INFO449 E
Image, Video & Audio

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Session2 2016 - 2017
Date: 17 July 2017
Duration: 2 hours

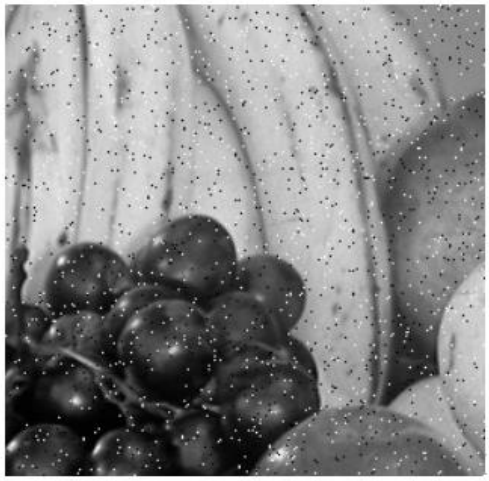
Lebanese University
Faculty of Sciences 5

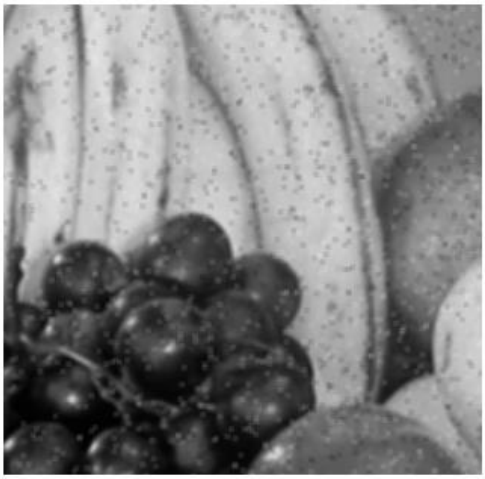
Exercise I: Multiple choices [12 pts]

Fill the following table with the correct answer.

1	2	3	4	5	6	7	8	9	10

1. The image in the figure on the left is affected by impulse noise (salt). If the image in the right figure is the result of convolving the image on the left with a convolution mask H having the form in the third figure, what are the most likely values for the parameters a and b?





$$\mathbf{H} = a \cdot \begin{bmatrix} 1 & 1 & 1 \\ 1 & b & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

a. a = 1; b = -8
b. a = 1/8; b = -8
c. a = 1; b = 1
d. a = 1/9; b = 1

2. Consider the original image below (an original image affected by salt and pepper noise). Most likely, the Fourier amplitude spectrum of this image will look like:

Fig a)

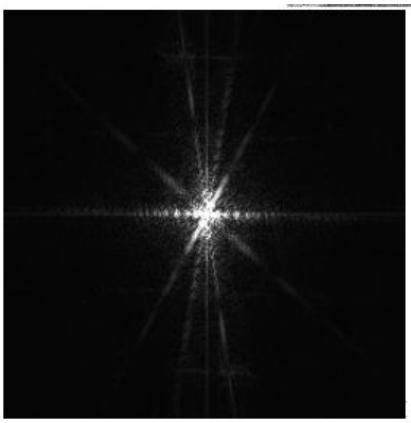


Fig. b)

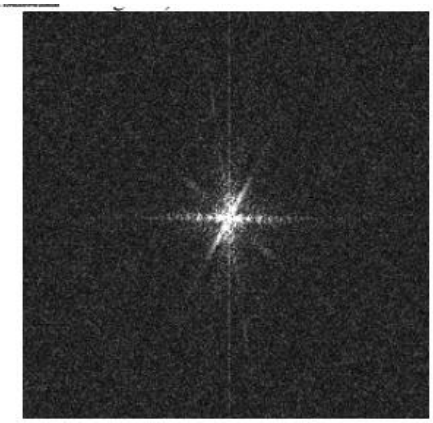


Fig. c)

Fig. d)

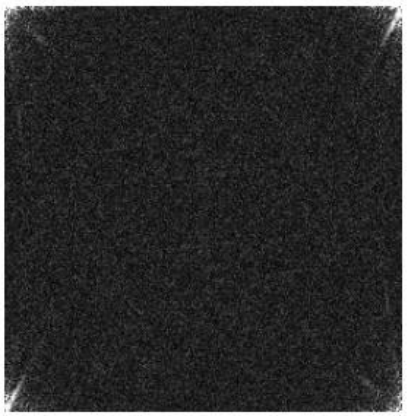


Fig. e)

a. Fig b)
b. Fig c)
c. Fig d)
d. Fig e)

3. In order to obtain the image in Fig. b) from the original image in Fig. a), the following point processing operation should be applied:

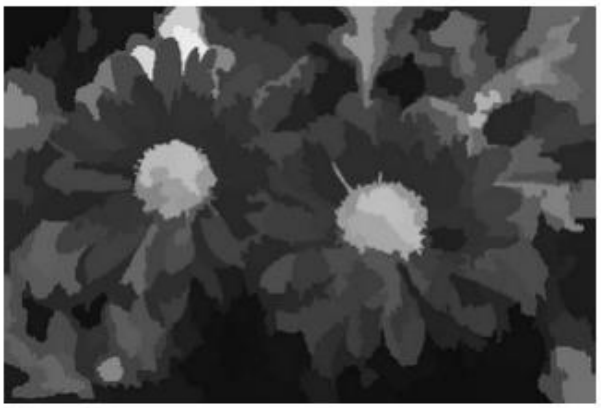


Fig. a

Fig. b.

a. Contrast compression;
b. negative
c. Histogram equalization
d. None of the above

4. On the original grey scale image from Fig. a), which of the following point processing operation(s) could have been applied to obtain the image in Fig. b)?

Fig. a

Fig. b

a. Contrast compression
b. Negative
c. Some grey scale slicing operation
d. Extraction of the most significant bit

5. Fig. a) represents the grey level histogram of a digital image. After processing this image, we get another grey level digital image with the grey level histogram shown in Fig. b). What is the most plausible processing applied on the original image from the ones below?
   a. Negative
   b. Binary thresholding
   c. Histogram equalization
   d. None of the above

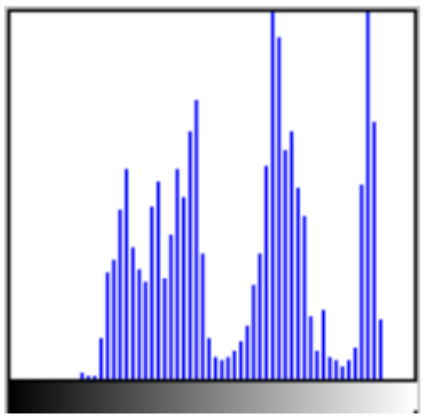


Fig. a)

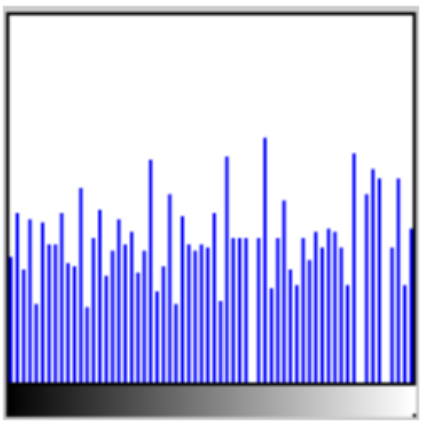


Fig. b)

6. A quantizer has the role of:

a. Converting a continuous variable into a discrete one	b. Reading signal samples discretely, at evenly spaced spatial positions
c. Improving the signal-to-noise ratio of an image	d. None of the above

7. In natural photographs, the highest energy is concentrated in:
   a. Lowest frequencies
   b. Highest frequencies
   c. Medium frequencies
   d. None of the above

8. JPG compression analyzes images in blocks of _____pixels in size and selectively reduces the detail within each block.

a. 8 x 8
b. 16 x 16
c. 32 x 32
d. 8 x 16

9. A source of 4 symbols a1, a2, a3, a4 having probabilities P(a1)=0.6, P(a2)=0.2, P(a3)=P(a4)=0.1 are encoded by four different encoding schemes and the corresponding codes are shown below. Which of the following gives us the best coding efficiency?
   a. a1 = 00, a2 =01, a3 =10, a4 =11
   b. a1 = 0, a2 =10, a3 =110, a4 =111
   c. a1 = 00, a2 =100, a3 =1100, a4 =1101
   d. a1 = 111, a2 =110, a3 =10, a4 =0

10. Match the following:

a. Hue	1. Amount of color
b. Saturation	2. Intensity
c. Brightness	3. Name of the color

Exercise II: True or False [10 pts]

For each of the following questions, fill the table with true or false.

1	2	3	4	5	6	7	8	9	10

1. Histogram of equalized image has better contrast than the original one.
2. Contrast stretching aims to reduce the contrast of an image.
3. When size of median filter increases, the image becomes more blurred.
4. Apply a max filter on an image twice has the same effect as if the filter is applied one time.
5. Two different images have necessarily two different histograms.
6. DCT is better for compression than DFT.
7. Median filter is more effective than average filter for salt and pepper noise.
8. Using machine intelligence algorithms, it is theoretically possible to search inside video files for a particular person.
9. Huffman and Arithmetic encoding both require symbol frequencies.
10. TV signals are sent in RGB.

Exercise III: Image Transformations [7 pts]

1	2	3	4	5	6	7

Given the table shown below in which the first column contains original images and the second column contains the transformed images. Fill in the table above for each image below, which

transformations among the ones below has been applied on the original image to obtain the transformed one. The transformations used are:

(a) image brightening, (b) image darkening, (c) gamma correction with lambda = 4, (d) gamma correction with lambda = 0.4, (e) equalization, (f) negative, (g) thresholding.

	Original image	**Transformed image**
(1)		
(2)		
(3)		

(4)		
(5)		
(6)		

(7)		

Exercise IV: Histograms [3 + 4 pts]

A. Given the following three images, associate each of them to one of the histograms below and indicate which one has low contrast, normal contrast or high contrast. Fill your answers in the table below.

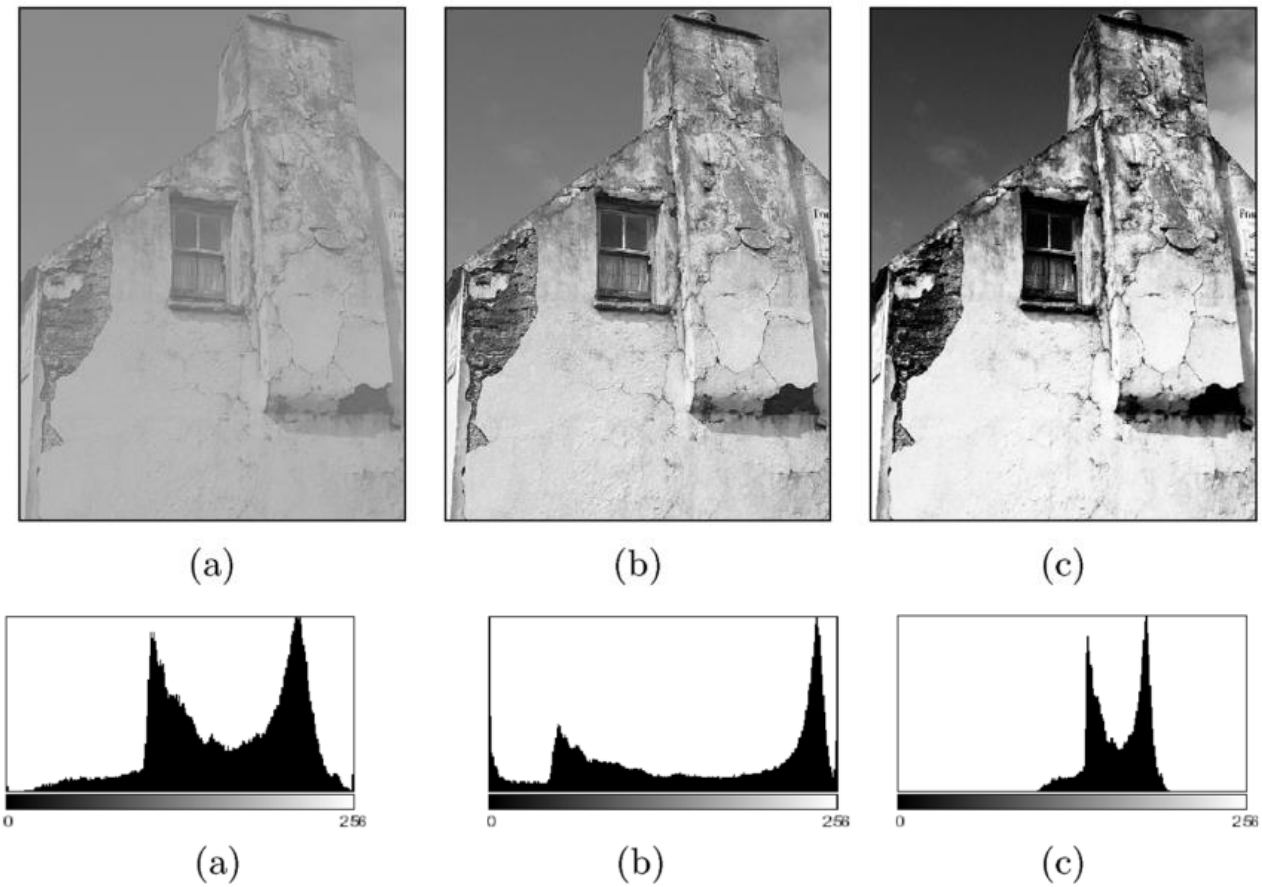
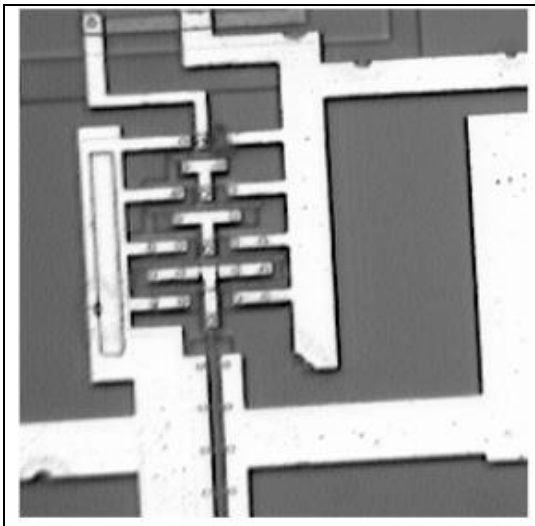


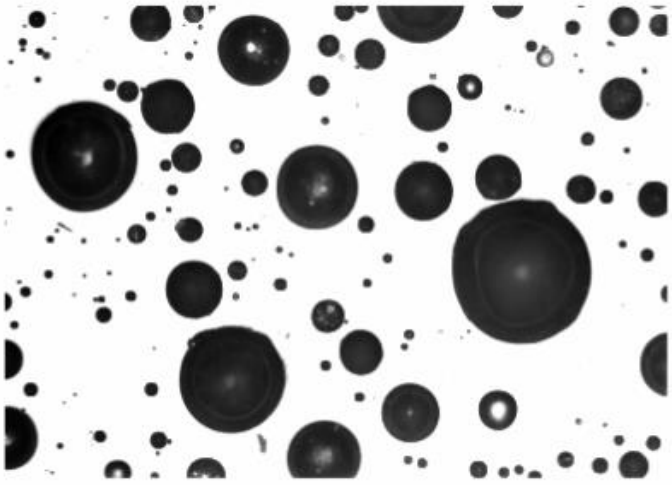
Image	Histogram	Contrast
(a)		
(b)		
(c)		

Answer table

B. Match each image with the corresponding correct histogram. Fill your answer in the table below.

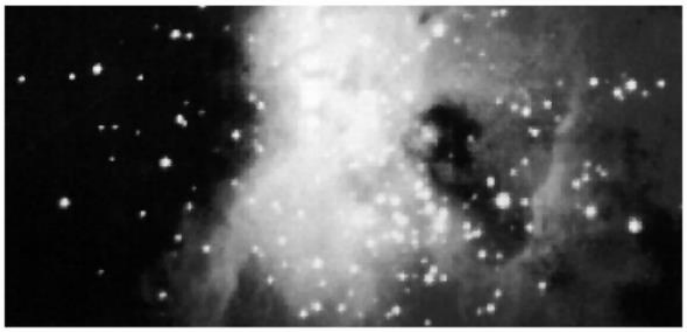


(a)

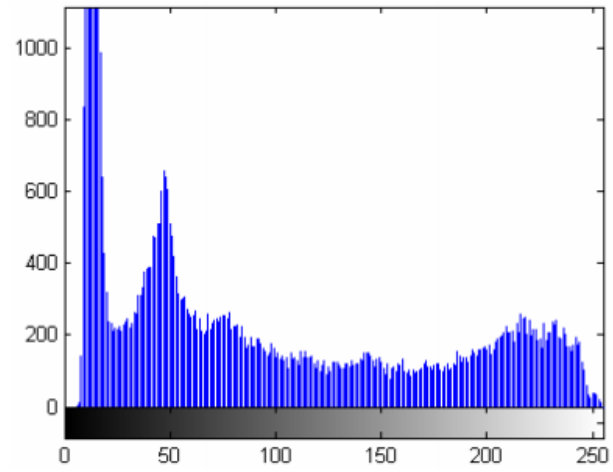


(b)

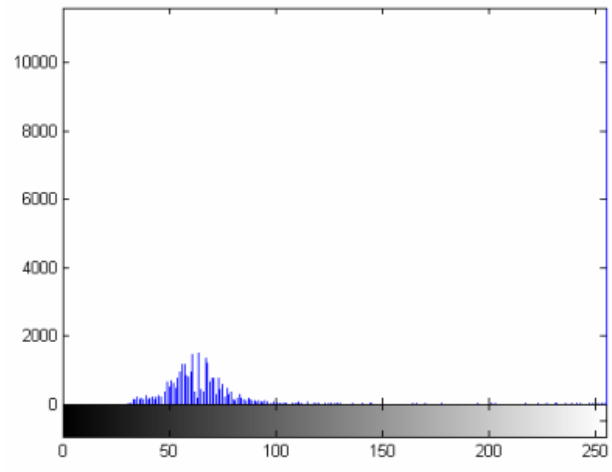
(c)



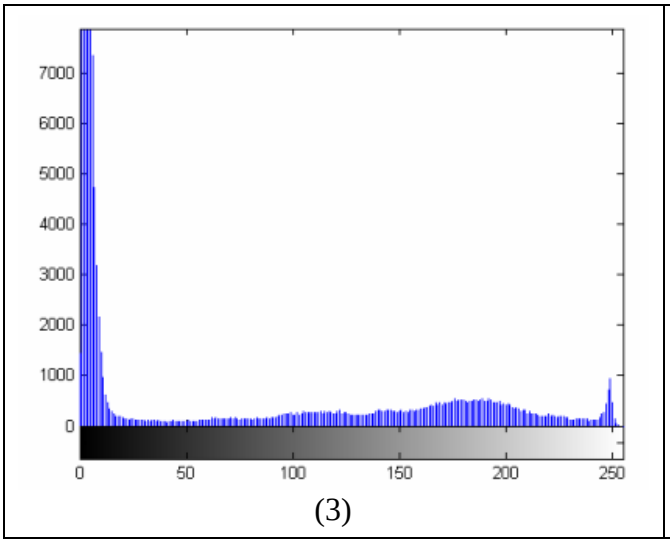
(d)



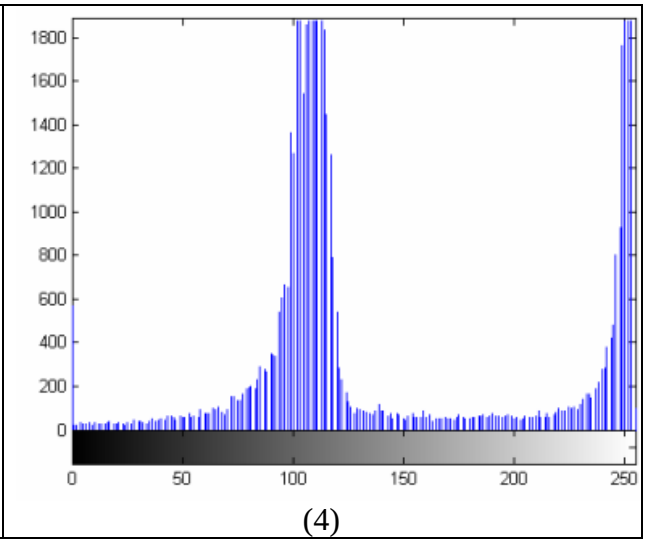
(1)



(2)



(3)



(4)

Image	Histogram
(a)	
(b)	
(c)	
(d)	

Answer table

Exercise V: Filtering [12 pts]

Let U be a 5×5 pixels block from a grey scale digital image, and U1 – a noisy version of this block (affected by salt and pepper noise with the levels 0 and 255).

$$\mathbf{U} = \begin{bmatrix} 16 & 16 & 120 & 120 & 120 \\ 16 & 16 & 120 & 120 & 120 \\ 16 & 16 & 120 & 120 & 120 \\ 120 & 120 & 120 & 120 & 120 \\ 120 & 120 & 120 & 120 & 120 \end{bmatrix} \quad \mathbf{U}_1 = \begin{bmatrix} 16 & 16 & 120 & 120 & 120 \\ 16 & 255 & 120 & 120 & 120 \\ 16 & 16 & 120 & 0 & 120 \\ 120 & 120 & 255 & 120 & 120 \\ 120 & 120 & 120 & 120 & 120 \end{bmatrix}$$

a. Apply the median filter on the noisy block U1 using filtering windows of 3×3 pixels. Do not perform the computations for the first and last lines and columns of the block U1; instead keep these lines in the resulting block the same as in U1.

b. Assess the performance of the median filtering in the removal of the noise in terms of the difference between the clean block U and the median filtered version of U1.

c. If one would like to apply a low pass linear filtering of U1 by a convolution operation with a low pass filtering mask, which of the following convolution masks would be suitable? Explain your answer.

$$\mathbf{H}_1 = \begin{bmatrix} -1 & 1 & -1 \\ 1 & 0 & 1 \\ -1 & 1 & -1 \end{bmatrix}; \mathbf{H}_2 = \frac{1}{8}\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}; ; \mathbf{H}_4 = \frac{1}{8}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 0 \end{bmatrix}.$$

d. Using a mask considered suitable from (b), compute the convolution result of the block U1 and assess again the performance of the resulting filtered image with the clean one. Compare the result with b and comment.

Exercise VI: Video size [12 pts]

Suppose that your company has been contacted to design the video system feeding a giant screen to be installed at a beach for the Opening Ceremony of the next Olympics. The digital transmission will be in HD - 1920×1152 (Y) and 960×1152 (Cr, Cb) at 25 Hz (8 bit/sample). Assume that you have available providing the necessary quality for each frame, a MPEG-2 Video codec reaching the compression factors indicated in the table below. To guarantee adequate random access, at least one frame has to be coded in Intra mode every 300 ms. Finally, to reach the compression factors in the table below, no more than three B frames should be introduced consecutively. Assuming that the intention is to minimize the bitrate to reduce the transmission costs, determine:

Frame Type	Luminance Compression Factor	Chrominance Compression Factor
I	10	15
P	15	20
B	20	30

a. The best M and N values characterizing the (regular) temporal coding structure of I, P and B frames to be adopted fulfilling the requirements above while minimizing the transmission bitrate.

b. The average bitrate associated to the coding structured determined in a).

c. The initial visualization delay at the receiver assuming that the transmission is made at the bitrate determined in b), the N value is the one defined in a), M=N, and the critical compression factors for the I frames (for the ‘more difficult’ frames) are 10% lower than the average compression factors indicated in the table above (while they are the same for the other frame types). Assume also that the coding and decoding times are negligible.

Exercise VII: Motion Vectors [10 pts]

Consider the encoding of a 640x480 video at 30 fps using I and P frames. To encode the P and B frames, we consider 8x8 macroblocks and a search area of k = 8. How many MADs is done to find the best motion vector for each macro-bloc in a P frame if the search method used is:

a. Sequential search.

b. Logarithmic search.

c. Hierarchical with 4 levels.

Suppose now that the search method is the logarithmic one.

d. How many macroblocks are there in each image.

Consider now 10 minutes of video knowing that one I frame is inserted after every 8 consecutive P frames and there are 4 B frames between each couple of P frames as follows:
I B B B B P B B B B P B B B B P B B B B P B B B B P B B B B I ……

e. How many MADs are done for the 10 minutes of the video.