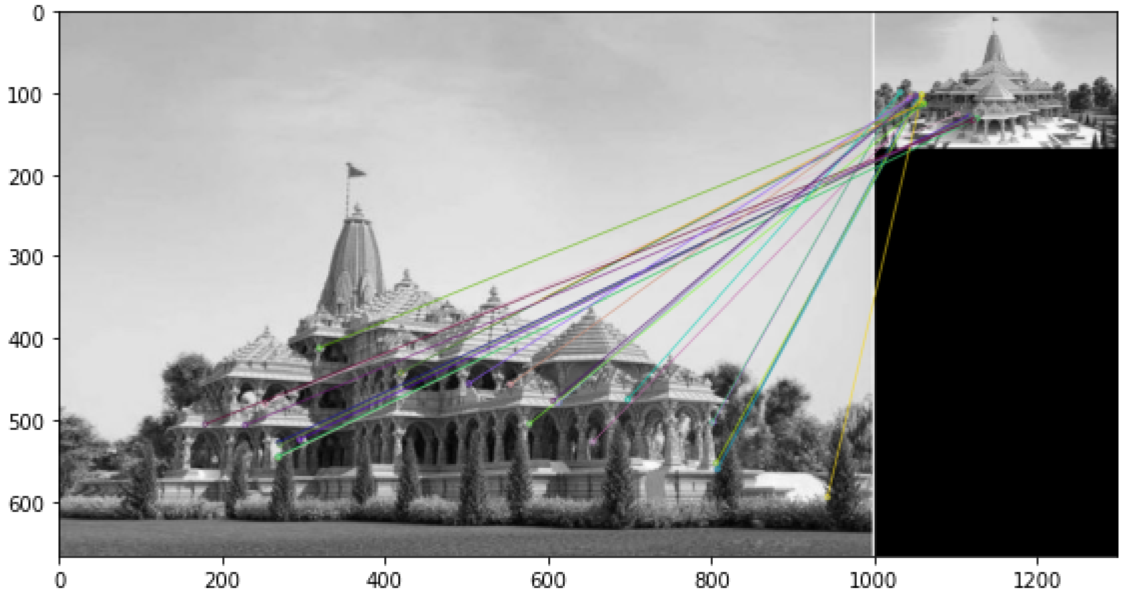
```
from skimage.measure import ransac, LineModelND
from skimage.transform import ProjectiveTransform, AffineTransform

# Choosing the source and destination points
src_pts = np.float32([keypoints_orb_1[m.queryIdx].pt for m in good ]).reshape(-1, 2)
dst_pts = np.float32([keypoints_orb_2[m.trainIdx].pt for m in good ]).reshape(-1, 2)

# Applying Ransac Algorithm
model, inliers = ransac(
            (src_pts, dst_pts),
            AffineTransform, min_samples=5,
            residual_threshold=8, max_trials=10000
        )

n_inliers = np.sum(inliers)

# Computing the homography on both images using chosen set of points
inlier_keypoints_left = [cv2.KeyPoint(point[0], point[1], 1) for point in src_pts[inlie
inlier_keypoints_right = [cv2.KeyPoint(point[0], point[1], 1) for point in dst_pts[inli
placeholder_matches = [cv2.DMatch(idx, idx, 1) for idx in range(n_inliers)]
image3 = cv2.drawMatches(gray_1, inlier_keypoints_left, gray_2, inlier_keypoints_right,
```

In [137…

```
# Visualization of the resulting image after applying homography
plt.figure(figsize = (20,5))
plt.imshow(image3)
```

Out[137…

```
<matplotlib.image.AxesImage at 0x28ce3308100>
```



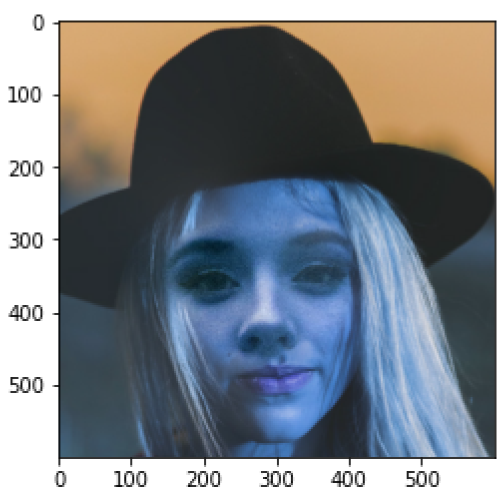
Observation regarding keypoint descriptors:-

- All repetitive structures have the same keypont descriptors and they uniquely identify that area.
- These are usually scale and rotation invariant.
- As these are scale and rotation invariant, keypoint descriptors are useful in finding similarities between to images, stitching two images having a common segment (e.g. making panorma)

Ans 6: Binary Classification (Face vs Non-Face)

In [29]:
```
# Loading and visualizing an image from the real and fake face images
image = cv2.imread("archive\\real_and_fake_face\\training_fake\\easy_12_1110.jpg")
plt.imshow(image)
print(image.shape)
```

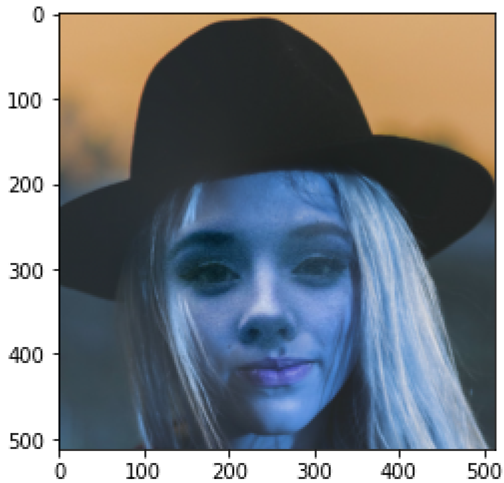
```
(600, 600, 3)
```



In [148…
```
from skimage.transform import resize
from skimage.feature import hog
from skimage import exposure
```

In [35]:
```
# applying HoG descriptor over the image
resized_img = resize(image, (512,512))
plt.imshow(resized_img)
print(resized_img.shape)
fd, hog_image = hog(resized_img, orientations=9, pixels_per_cell=(32, 32),
                cells_per_block=(2, 2), visualize=True, multichannel=True)
```

```
(512, 512, 3)
C:\Users\SHRADDHA\AppData\Local\Temp/ipykernel_46572/328160552.py:4: FutureWarning: `mul
tichannel` is a deprecated argument name for `hog`. It will be removed in version 1.0. P
lease use `channel_axis` instead.
  fd, hog_image = hog(resized_img, orientations=9, pixels_per_cell=(32, 32),
```



In [36]:
```
import os
list_of_training_images_fake = os.listdir("archive\\real_and_fake_face\\training_fake\\
len(list_of_training_images_fake)
```

Out[36]: 960

In [37]:
```
# Applying HoG transform and extracting the features of the training fake images
df_fake = pd.DataFrame()
j = 0
for i in list_of_training_images_fake:
    img = imread("archive\\real_and_fake_face\\training_fake\\"+i)
    resized_img = resize(img, (512,512))
    fd_fake, hog_image = hog(resized_img, orientations=9, pixels_per_cell=(32, 32),
                    cells_per_block=(2, 2), visualize=True, multichannel=True)
    j = j+1
    print(fd_fake, len(fd_fake), " ", j)
    fds_fake = pd.Series(fd_fake)
    df_fake = df_fake.append(fds_fake,ignore_index=True)
```

```
C:\Users\SHRADDHA\AppData\Local\Temp/ipykernel_46572/526714694.py:6: FutureWarning: `mul
tichannel` is a deprecated argument name for `hog`. It will be removed in version 1.0. P
lease use `channel_axis` instead.
  fd_fake, hog_image = hog(resized_img, orientations=9, pixels_per_cell=(32, 32),
[0.2306518  0.14188074 0.0763801  ... 0.07210345 0.09160626 0.16128694] 8100   1
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```

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In [38]:

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# preparing the fake images dataset
df_fake
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Out[38]:

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1	0.206942	0.005988	0.000000	0.001524	0.016285	0.012087	0.084780	0.271736	0.351903	0.282223
2	0.220921	0.135979	0.089265	0.107344	0.192139	0.140808	0.149828	0.152157	0.201345	0.126733
3	0.117852	0.088537	0.139416	0.132211	0.192544	0.049583	0.041581	0.029319	0.059215	0.153898
4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.172559
...	...	...	...	...	...	...	...	...	...	...
955	0.197414	0.159516	0.169568	0.166451	0.197653	0.164442	0.160833	0.161003	0.159776	0.183949
956	0.180262	0.229648	0.229648	0.229648	0.196851	0.080102	0.069893	0.097163	0.116690	0.229648
957	0.201763	0.153613	0.175227	0.169771	0.171106	0.185646	0.160898	0.115232	0.148196	0.178840
958	0.218632	0.161152	0.124531	0.125373	0.176472	0.131256	0.217847	0.218632	0.218632	0.190126
959	0.190492	0.153349	0.150419	0.191998	0.206232	0.162154	0.206232	0.166520	0.130216	0.206232

960 rows × 8100 columns

In [39]:

```
list_of_training_images_real = os.listdir("archive\\real_and_fake_face\\training_real\\
len(list_of_training_images_real)
```

Out[39]:

```
1081
```

In [40]:

```
# Applying HoG transform and extracting the features of the training real images
df_real = pd.DataFrame()
j = 0
for i in list_of_training_images_real:
    img = imread("archive\\real_and_fake_face\\training_real\\"+i)
    resized_img = resize(img, (512,512))
    fd_real, hog_image = hog(resized_img, orientations=9, pixels_per_cell=(32, 32),
                    cells_per_block=(2, 2), visualize=True, multichannel=True)
    j = j+1
    print(fd_real, len(fd_real), " ", j)
```

```
    fds_real = pd.Series(fd_real)
    df_real = df_real.append(fds_real,ignore_index=True)
```

```
C:\Users\SHRADDHA\AppData\Local\Temp/ipykernel_46572/3927942607.py:6: FutureWarning: `mu
ltichannel` is a deprecated argument name for `hog`. It will be removed in version 1.0.
Please use `channel_axis` instead.
  fd_real, hog_image = hog(resized_img, orientations=9, pixels_per_cell=(32, 32),
[0.18636688 0.2852772  0.2852772  ... 0.19410722 0.14874346 0.13728834] 8100   1
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[0.03163535 0.04691583 0.31072882 ... 0.08747685 0.20456808 0.26169303] 8100   948
[0.06734069 0.03438511 0.04421735 ... 0.11142878 0.10710726 0.08297245] 8100   949
[0.12416113 0.08236629 0.0727275  ... 0.14294093 0.10642001 0.08819211] 8100   950
[0.18572871 0.14875622 0.14627054 ... 0.36473384 0.3535862  0.04310164] 8100   951
[0.1072671  0.05588977 0.06390689 ... 0.02000685 0.01996309 0.0169106 ] 8100   952
[0.34180999 0.40537792 0.40537792 ... 0.0694709  0.08027023 0.0970774 ] 8100   953
[0.17673914 0.22647349 0.23298992 ... 0.09687324 0.11854956 0.13219548] 8100   954
[0.16759323 0.14692511 0.16289057 ... 0.06772289 0.30812639 0.30812639] 8100   955
[0.24251398 0.24251398 0.18422931 ... 0.16757743 0.19233025 0.12461902] 8100   956
[0.01072828 0.00491436 0.00335532 ... 0.0408079  0.17079656 0.32947605] 8100   957
[0.13643855 0.11840593 0.08641492 ... 0.23561503 0.23561503 0.18893895] 8100   958
[0.2013649  0.15346111 0.11075189 ... 0.14222958 0.16812678 0.16745677] 8100   959
[0.21033255 0.21033255 0.21033255 ... 0.21372713 0.13665434 0.10171559] 8100   960
[0.19148198 0.04135125 0.03031482 ... 0.23889743 0.20237839 0.15879013] 8100   961
[0.16037617 0.14600459 0.21779935 ... 0.         0.         0.        ] 8100   962
[0.25546448 0.10781255 0.0861545  ... 0.06131639 0.03946726 0.04609427] 8100   963
[0.20648642 0.16657763 0.14542882 ... 0.24285948 0.20134834 0.1530562 ] 8100   964
[0.19751788 0.14315151 0.15610462 ... 0.11508716 0.14690233 0.1867265 ] 8100   965
[0.01634823 0.01783516 0.08453873 ... 0.08862556 0.14426467 0.26200782] 8100   966
[0.39746282 0.02192558 0.00726158 ... 0.14503107 0.29920034 0.29920034] 8100   967
[0.02223486 0.02839077 0.12314581 ... 0.05104374 0.07057162 0.11244891] 8100   968
[0.20841973 0.2817846  0.2817846  ... 0.17718745 0.09716127 0.06712894] 8100   969
[0.21250102 0.19977349 0.21250102 ... 0.11133249 0.07293999 0.09953375] 8100   970
[0.07855862 0.08336178 0.18612797 ... 0.04596136 0.06161507 0.1127415 ] 8100   971
[0.15227436 0.15118456 0.21696096 ... 0.03106121 0.08009967 0.23580579] 8100   972
[0.02876266 0.03139921 0.05957552 ... 0.1135988  0.0873968  0.1452663 ] 8100   973
[0.20564266 0.20564266 0.16752785 ... 0.11271393 0.06267405 0.230028  ] 8100   974
[0.27752622 0.09925767 0.13451085 ... 0.11116053 0.20599394 0.23764669] 8100   975
[0.28127179 0.13248982 0.12373109 ... 0.13279506 0.17535581 0.22894835] 8100   976
[0.19447231 0.14339218 0.14946813 ... 0.14456331 0.09675518 0.0791114 ] 8100   977
[0.18100914 0.08520197 0.10808276 ... 0.16489731 0.27696175 0.27696175] 8100   978
[0.16431286 0.05955457 0.09191398 ... 0.06787244 0.07179465 0.11265492] 8100   979
[0.24560721 0.13817645 0.10380096 ... 0.20845758 0.20845758 0.19079635] 8100   980
[0.26282853 0.26282853 0.26282853 ... 0.08415144 0.34560732 0.34560732] 8100   981
[0.10758515 0.1069529  0.16015329 ... 0.11924079 0.10981519 0.0859195 ] 8100   982
[0.08421333 0.16574526 0.15238422 ... 0.05917557 0.24087744 0.35746956] 8100   983
[0.24461406 0.15834394 0.09539859 ... 0.07872485 0.19365446 0.1965943 ] 8100   984
[0.20005875 0.06846159 0.04778332 ... 0.25249454 0.25249454 0.16139915] 8100   985
[0.26743058 0.26743058 0.19614688 ... 0.03330575 0.02925525 0.02599618] 8100   986
[0.35487361 0.16807044 0.05485809 ... 0.1324473  0.28373612 0.28373612] 8100   987
[0.20388408 0.19766671 0.15032118 ... 0.00581399 0.00536333 0.0108631 ] 8100   988
[0.12405358 0.07017354 0.08838369 ... 0.17807809 0.24728611 0.24728611] 8100   989
[0.02671785 0.01580615 0.01869165 ... 0.05193891 0.1397412  0.23776173] 8100   990
[0.20253234 0.15749751 0.18093873 ... 0.10445794 0.27929866 0.27929866] 8100   991
[0.20593339 0.19186051 0.12947155 ... 0.05881123 0.26787336 0.32815022] 8100   992
[0.20243343 0.20243343 0.17170995 ... 0.15669006 0.15813266 0.15812674] 8100   993
[0.22135211 0.22135211 0.22135211 ... 0.06197543 0.12963857 0.21396233] 8100   994
[0.28246318 0.08457733 0.02991058 ... 0.28518823 0.28518823 0.11019476] 8100   995
[0.10154243 0.08219657 0.18738649 ... 0.01988022 0.01808612 0.02899918] 8100   996
[0.19560078 0.13850629 0.14769981 ... 0.16283348 0.12880689 0.10300389] 8100   997
[0.20865543 0.04388676 0.02222072 ... 0.14158909 0.10282107 0.07177572] 8100   998
[0.15402413 0.14299724 0.15823596 ... 0.13769435 0.15961281 0.15373656] 8100   999
```

```
[0.20621178 0.17191598 0.13643081 ... 0.24781774 0.09949473 0.03670218] 8100   1000
[0.11490042 0.09221791 0.13382239 ... 0.21125634 0.16775698 0.15091352] 8100   1001
[0.20813127 0.21722905 0.21330646 ... 0.25772631 0.2918847  0.27949682] 8100   1002
[0.22685545 0.22685545 0.14163054 ... 0.06855677 0.07599932 0.06610517] 8100   1003
[0.16176073 0.1332586  0.09276021 ... 0.07341699 0.16517644 0.31904797] 8100   1004
[0.         0.         0.         ... 0.27749632 0.27749632 0.23572136] 8100   1005
[0.19908064 0.1235511  0.16482645 ... 0.14309724 0.08875537 0.15266208] 8100   1006
[0.12972757 0.08646159 0.10889272 ... 0.25160279 0.24463429 0.23900707] 8100   1007
[0.17240963 0.20653568 0.18048045 ... 0.13413748 0.11357517 0.13616833] 8100   1008
[0.10391113 0.05355779 0.07038041 ... 0.09518525 0.02101529 0.0192133 ] 8100   1009
[0.18529568 0.21171176 0.18955333 ... 0.19386158 0.13718654 0.08330556] 8100   1010
[0.05588183 0.04861345 0.07059374 ... 0.07143996 0.09570938 0.10934251] 8100   1011
[0.26516883 0.3058375  0.3058375  ... 0.05390286 0.24907603 0.29947043] 8100   1012
[0.08881675 0.11866567 0.15004383 ... 0.04935533 0.05053171 0.14851196] 8100   1013
[1.01925761e-04 0.00000000e+00 0.00000000e+00 ... 8.66107800e-02
 1.24980740e-01 1.54177492e-01] 8100   1014
[0.066146   0.04625857 0.08421249 ... 0.23911852 0.06470902 0.01979742] 8100   1015
[0.18565622 0.13157616 0.14195637 ... 0.23536679 0.23536679 0.2090319 ] 8100   1016
[0.20849964 0.16962573 0.16239232 ... 0.15713064 0.21949665 0.21135126] 8100   1017
[0.22973077 0.10569455 0.10758843 ... 0.07846596 0.12706702 0.23420273] 8100   1018
[0.37563777 0.13279059 0.01238545 ... 0.04662419 0.03589722 0.14470857] 8100   1019
[5.04149852e-03 5.76447557e-16 3.11882570e-03 ... 1.04193960e-01
 3.29926570e-01 3.29926570e-01] 8100   1020
[0.31878925 0.04074345 0.02401683 ... 0.01323556 0.01547278 0.03946556] 8100   1021
[0.23925039 0.16126103 0.18291321 ... 0.09589326 0.08336483 0.08979077] 8100   1022
[0.         0.         0.         ... 0.04726475 0.34498363 0.34498363] 8100   1023
[0.10848222 0.08993652 0.08815952 ... 0.0470555  0.03154577 0.10515266] 8100   1024
[0.15015224 0.16600599 0.19225045 ... 0.07695586 0.12143773 0.14090083] 8100   1025
[0.25655045 0.25471598 0.17030035 ... 0.30588273 0.26321646 0.1323791 ] 8100   1026
[0.13162458 0.11183376 0.09480939 ... 0.2532042  0.2532042  0.23509322] 8100   1027
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[1.64798730e-07 0.00000000e+00 6.43983433e-08 ... 1.02868387e-01
 6.53191661e-02 7.55468176e-02] 8100   1029
[0.19065917 0.11861715 0.16899128 ... 0.02083276 0.03401447 0.03409612] 8100   1030
[0.20618701 0.18801831 0.20618701 ... 0.14816728 0.16206143 0.1768057 ] 8100   1031
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[0.21119131 0.21119131 0.1505576  ... 0.08719717 0.19127297 0.29663593] 8100   1035
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[0.17600884 0.14150099 0.1396831  ... 0.03298054 0.04090907 0.07377588] 8100   1037
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[0.10436809 0.27997205 0.27997205 ... 0.14193312 0.10080674 0.07722267] 8100   1041
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[0.0977278  0.02528165 0.03311032 ... 0.32540383 0.32540383 0.14068533] 8100   1043
[0.09566695 0.03918932 0.13413113 ... 0.12234035 0.23369544 0.22861932] 8100   1044
[0.15119353 0.12926748 0.13640471 ... 0.06397237 0.07474113 0.07953495] 8100   1045
[0.09973494 0.26020038 0.283447   ... 0.06752626 0.09523263 0.23026823] 8100   1046
[0.07840355 0.04864138 0.04206292 ... 0.02080695 0.05460324 0.13782337] 8100   1047
[0.20778961 0.15694416 0.17030765 ... 0.05054224 0.26216896 0.09288588] 8100   1048
[0. 0. 0. ... 0. 0. 0.] 8100   1049
[0.23770685 0.18430651 0.11644488 ... 0.09382661 0.19726475 0.27092692] 8100   1050
[0.13049911 0.08717531 0.06992795 ... 0.12811857 0.29317186 0.29319294] 8100   1051
[0.21758603 0.20954186 0.18777356 ... 0.36657277 0.16339474 0.07740703] 8100   1052
[0.09323017 0.04342333 0.02103176 ... 0.02430856 0.0265612  0.03462032] 8100   1053
[0.08792911 0.05324001 0.06786439 ... 0.02251434 0.03918944 0.05340299] 8100   1054
[0.1430618  0.12902508 0.12481716 ... 0.24451756 0.24451756 0.24451756] 8100   1055
[0.27301434 0.03519704 0.01444944 ... 0.27807562 0.27807562 0.27807562] 8100   1056
```

```
[0.22093414 0.22093414 0.22093414 ... 0.13127604 0.13072162 0.16470922] 8100   1057
[0.32725979 0.10812615 0.03579712 ... 0.06593813 0.11420991 0.19780384] 8100   1058
[0.04949491 0.02383381 0.10556681 ... 0.18596398 0.30082261 0.0948179 ] 8100   1059
[0.26254018 0.12442786 0.11644358 ... 0.15085699 0.18681528 0.1307072 ] 8100   1060
[0.24462213 0.04277971 0.04756519 ... 0.24587696 0.27212795 0.27212795] 8100   1061
[0.17093612 0.15129025 0.11937627 ... 0.15068516 0.1478946  0.1484308 ] 8100   1062
[0.23080293 0.10205452 0.11667728 ... 0.13249114 0.15148262 0.18150052] 8100   1063
[0.23326017 0.14539758 0.18866735 ... 0.19595036 0.1827569  0.14785525] 8100   1064
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[0.21719044 0.17470467 0.16520203 ... 0.07841104 0.06872688 0.07413959] 8100   1066
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[0.16601882 0.17411376 0.23953811 ... 0.08352037 0.12882034 0.14220411] 8100   1068
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[0.15785486 0.12029421 0.17595925 ... 0.11964996 0.14567334 0.15634565] 8100   1070
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[0.08503288 0.087173   0.16176642 ... 0.40020037 0.05425105 0.02437338] 8100   1072
[0.21677261 0.25228761 0.25228761 ... 0.1150664  0.11948147 0.14119624] 8100   1073
[0.23794866 0.23794866 0.2098762  ... 0.04290566 0.26702671 0.35336663] 8100   1074
[0.21706141 0.16439563 0.11841519 ... 0.06337159 0.17550832 0.26234969] 8100   1075
[0.21479143 0.13134172 0.12907123 ... 0.29472149 0.29472149 0.14680558] 8100   1076
[0. 0. 0. ... 0. 0. 0.] 8100   1077
[0.11057249 0.04325797 0.04454689 ... 0.14525369 0.13224063 0.2093624 ] 8100   1078
[1.65283969e-15 0.00000000e+00 4.78118639e-16 ... 2.31640401e-01
 2.14104261e-01 2.19956689e-01] 8100   1079
[0.1547211  0.14083809 0.13732847 ... 0.1796666  0.28693369 0.28693369] 8100   1080
[0.20513701 0.16566309 0.19166733 ... 0.1875827  0.15985718 0.16871738] 8100   1081
```

In [41]:

```python
# preparing the real images dataset
df_real
```

Out[41]:

	0	1	2	3	4	5	6
0	1.863669e-01	0.285277	2.852772e-01	1.716521e-01	1.498003e-01	4.427886e-02	2.985140e-02
1	0.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
2	1.904329e-01	0.154233	1.426275e-01	1.573469e-01	1.834742e-01	1.666708e-01	1.745083e-01
3	8.576781e-02	0.228297	2.781817e-01	6.888594e-02	4.988356e-02	4.124591e-02	4.281152e-02
4	1.849639e-01	0.173938	1.412881e-01	1.535252e-01	1.742698e-01	1.354031e-01	1.463914e-01
...	...	...	...	...	...	...	...
1076	0.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
1077	1.105725e-01	0.043258	4.454689e-02	3.499102e-02	8.079261e-02	3.728255e-02	2.766594e-02
1078	1.652840e-15	0.000000	4.781186e-16	2.099922e-17	1.812489e-15	2.099922e-17	3.320267e-16
1079	1.547211e-01	0.140838	1.373285e-01	1.542302e-01	2.013386e-01	1.908126e-01	1.748248e-01
1080	2.051370e-01	0.165663	1.916673e-01	1.773299e-01	2.051370e-01	2.051370e-01	2.051370e-01

1081 rows × 8100 columns

In [42]:

```python
target_fake = [0 for i in range(len(list_of_training_images_fake))]
target_real = [1 for i in range(len(list_of_training_images_real))]
```

```
target_fake = pd.Series(target_fake)
target_real = pd.Series(target_real)
```

In [43]:

```
# Defining the target variable for the fake images dataset
df_fake["Target"] = target_fake
df_fake
```

Out[43]:

	0	1	2	3	4	5	6	7	8	9
0	0.230652	0.141881	0.076380	0.077703	0.093578	0.129680	0.228946	0.230652	0.230652	0.154647
1	0.206942	0.005988	0.000000	0.001524	0.016285	0.012087	0.084780	0.271736	0.351903	0.282223
2	0.220921	0.135979	0.089265	0.107344	0.192139	0.140808	0.149828	0.152157	0.201345	0.126733
3	0.117852	0.088537	0.139416	0.132211	0.192544	0.049583	0.041581	0.029319	0.059215	0.153898
4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.172559
...	...	...	...	...	...	...	...	...	...	...
955	0.197414	0.159516	0.169568	0.166451	0.197653	0.164442	0.160833	0.161003	0.159776	0.183949
956	0.180262	0.229648	0.229648	0.229648	0.196851	0.080102	0.069893	0.097163	0.116690	0.229648
957	0.201763	0.153613	0.175227	0.169771	0.171106	0.185646	0.160898	0.115232	0.148196	0.178840
958	0.218632	0.161152	0.124531	0.125373	0.176472	0.131256	0.217847	0.218632	0.218632	0.190126
959	0.190492	0.153349	0.150419	0.191998	0.206232	0.162154	0.206232	0.166520	0.130216	0.206232

960 rows × 8101 columns

In [44]:

```
# Defining the target variable for the real images dataset
df_real["Target"] = target_real
df_real
```

Out[44]:

	0	1	2	3	4	5	6
0	1.863669e-01	0.285277	2.852772e-01	1.716521e-01	1.498003e-01	4.427886e-02	2.985140e-02
1	0.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
2	1.904329e-01	0.154233	1.426275e-01	1.573469e-01	1.834742e-01	1.666708e-01	1.745083e-01
3	8.576781e-02	0.228297	2.781817e-01	6.888594e-02	4.988356e-02	4.124591e-02	4.281152e-02
4	1.849639e-01	0.173938	1.412881e-01	1.535252e-01	1.742698e-01	1.354031e-01	1.463914e-01
...	...	...	...	...	...	...	...
1076	0.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
1077	1.105725e-01	0.043258	4.454689e-02	3.499102e-02	8.079261e-02	3.728255e-02	2.766594e-02
1078	1.652840e-15	0.000000	4.781186e-16	2.099922e-17	1.812489e-15	2.099922e-17	3.320267e-16
1079	1.547211e-01	0.140838	1.373285e-01	1.542302e-01	2.013386e-01	1.908126e-01	1.748248e-01
1080	2.051370e-01	0.165663	1.916673e-01	1.773299e-01	2.051370e-01	2.051370e-01	2.051370e-01

1081 rows × 8101 columns

In [45]:

```
df = pd.concat([df_fake, df_real])
df
```

Out[45]:

	0	1	2	3	4	5	6
0	2.306518e-01	0.141881	7.638010e-02	7.770277e-02	9.357835e-02	1.296796e-01	2.289461e-01
1	2.069423e-01	0.005988	0.000000e+00	1.524289e-03	1.628492e-02	1.208734e-02	8.478019e-02
2	2.209210e-01	0.135979	8.926472e-02	1.073439e-01	1.921391e-01	1.408084e-01	1.498278e-01
3	1.178523e-01	0.088537	1.394164e-01	1.322113e-01	1.925438e-01	4.958338e-02	4.158076e-02
4	0.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
...	...	...	...	...	...	...	...
1076	0.000000e+00	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
1077	1.105725e-01	0.043258	4.454689e-02	3.499102e-02	8.079261e-02	3.728255e-02	2.766594e-02
1078	1.652840e-15	0.000000	4.781186e-16	2.099922e-17	1.812489e-15	2.099922e-17	3.320267e-16
1079	1.547211e-01	0.140838	1.373285e-01	1.542302e-01	2.013386e-01	1.908126e-01	1.748248e-01
1080	2.051370e-01	0.165663	1.916673e-01	1.773299e-01	2.051370e-01	2.051370e-01	2.051370e-01

2041 rows × 8101 columns

In [47]:

```
import csv
import numpy as np
import matplotlib.pyplot as plt
from sklearn import datasets
from collections import Counter
from sklearn.model_selection import GridSearchCV
from sklearn.pipeline import Pipeline
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn import svm
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.feature_selection import SelectKBest,chi2
from sklearn.model_selection import StratifiedKFold, train_test_split
from sklearn.metrics import classification_report
import pylab as p
```

In [50]:

```
# Splitting the data into trining and test set
X_train, X_test, Y_train, Y_test = train_test_split(df.drop("Target",axis = 1), df["Tar

Y_train = [str(x) for x in Y_train]
print('\n Training Data Class  Names:\t['+','.join(list(Counter(Y_train).keys()))+']\n'
clas_labels = [str(x) for  x in list(Counter(Y_train).values())]
```

```
print(' Instances in Individual Classes: '+','.join(clas_labels))

Y_test = [str(x) for x in Y_test]
print('\n Test Data Class  Names:\t['+','.join(list(Counter(Y_test).keys()))+']\n')
clas_labels = [str(x) for  x in list(Counter(Y_test).values())]
print(' Instances in Individual Classes: '+','.join(clas_labels))
```

```
Training Data Class  Names:    [1,0]

Instances in Individual Classes: 810,720

Test Data Class  Names:        [1,0]

Instances in Individual Classes: 271,240
```

In [51]:

```
# Applying svm classifier to train the prepared data  and predict the test set and comp
clf = svm.SVC(class_weight='balanced',kernel='rbf',C=1,probability=True)

clf.fit(X_train, Y_train)
predicted=clf.predict(X_test)
print(classification_report(Y_test, predicted, target_names=['0','1']))
```

```
              precision    recall  f1-score   support

           0       0.62      0.58      0.60       240
           1       0.65      0.68      0.66       271

    accuracy                           0.63       511
   macro avg       0.63      0.63      0.63       511
weighted avg       0.63      0.63      0.63       511
```

f1-accuracy of SVM classifier is 63%

Ans 7: Multi-Class Classification Model (OCR)

In [163…

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import struct
import numpy as np # linear algebra
import json
from matplotlib import pyplot as plt
from skimage import color
from skimage.feature import hog
from sklearn import svm
from sklearn.metrics import confusion_matrix, classification_report,accuracy_score
from sklearn.model_selection import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.preprocessing import StandardScaler
from collections import Counter
import os
import cv2
from tqdm import tqdm
from random import shuffle
import pandas as pd
```

In [154…

```
# Extracting the training images along woth their labels
with open('Q7 data/train-images.idx3-ubyte', 'rb') as f:
    magic, size = struct.unpack('>II', f.read(8))
    nrows, ncols = struct.unpack('>II', f.read(8))
    data = np.fromfile(f, dtype=np.dtype(np.uint8)).newbyteorder(">")
    data = data.reshape((size,nrows,ncols))
with open('Q7 data/train-labels.idx1-ubyte', 'rb') as i:
    magic, size = struct.unpack('>II', i.read(8))
    data_1 = np.fromfile(i, dtype=np.dtype(np.uint8)).newbyteorder(">")
data, labels = data, data_1
```

In [155…

```
# Returns a 1D vector for an image
ppcr = 8
ppcc = 8
hog_images = []
hog_features = []
for image in tqdm(data):
    # Applyng HoG Descriptor
    fd,hog_image = hog(image, orientations=8, pixels_per_cell=(ppcr,ppcc),cells_per_blo
    hog_images.append(hog_image)
    hog_features.append(fd)
hog_features = np.array(hog_features)
hog_features.shape
```

```
100%|██████████████████████████████████████████████████| 60000/
60000 [05:25<00:00, 184.30it/s]
```

Out[155…

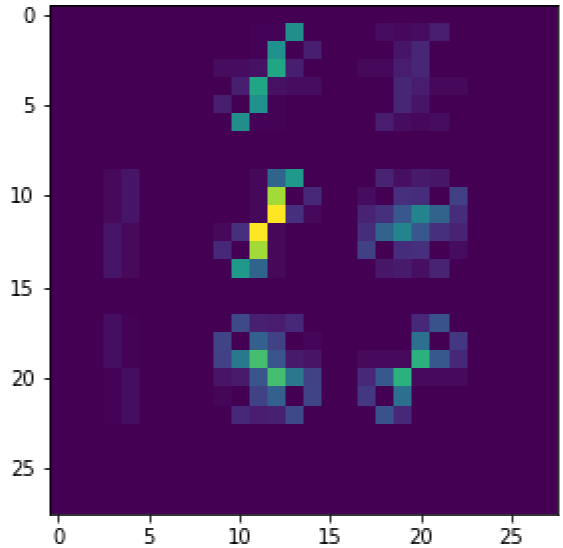
```
(60000, 128)
```

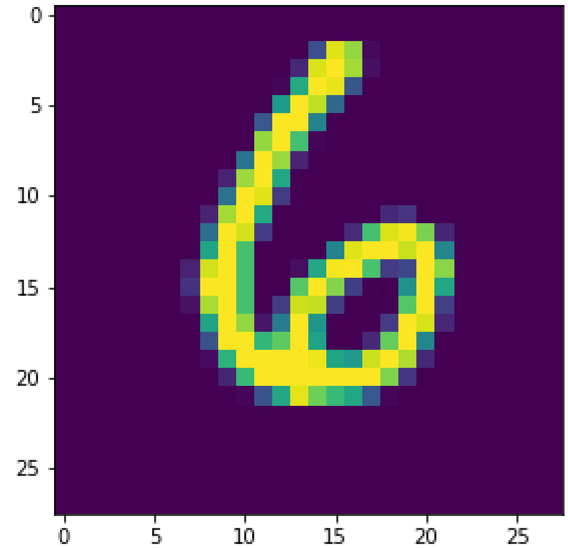
In [160…

```
plt.figure(figsize = (10, 10))

# Visualizing the HoG descriptor
plt.subplot(121)
plt.imshow(hog_images[8911])

# Visualing the original image
plt.subplot(122)
plt.imshow(data[8911])
```

Out[160…

```
<matplotlib.image.AxesImage at 0x28ce1fcfdf0>
```





In [157…

```
labels = np.asarray(labels)
```

In [158…

```
# splitting the data into training and testing set
X_train, X_test, y_train, y_test = train_test_split(hog_features,labels,test_size=0.2)
print('Training data and target sizes: \n{}, {}'.format(X_train.shape,y_train.shape))
print('Test data and target sizes: \n{}, {}'.format(X_test.shape,y_test.shape))
```

```
Training data and target sizes:
(48000, 128), (48000,)
Test data and target sizes:
(12000, 128), (12000,)
```

In [170…

```
# scaling the training set
scaler = StandardScaler()
X_scaled = scaler.fit_transform(X_train)
```

In [171…

```
# Applying K-Nearest Neighbors Classifier to train the prepared data and predict the te
knn = KNeighborsClassifier(n_neighbors=3, algorithm='brute')
knn.fit(X_scaled, y_train)
predicted = knn.predict(X_test)
```

In [164…

```
class_names = list(Counter(y_test).keys())
class_names = [str(x) for x in class_names]
```

In [172…

```
# Computing the accuracy of KNN classifier
test_accuracy = knn.score(scaler.transform(X_test), y_test)
print("Accuracy Score of KNN classifier:", test_accuracy)
```

```
Accuracy Score of KNN classifier: 0.94375
```

Session 2

Ans 8: CNN based Classifer using Transfer Learning

In [14]:

```
import keras
from keras.datasets import mnist
from tensorflow.keras.utils import to_categorical
from keras.applications.vgg19 import VGG19
from keras import backend as K
from keras.utils.vis_utilsls import plot_model
from keras.models import Sequential
from keras.layers import Dense, Flatten, Conv2D, MaxPooling2D
from keras.callbacks import ModelCheckpoint, EarlyStopping
from sklearn.model_selection import train_test_split
```

In [43]:

```
# Loading the mnist dataset
(X_train, y_train), (X_test, y_test) = mnist.load_data()
```

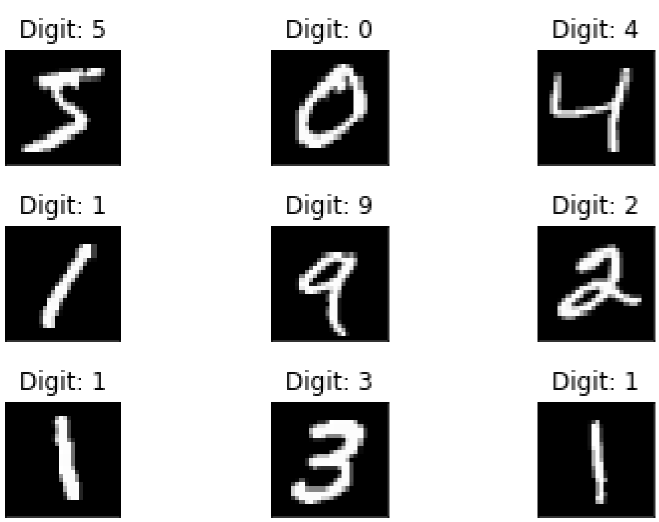
In [44]:

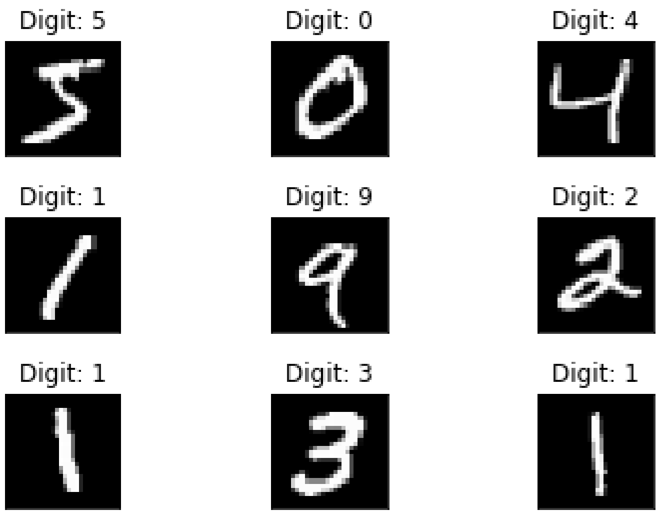
```
X_train = X_train[:1000, :, :]
Y_train = y_train[:1000]
X_test = X_test[:400, :, :]
Y_test = y_test[:400]
```

In [45]:

```
# Visualizing the data
fig = plt.figure()
for i in range(9):
    plt.subplot(3,3,i+1)
    plt.tight_layout()
    plt.imshow(X_train[i], cmap='gray', interpolation='none')
    plt.title("Digit: {}".format(y_train[i]))
    plt.xticks([])
    plt.yticks([])
fig
```

Out[45]:





In [46]:

```
IMG_SIZE = 32
def resize(img_array):
    tmp = np.empty((img_array.shape[0], IMG_SIZE, IMG_SIZE))

    for i in range(len(img_array)):
        img = img_array[i].reshape(28, 28).astype('uint8')
        img = cv2.resize(img, (IMG_SIZE, IMG_SIZE))
        img = img.astype('float32')/255
        tmp[i] = img

    return tmp
```

In [47]:

```
X_train = resize(X_train)
X_test = resize(X_test)
X_train = np.stack((X_train,)*3, axis=-1)
X_test = np.stack((X_test,)*3, axis=-1)
print('X_train shape:', X_train.shape)
print('X_test shape:', X_test.shape)
```

```
X_train shape: (1000, 32, 32, 3)
X_test shape: (400, 32, 32, 3)
```

In [53]:

```
# set number of categories
num_category = 10

# convert class vectors to binary class matrices
Y_train = keras.utils.np_utils.to_categorical(Y_train, num_category)
Y_test = keras.utils.np_utils.to_categorical(Y_test, num_category)
```

In [54]:

```
# building the CNN model
vgg19 = VGG19(weights = 'imagenet',
              include_top = False,
              input_shape=(IMG_SIZE, IMG_SIZE, 3)
              )

model = Sequential()
model.add(vgg19)
model.add(Flatten())
```

```
model.add(Dense(10, activation='softmax'))
model.compile(loss='categorical_crossentropy',
              optimizer='sgd',
              metrics=['accuracy'])

model.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 vgg19 (Functional)          (None, 1, 1, 512)         20024384

 flatten_3 (Flatten)         (None, 512)               0

 dense_3 (Dense)             (None, 10)                5130

=================================================================
Total params: 20,029,514
Trainable params: 20,029,514
Non-trainable params: 0
_________________________________________________________________
```

In [55]:

```
print(X_train.shape)
print(X_test.shape)
print(Y_train.shape)
print(Y_test.shape)
```

```
(1000, 32, 32, 3)
(400, 32, 32, 3)
(1000, 10)
(400, 10)
```

In [56]:

```
es = EarlyStopping(monitor='val_accuracy', verbose=1, patience=5)
mc = ModelCheckpoint(filepath='mnist-vgg19.h5', verbose=1, monitor='val_accuracy')
cb = [es, mc]
```

In [59]:

```
# fitting the model
model.fit(X_train, Y_train, epochs=10, batch_size=128, validation_data=(X_test, Y_test)
```

```
Epoch 1/10
8/8 [==============================] - ETA: 0s - loss: 2.1425 - accuracy: 0.2840
Epoch 1: saving model to mnist-vgg19.h5
8/8 [==============================] - 47s 6s/step - loss: 2.1425 - accuracy: 0.2840 - v
al_loss: 2.2556 - val_accuracy: 0.2825
Epoch 2/10
8/8 [==============================] - ETA: 0s - loss: 1.8833 - accuracy: 0.4290
Epoch 2: saving model to mnist-vgg19.h5
8/8 [==============================] - 51s 7s/step - loss: 1.8833 - accuracy: 0.4290 - v
al_loss: 1.6291 - val_accuracy: 0.4500
Epoch 3/10
8/8 [==============================] - ETA: 0s - loss: 1.7594 - accuracy: 0.4370
Epoch 3: saving model to mnist-vgg19.h5
8/8 [==============================] - 54s 7s/step - loss: 1.7594 - accuracy: 0.4370 - v
al_loss: 1.5836 - val_accuracy: 0.4800
Epoch 4/10
8/8 [==============================] - ETA: 0s - loss: 1.3742 - accuracy: 0.5280
```

```
Epoch 4: saving model to mnist-vgg19.h5
8/8 [==============================] - 57s 7s/step - loss: 1.3742 - accuracy: 0.5280 - v
al_loss: 1.0619 - val_accuracy: 0.6600
Epoch 5/10
8/8 [==============================] - ETA: 0s - loss: 0.6573 - accuracy: 0.8140
Epoch 5: saving model to mnist-vgg19.h5
8/8 [==============================] - 62s 8s/step - loss: 0.6573 - accuracy: 0.8140 - v
al_loss: 0.4362 - val_accuracy: 0.8600
Epoch 6/10
8/8 [==============================] - ETA: 0s - loss: 0.8556 - accuracy: 0.7580
Epoch 6: saving model to mnist-vgg19.h5
8/8 [==============================] - 57s 7s/step - loss: 0.8556 - accuracy: 0.7580 - v
al_loss: 0.3175 - val_accuracy: 0.9425
Epoch 7/10
8/8 [==============================] - ETA: 0s - loss: 0.1812 - accuracy: 0.9550
Epoch 7: saving model to mnist-vgg19.h5
8/8 [==============================] - 55s 7s/step - loss: 0.1812 - accuracy: 0.9550 - v
al_loss: 0.2033 - val_accuracy: 0.9475
Epoch 8/10
8/8 [==============================] - ETA: 0s - loss: 0.3274 - accuracy: 0.8990
Epoch 8: saving model to mnist-vgg19.h5
8/8 [==============================] - 53s 7s/step - loss: 0.3274 - accuracy: 0.8990 - v
al_loss: 0.7457 - val_accuracy: 0.8125
Epoch 9/10
8/8 [==============================] - ETA: 0s - loss: 0.2640 - accuracy: 0.9300
Epoch 9: saving model to mnist-vgg19.h5
8/8 [==============================] - 52s 7s/step - loss: 0.2640 - accuracy: 0.9300 - v
al_loss: 0.1221 - val_accuracy: 0.9625
Epoch 10/10
8/8 [==============================] - ETA: 0s - loss: 0.0781 - accuracy: 0.9750
Epoch 10: saving model to mnist-vgg19.h5
8/8 [==============================] - 52s 7s/step - loss: 0.0781 - accuracy: 0.9750 - v
al_loss: 0.1039 - val_accuracy: 0.9675
```

Out[59]:
```
<keras.callbacks.History at 0x23dfb25e910>
```

In [61]:
```python
# evaluating the accuracy of the model
model.evaluate(X_test, Y_test)
```

```
13/13 [==============================] - 1s 111ms/step - loss: 0.1039 - accuracy: 0.9675
```

Out[61]:
```
[0.1038966104388237, 0.9674999713897705]
```

The Accuracy of pretrained model of CNN (0.9675) is more than accuracy of KNN model (0.9437) on Hog Descriptors. Generally, efficiently trained CNN models are to robust for classification as we in this case.

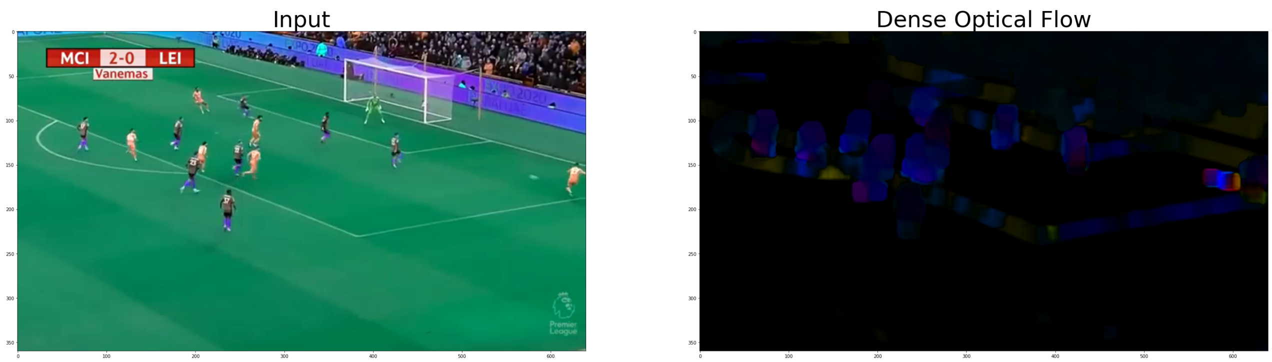
Ans 4: Optic Flow and LK feature tracking

In [4]:
```python
# Applying Optic flow
cap = cv2.VideoCapture("videoplayback_Trim.mp4")
ret, first_frame = cap.read()
prev_gray = cv2.cvtColor(first_frame, cv2.COLOR_BGR2GRAY)
mask = np.zeros_like(first_frame)
mask[..., 1] = 255

while(cap.isOpened()):
    ret, frame = cap.read()
```

```
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
    flow = cv2.calcOpticalFlowFarneback(prev_gray, gray,
                                        None,
                                        0.5, 3, 15, 3, 5, 1.2, 0)
    magnitude, angle = cv2.cartToPolar(flow[..., 0], flow[..., 1])
    mask[..., 0] = angle * 180 / np.pi / 2
    mask[..., 2] = cv2.normalize(magnitude, None, 0, 255, cv2.NORM_MINMAX)
    rgb = cv2.cvtColor(mask, cv2.COLOR_HSV2BGR)
    prev_gray = gray
    break
```

In [5]:

```
plt.figure(figsize = (50, 50))

plt.subplot(1,2,1)
plt.imshow(frame)
plt.title('Input', fontsize = 50)

plt.subplot(1,2,2)
plt.imshow(rgb)
plt.title('Dense Optical Flow', fontsize = 50)
plt.show()
```



In [11]:

```
# Applying LK feature tracking
cap = cv2.VideoCapture("videoplayback_Trim.mp4")

# params for corner detection
feature_params = dict( maxCorners = 100,
                       qualityLevel = 0.3,
                       minDistance = 7,
                       blockSize = 7 )

# Parameters for lucas kanade optical flow
lk_params = dict( winSize = (15, 15),
                  maxLevel = 2,
                  criteria = (cv2.TERM_CRITERIA_EPS | cv2.TERM_CRITERIA_COUNT,
                              10, 0.03))

# Create some random colors
color = np.random.randint(0, 255, (100, 3))

# Take first frame and find corners in it
ret, old_frame = cap.read()
old_gray = cv2.cvtColor(old_frame, cv2.COLOR_BGR2GRAY)
p0 = cv2.goodFeaturesToTrack(old_gray, mask = None, **feature_params)

# Create a mask image for drawing purposes
```

```
mask = np.zeros_like(old_frame)

while True:

    ret, frame = cap.read()
    if not ret:
        break
    frame_gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)

    # calculate optical flow
    p1, st, err = cv2.calcOpticalFlowPyrLK(old_gray,
                                           frame_gray,
                                           p0, None,
                                           **lk_params)

    # Select good points
    good_new = p1[st == 1]
    good_old = p0[st == 1]

    # draw the tracks
    for i, (new, old) in enumerate(zip(good_new,
                                       good_old)):
        a, b = new.ravel().astype(int)
        c, d = old.ravel().astype(int)

        mask = cv2.line(mask, (a, b), (c, d), color[i].tolist(), 2)
        frame = cv2.circle(old_frame, (a, b), 5, color[i].tolist(), -1)

    img = cv2.add(frame, mask)
    # Updating Previous frame and points
    old_gray = frame_gray.copy()
    p0 = good_new.reshape(-1, 1, 2)

plt.imshow(img)
plt.title('Lucas-Kenade feature tracking', fontsize = 20)
plt.show()
```

DSE-312: Computer Vision

Assignment

- **Name:** Shraddha Agarwal
- **Roll No.:** 19294
- **Department:** Data Science and Engineering

In [16]:
```
import cv2
from cv2 import imread
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import shutil
```

Session 2

Ans 3: CNN Model on Face vs Non-Face

In [17]:
```
import numpy as np
import matplotlib.pyplot as plt
import glob
import cv2

from keras.models import Model, Sequential
from keras.layers import Dense, Flatten, Conv2D, MaxPooling2D

from tensorflow.keras.layers import BatchNormalization
import os
import seaborn as sns
from keras.applications.vgg16 import VGG16
```

In [18]:
```
print(os.listdir("archive/real_and_fake_face/"))
```

```
['training_fake', 'training_real']
```

In [19]:
```
SIZE = 256  #Resize images

#Capture training data and labels into respective lists
train_images = []
train_labels = []

for directory_path in glob.glob("archive\\train\\fake\\"):
    label = "fake"
    for img_path in glob.glob(os.path.join(directory_path, "*.jpg")):
        img = cv2.imread(img_path, cv2.IMREAD_COLOR)
        img = cv2.resize(img, (SIZE, SIZE))
```

```
        img = cv2.cvtColor(img, cv2.COLOR_RGB2BGR)
        train_images.append(img)
        train_labels.append(label)
```

In [20]:

```
for directory_path in glob.glob("archive\\train\\real\\"):
    label = "real"
    for img_path in glob.glob(os.path.join(directory_path, "*.jpg")):
        img = cv2.imread(img_path, cv2.IMREAD_COLOR)
        img = cv2.resize(img, (SIZE, SIZE))
        img = cv2.cvtColor(img, cv2.COLOR_RGB2BGR)
        train_images.append(img)
        train_labels.append(label)
```

In [21]:

```
# Convert lists to arrays
train_images = np.array(train_images)
train_labels = np.array(train_labels)
```

In [22]:

```
# Capture test/validation data and labels into respective lists
test_images = []
test_labels = []
for directory_path in glob.glob("archive\\validation\\fake\\"):
    fruit_label = "fake"
    for img_path in glob.glob(os.path.join(directory_path, "*.jpg")):
        img = cv2.imread(img_path, cv2.IMREAD_COLOR)
        img = cv2.resize(img, (SIZE, SIZE))
        img = cv2.cvtColor(img, cv2.COLOR_RGB2BGR)
        test_images.append(img)
        test_labels.append(fruit_label)
```

In [23]:

```
for directory_path in glob.glob("archive\\validation\\real\\"):
    fruit_label = "real"
    for img_path in glob.glob(os.path.join(directory_path, "*.jpg")):
        img = cv2.imread(img_path, cv2.IMREAD_COLOR)
        img = cv2.resize(img, (SIZE, SIZE))
        img = cv2.cvtColor(img, cv2.COLOR_RGB2BGR)
        test_images.append(img)
        test_labels.append(fruit_label)
```

In [24]:

```
# Convert lists to arrays
test_images = np.array(test_images)
test_labels = np.array(test_labels)
```

In [25]:

```
# Encode labels from text to integers.
from sklearn import preprocessing
le = preprocessing.LabelEncoder()
le.fit(test_labels)
test_labels_encoded = le.transform(test_labels)
le.fit(train_labels)
train_labels_encoded = le.transform(train_labels)
```

In [26]:

```
# Split data into test and train datasets (already split but assigning to meaningful co
x_train, y_train, x_test, y_test = train_images, train_labels_encoded, test_images, tes
```

In [27]:

```
# Normalize pixel values to between 0 and 1
x_train, x_test = x_train / 255.0, x_test / 255.0

#One hot encode y values for neural network.
from tensorflow.keras.utils import to_categorical
y_train_one_hot = to_categorical(y_train)
y_test_one_hot = to_categorical(y_test)
```

In [28]:

```
#Load model wothout classifier/fully connected layers
VGG_model = VGG16(weights='imagenet', include_top=False, input_shape=(SIZE, SIZE, 3))

#Make loaded layers as non-trainable. This is important as we want to work with pre-tra
for layer in VGG_model.layers:
    layer.trainable = False
```

In [29]:

```
VGG_model.summary()  #Trainable parameters will be 0
```

```
Model: "vgg16"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 256, 256, 3)]     0

 block1_conv1 (Conv2D)       (None, 256, 256, 64)      1792

 block1_conv2 (Conv2D)       (None, 256, 256, 64)      36928

 block1_pool (MaxPooling2D)  (None, 128, 128, 64)      0

 block2_conv1 (Conv2D)       (None, 128, 128, 128)     73856

 block2_conv2 (Conv2D)       (None, 128, 128, 128)     147584

 block2_pool (MaxPooling2D)  (None, 64, 64, 128)       0

 block3_conv1 (Conv2D)       (None, 64, 64, 256)       295168

 block3_conv2 (Conv2D)       (None, 64, 64, 256)       590080

 block3_conv3 (Conv2D)       (None, 64, 64, 256)       590080

 block3_pool (MaxPooling2D)  (None, 32, 32, 256)       0

 block4_conv1 (Conv2D)       (None, 32, 32, 512)       1180160

 block4_conv2 (Conv2D)       (None, 32, 32, 512)       2359808

 block4_conv3 (Conv2D)       (None, 32, 32, 512)       2359808

 block4_pool (MaxPooling2D)  (None, 16, 16, 512)       0

 block5_conv1 (Conv2D)       (None, 16, 16, 512)       2359808
```

```
 block5_conv2 (Conv2D)       (None, 16, 16, 512)       2359808

 block5_conv3 (Conv2D)       (None, 16, 16, 512)       2359808

 block5_pool (MaxPooling2D)  (None, 8, 8, 512)         0

=================================================================
Total params: 14,714,688
Trainable params: 0
Non-trainable params: 14,714,688
_________________________________________________________________
```

In [23]:
```
# Use features from convolutional network for RF
feature_extractor=VGG_model.predict(x_train)
features = feature_extractor.reshape(feature_extractor.shape[0], -1)
```

In [24]:
```
#This is our X input to RF
X = features
df = pd.DataFrame(X)
```

In [30]:
```
import csv
import numpy as np
import matplotlib.pyplot as plt
from sklearn import datasets
from collections import Counter
from sklearn.model_selection import GridSearchCV
from sklearn.pipeline import Pipeline
from sklearn.ensemble import AdaBoostClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn import svm
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.feature_selection import SelectKBest,chi2
from sklearn.model_selection import StratifiedKFold, train_test_split
from sklearn.metrics import classification_report
import pylab as p
```

In [31]:
```
# Train the SVM classifier on training data
clf = svm.SVC(class_weight='balanced',kernel='rbf',C=1,probability=True)
clf.fit(X, y_train)
```

In [33]:
```
# Send test data through same feature extractor process
X_test_feature = VGG_model.predict(x_test)
X_test_features = X_test_feature.reshape(X_test_feature.shape[0], -1)
```

In [34]:
```
# Predict using the trained RF model.
prediction_RF = clf.predict(X_test_features)
#Inverse le transform to get original label back.
prediction_RF = le.inverse_transform(prediction_RF)
```

In [35]:
```
#Print overall accuracy
from sklearn import metrics
print ("Accuracy = ", metrics.accuracy_score(test_labels, prediction_RF))
```

```
Accuracy =  0.6786296900489397
```

In [37]:
```
#Confusion Matrix - verify accuracy of each class
from sklearn.metrics import confusion_matrix
cm = confusion_matrix(test_labels, prediction_RF)
print(cm)
```

```
[[197  91]
 [106 219]]
```

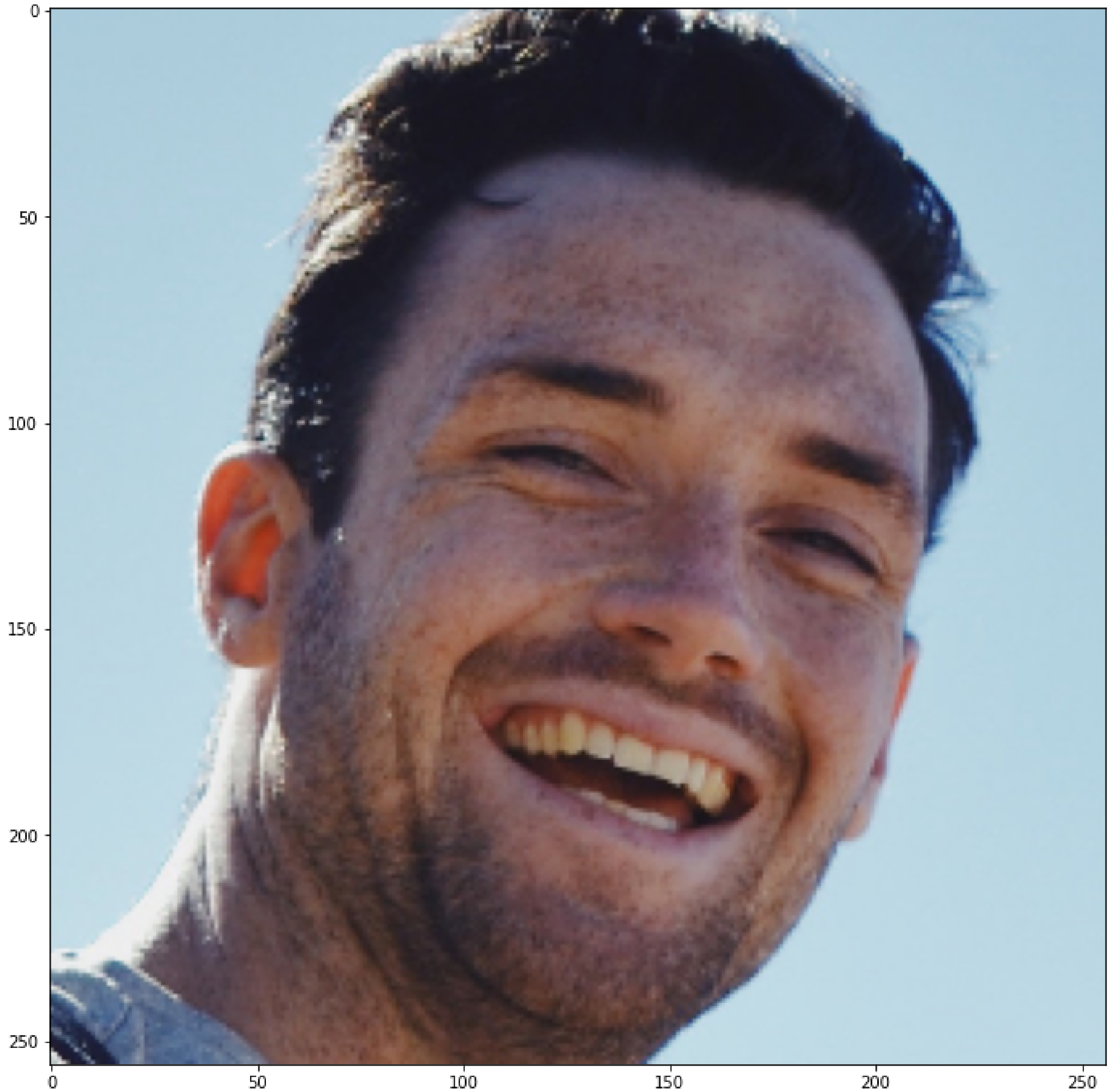
In [46]:
```
plt.figure(figsize=(20,15))
sns.heatmap(cm, annot=True)
```

Out[46]: <AxesSubplot:>

In [48]:
```
#Check results on a few select images
n=np.random.randint(0, x_test.shape[0])
img = x_test[n]
plt.figure(figsize=(16,12))
plt.imshow(img)
input_img = np.expand_dims(img, axis=0) #Expand dims so the input is (num images, x, y,
```

```
input_img_feature=VGG_model.predict(input_img)
input_img_features=input_img_feature.reshape(input_img_feature.shape[0], -1)
prediction_RF = clf3.predict(input_img_features)[0]
prediction_RF = le.inverse_transform([prediction_RF])  #Reverse the label encoder to or
print("The prediction for this image is: ", prediction_RF)
print("The actual label for this image is: ", test_labels[n])
```

```
The prediction for this image is:  ['real']
The actual label for this image is:  real
```



In [49]:

```
#Check results on a few select images
n=np.random.randint(0, x_test.shape[0])
img = x_test[n]
plt.figure(figsize=(16,12))
plt.imshow(img)
input_img = np.expand_dims(img, axis=0) #Expand dims so the input is (num images, x, y,
input_img_feature=VGG_model.predict(input_img)
input_img_features=input_img_feature.reshape(input_img_feature.shape[0], -1)
prediction_RF = clf3.predict(input_img_features)[0]
prediction_RF = le.inverse_transform([prediction_RF])  #Reverse the label encoder to or
```

```
print("The prediction for this image is: ", prediction_RF)
print("The actual label for this image is: ", test_labels[n])
```

```
The prediction for this image is:  ['fake']
The actual label for this image is:  real
```

In [50]:

```
#Check results on a few select images
n=np.random.randint(0, x_test.shape[0])
img = x_test[n]
plt.figure(figsize=(16,12))
plt.imshow(img)
input_img = np.expand_dims(img, axis=0) #Expand dims so the input is (num images, x, y,
input_img_feature=VGG_model.predict(input_img)
input_img_features=input_img_feature.reshape(input_img_feature.shape[0], -1)
prediction_RF = clf3.predict(input_img_features)[0]
prediction_RF = le.inverse_transform([prediction_RF])  #Reverse the label encoder to or
print("The prediction for this image is: ", prediction_RF)
print("The actual label for this image is: ", test_labels[n])
```

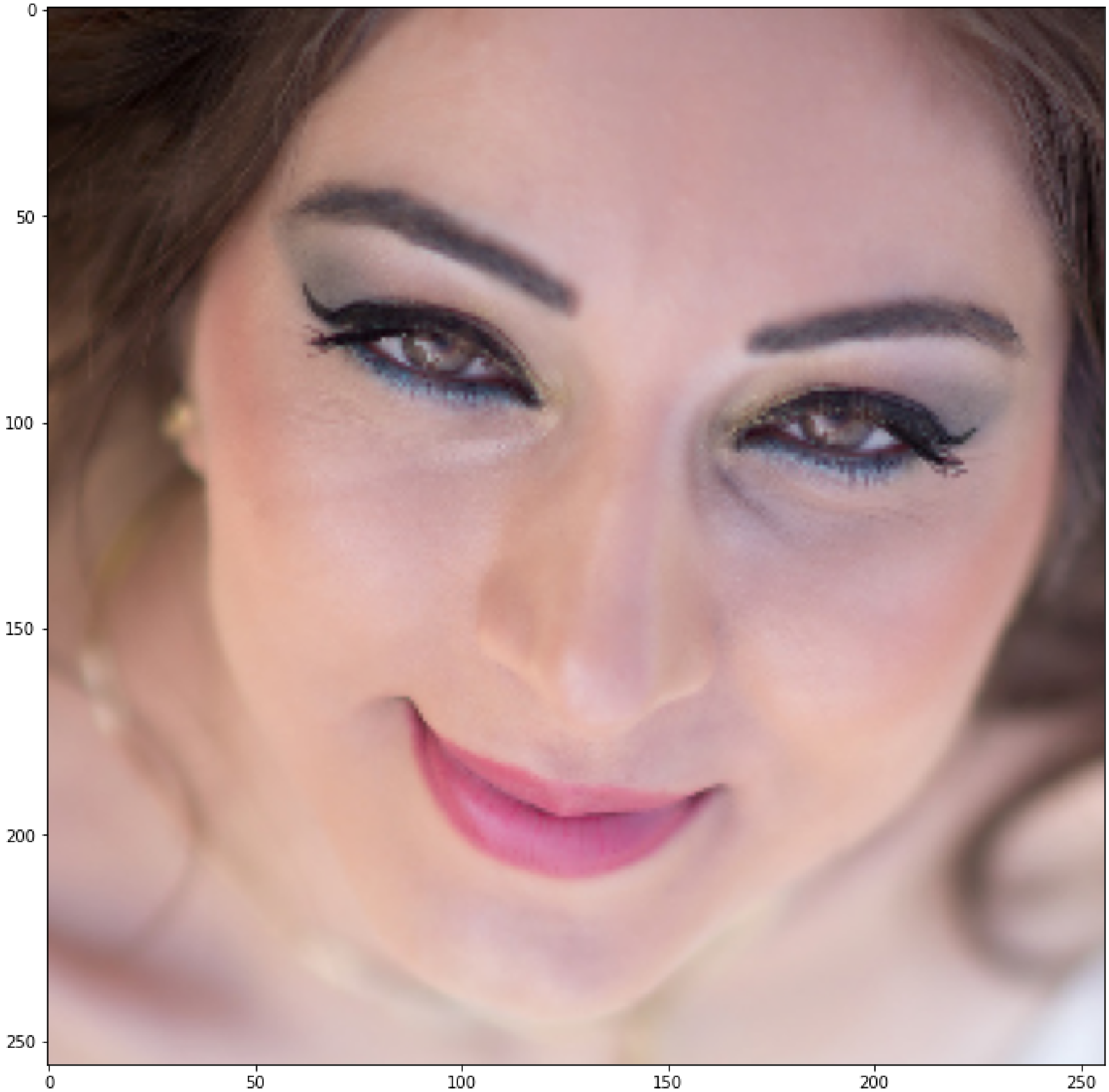
```
The prediction for this image is:  ['real']
```

```
The actual label for this image is:  real
```

In [51]:

```
#Check results on a few select images
n=np.random.randint(0, x_test.shape[0])
img = x_test[n]
plt.figure(figsize=(16,12))
plt.imshow(img)
input_img = np.expand_dims(img, axis=0) #Expand dims so the input is (num images, x, y,
input_img_feature=VGG_model.predict(input_img)
input_img_features=input_img_feature.reshape(input_img_feature.shape[0], -1)
prediction_RF = clf3.predict(input_img_features)[0]
prediction_RF = le.inverse_transform([prediction_RF])  #Reverse the label encoder to or
print("The prediction for this image is: ", prediction_RF)
print("The actual label for this image is: ", test_labels[n])
```

```
The prediction for this image is:  ['real']
The actual label for this image is:  real
```



In [52]:

```
#Check results on a few select images
n=np.random.randint(0, x_test.shape[0])
img = x_test[n]
plt.figure(figsize=(16,12))
plt.imshow(img)
input_img = np.expand_dims(img, axis=0) #Expand dims so the input is (num images, x, y,
input_img_feature=VGG_model.predict(input_img)
input_img_features=input_img_feature.reshape(input_img_feature.shape[0], -1)
prediction_RF = clf3.predict(input_img_features)[0]
prediction_RF = le.inverse_transform([prediction_RF])  #Reverse the label encoder to or
print("The prediction for this image is: ", prediction_RF)
print("The actual label for this image is: ", test_labels[n])
```

```
The prediction for this image is:  ['real']
The actual label for this image is:  real
```

In [53]:

```
#Check results on a few select images
n=np.random.randint(0, x_test.shape[0])
img = x_test[n]
plt.figure(figsize=(16,12))
plt.imshow(img)
input_img = np.expand_dims(img, axis=0) #Expand dims so the input is (num images, x, y,
input_img_feature=VGG_model.predict(input_img)
input_img_features=input_img_feature.reshape(input_img_feature.shape[0], -1)
prediction_RF = clf3.predict(input_img_features)[0]
prediction_RF = le.inverse_transform([prediction_RF])  #Reverse the label encoder to or
print("The prediction for this image is: ", prediction_RF)
print("The actual label for this image is: ", test_labels[n])
```

```
The prediction for this image is:  ['fake']
The actual label for this image is:  fake
```


0
50
100
150
200
250
0
50
100
150
200
250