# CS 5330 Week 4 Homework

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## Questions

### 1. Give an intuitive definition of the meaning of eigenvectors in the context of image analysis (think about the faces example).

***Answer:***
In image analysis, feature vectors can be understood as a "special direction" that can tell us the most important change patterns in image data. For example, in face recognition, feature vectors are some "basic face templates" that can represent the main features of all faces.

For example:

The first feature vector may be an "average face", which is the common feature of all faces, such as the general outline of the face.

The second feature vector may be some details, such as the position of the eyes or the shape of the nose.

The third feature vector may be a more subtle change, such as the shape of the mouth or the shadow of the face.

These feature vectors are actually "common patterns" extracted from all face data. They can help us simplify complex face images into several main feature directions. In this way, we can use these feature vectors to represent each face. For example, a face can be regarded as a combination of these "templates".

### 2. You have the set of eigenvalues 0.3, 0.25, 0.24, 0.12, 0.06, 0.02, 0.01

### A. What is the dimensionality of original data?

***Answer:***
The dimension of the original data is 7 because there are 7 eigenvalues.

### B. How many dimensions of the data would you need to keep to represent 75% of the variation?

***Answer:***
We need to sort the eigenvalues from large to small, and then add them up until they reach 75%.

Sorted eigenvalues: 0.3, 0.25, 0.24, 0.12, 0.06, 0.02, 0.01, the first three principal components: 0.55 + 0.24 = 0.79 → 79% is greater than 75%, so we need to keep 3 dimensions.

**C. How many dimensions of the data would you need to keep to represent 90% of the variation?**

***Answer:***

The first four principal components: 0.79 + 0.12 = 0.91 → 91% is greater than 90%, so 4 dimensions need to be retained.

**D. If you wanted to see best visualization of the data in 2-D, how would you do it?**

***Answer:***

To visualize the data in 2-D, we need to select the two principal components that best explain the variance of the data, that is, the principal components corresponding to the two largest eigenvalues, so we choose 0.3 and 0.25 because they have the largest eigenvalues and explain 30% and 25% of the variance respectively.

**3. Find an example of aliasing in visual media. It can be spatial, temporal, or spectral aliasing. Include either a link to your example or the example itself in your submission, along with a description.**

***Answer:***

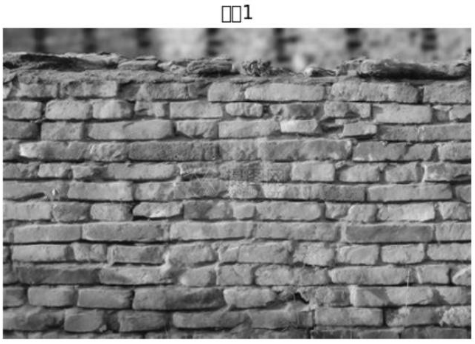
https://www.youtube.com/shorts/3FlN0DPf-2c

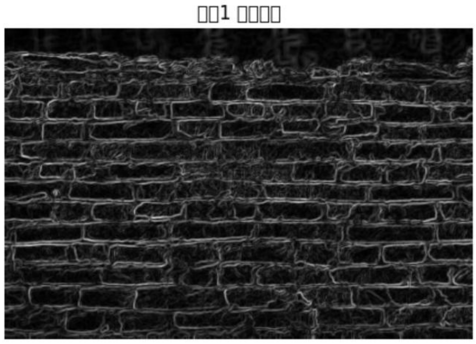
This video shows a typical time aliasing phenomenon, called the Wagon Wheel Effect. You can see that when the wheel is spinning quickly, it looks like it is spinning backwards or standing still instead of spinning forward normally.

In the video, the picture is shot at a certain frame rate, and each frame is a sample of the continuous motion. When the speed of the wheel rotation approaches or exceeds the frame rate, the sample will "not keep up" with the actual motion, causing the wheel to look like it is reversing or standing still.

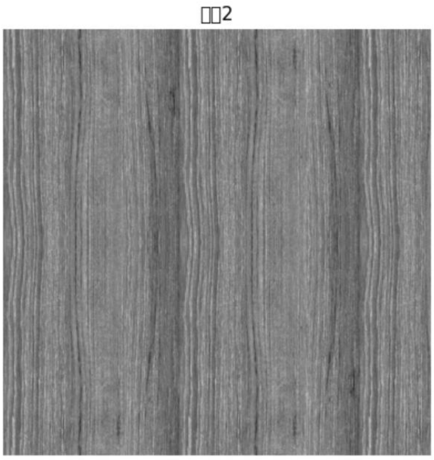
**4. Select two different textures and use your project 1 program to show the gradient magnitude for each texture. Would average energy of gradient magnitude be a useful feature for differentiating these two images?**

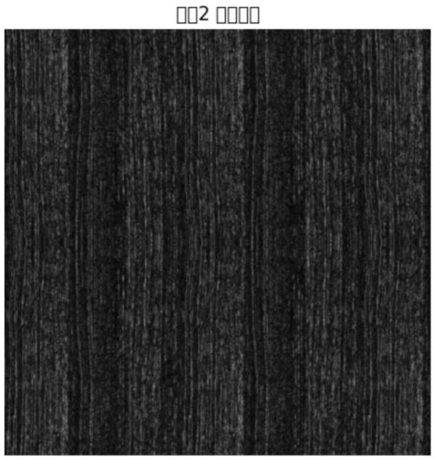
***Answer:***




Texture 1 Average Gradient Energy: 25763.529877436205




Texture 2 Average Gradient Energy: 8700.24204826355

The average gradient energy can be used as a useful feature to distinguish wood grain from brick walls.

### 5. When using Law's texture filters, why do you think it is helpful to divide the responses by the Gaussian filter (L5 x L5)?

***Answer:***

Normalizing the response of the Law's filter with a Gaussian filter (L5 x L5) can remove the effects of illumination, enhance local contrast, and normalize the response scale. In this way, the extracted texture features are more stable and reliable, suitable for subsequent analysis and classification.