- New concepts:
  - Extracting large scale and small scale features from data
  - Image processing
  - Image composition
  - Generating art from algorithms

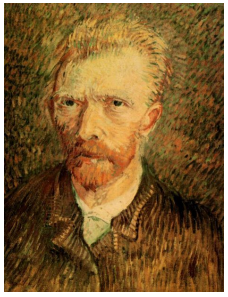
- Tate Modern Gallery in London: Electric Dreams exhibition
- Art related to mathematics has a long history

Figure 1. "Op art"

- M.C. Escher

Figure 2. Perception paradoxes and evolution

- A distinction is made in the visual arts between composition and technique



- Read an image from which large-scale features will be extracted, the painting composition. Find its size, and transform from color to gray scale image and then to a matrix of real-valued components A_1

```
>> im1=imread("./courses/MATH347/paintings/Andy_Warhol_2.jpg");
>> im1BW=rgb2gray(im1); [px,py,nc]=size(im1); [px py nc]
>> A1=im2double(im1BW);
>> imwrite(im1BW,"./courses/MATH347/paintings/im1BW.jpg");
>>
```

Figure 3. Image from which large-scale features (composition) is extracted

- Read an image from which large-scale features will be extracted, the painting composition. Find its size, and transform from color to gray scale image and then to a matrix of real-valued components A_1

```
>> im1=imread("./courses/MATH347/paintings/Andy_Warhol_2.jpg");
>> im1BW=rgb2gray(im1); [px,py,nc]=size(im1); [px py nc]
```

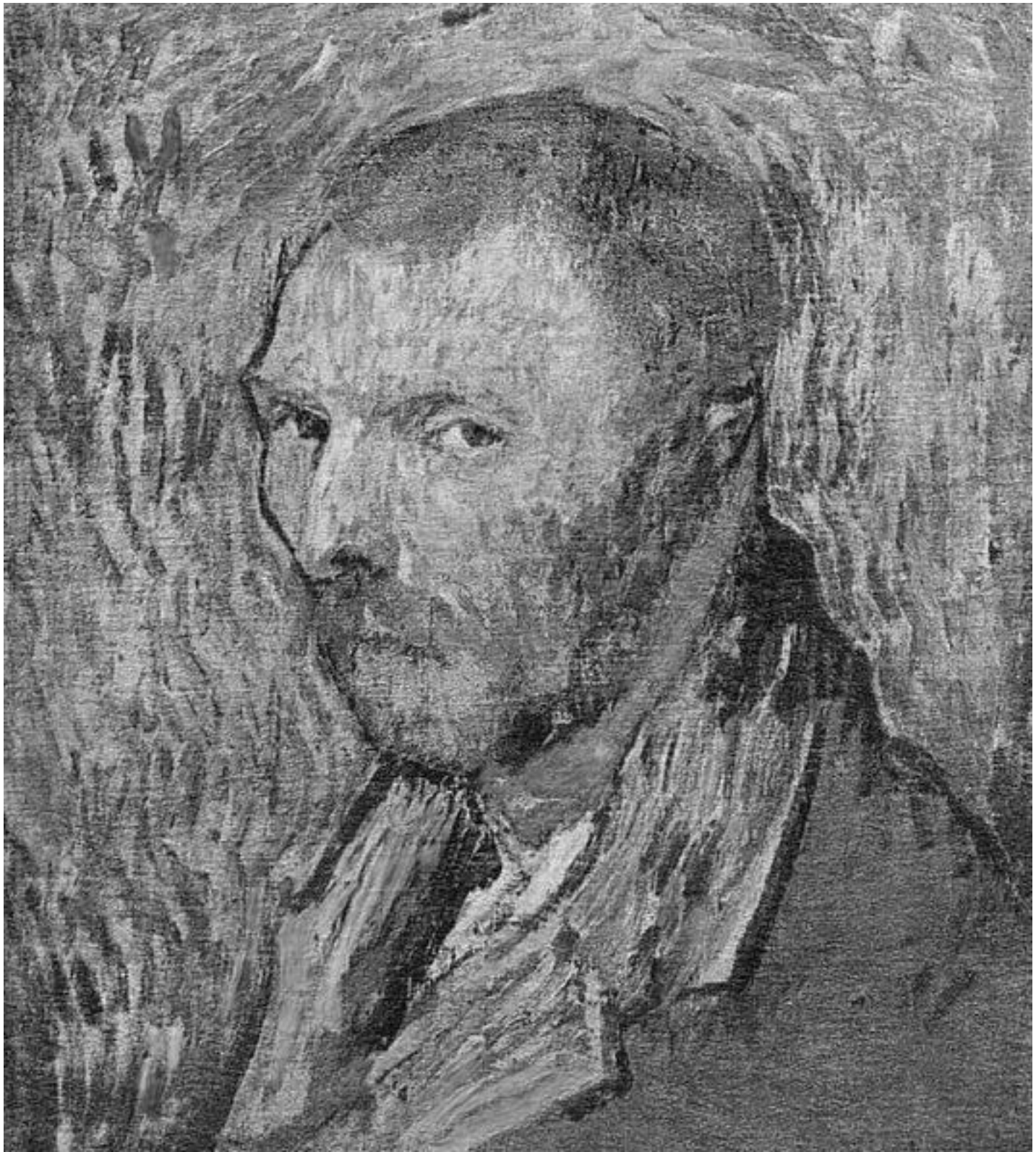
(450 300 3)

```
>> A1=im2double(im1BW);
>> imwrite(im1BW,"./courses/MATH347/paintings/im1BW.jpg");
>>
```

Figure 4. Image from which large-scale features (composition) is extracted

- Read a portion of another image of the same size as the first image. Small-scale features will be extracted from this second image, the painting brushwork style

```
>> im2=imread("./courses/MATH347/paintings/Vincent_van_Gogh_95.jpg");
>> im2BW=rgb2gray(im2); [qx,qy,nc]=size(im2); [qx qy nc]
>> A2=im2double(im2BW);
>> imwrite(im2BW,"./courses/MATH347/paintings/im2BW.jpg");
>>
```

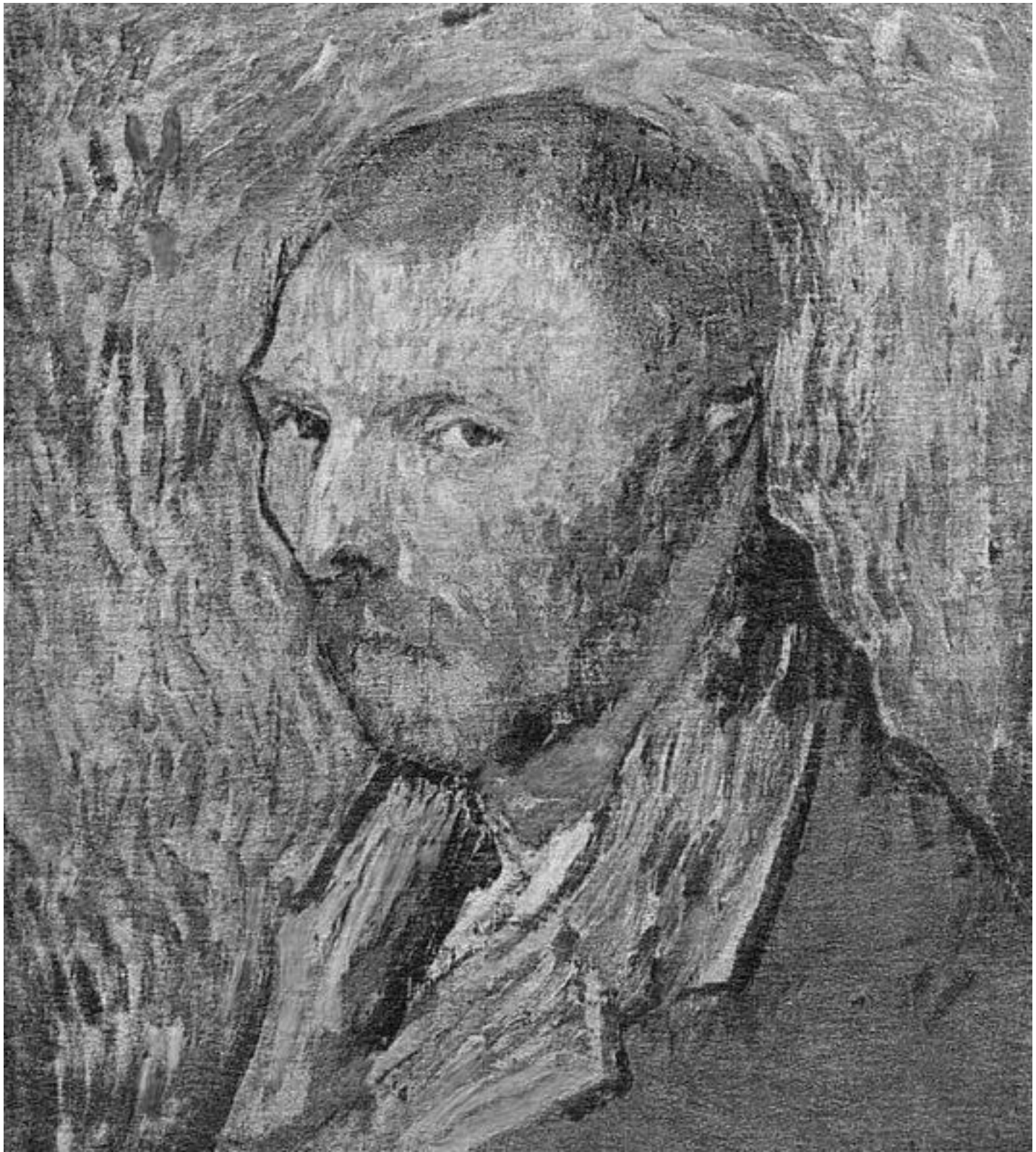


- Read a portion of another image of the same size as the first image. Small-scale features will be extracted from this second image, the painting brushwork style

```
>> im2=imread("./courses/MATH347/paintings/Vincent_van_Gogh_95.jpg");
>> im2BW=rgb2gray(im2); [qx,qy,nc]=size(im2); [qx qy nc]
```

```
( 614  535  3 )
```

```
>> A2=im2double(im2BW);
>> imwrite(im2BW,"./courses/MATH347/paintings/im2BW.jpg");
>>
```



- Compute the SVDs of the matrices whose components are the grayscale intensity values of the image

```
>> [U1,S1,V1]=svd(A1); [U2,S2,V2]=svd(A2(1:px,1:py));
```

- Form a new image from the first j modes of the composition image and modes from k to l of the brushstyle image. Weight the contribution of the large-scale and small-scale features by w_1, w_2 with $w_1 + w_2 = 1$

```
>> j=25; k=50; l=75; w1=0.25; w2=0.75;
>> composition = w1*U1(:,1:j)*S1(1:j,1:j)*V1(:,1:j)';
>> style = w2*U2(:,k:l)*S2(k:l,k:l)*V2(:,k:l)';
>> newimage = rescale(composition + style);
>> imwrite(newimage,"./courses/MATH347/paintings/newimage.jpg");
>>
```

Figure 7. New image with same composition as first image, but brush stroke mimicking that of image 2.