Tutorial 5

Qu Xiaofeng, Teaching Asistant
quxiaofeng.at.polyu@gmail.com

COMP435p
Biometrics Authentication

February 20, 2012

The Hong Kong Polytechnic University
香港理工大學

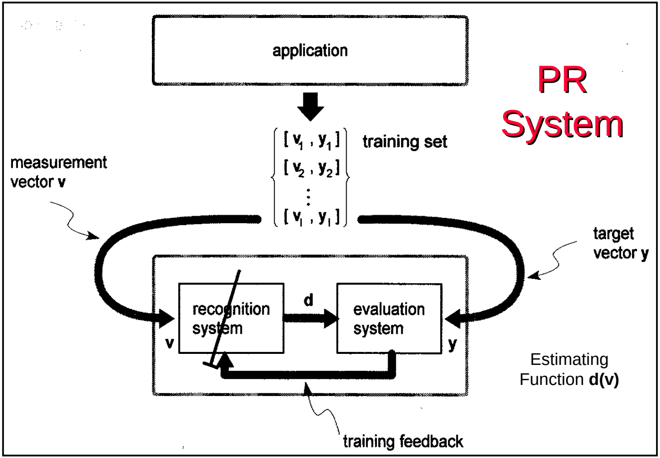
Table of Contents

Outline

Problem 1.1 PR system

Explain about PR system using the figure in P6:4

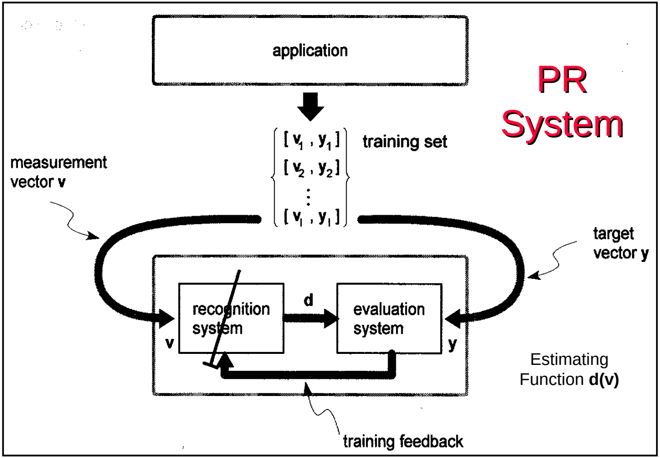
Problem 1.1 PR system



Problem 1.2 Decision Function

What is the definition about Decision Function (P6:4-9)

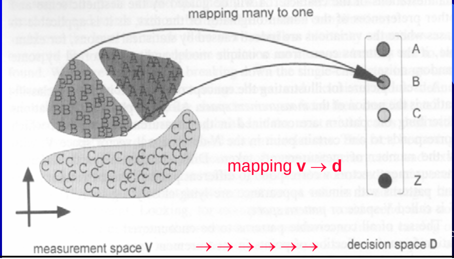
Problem 1.2 Decision Function



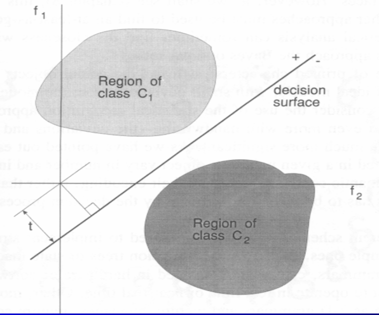
Problem 1.2 Decision Function

Pattern Classification

- The principal function of a PR system is to yield decisions *concerning the class membership of the patterns* with which it is confronted.
- In order to accomplish this task, it is necessary to establish some rule upon which to base these decisions. One important approach is the use of decision functions.



Problem 1.2 Decision Function



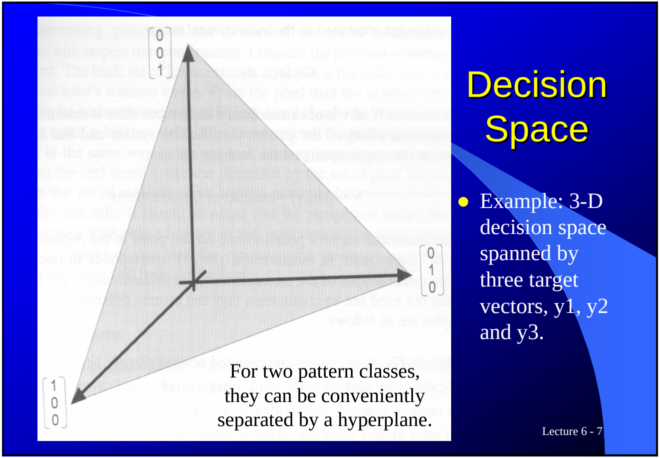
Decision Function

- Example: 2-D decision space

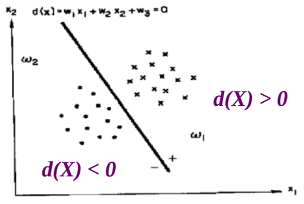
- As a way of introduction to this relatively simple concept, consider two pattern classes, which can be conveniently separated by a line.

Biometric Authentication Lecture 6 - 6

Problem 1.2 Decision Function



Problem 1.2 Decision Function



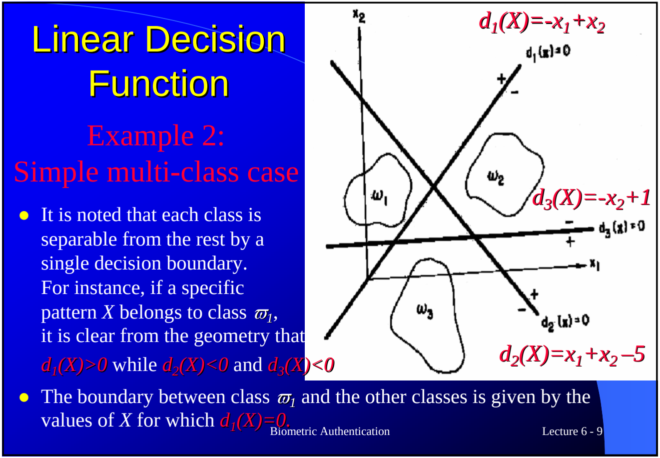
Decision Function

Example 1:
Two pattern classes

- Let $d(X)=w_1x_1+w_2x_2+w_3=0$ be the equation of a separating line where *W's* are parameters and x_1 and x_2 are the general coordinate variables. It is clear that any pattern *X* belonging to ϖ_1 will yield a positive quantity when substituted in *d(X)*.
- Similarly, *d(X)* becomes negative upon substitution of any pattern *X* from ϖ_2. Therefore, *d(X)* can be used as a ***decision (or discriminate) function*** since, given a pattern *X* of unknown classification, we may say that *X* belongs to ϖ_1 if $d(X) > 0$, or to ϖ_2 if $d(X) < 0$.

Biometric Authentication Lecture 6 - 8

Problem 1.2 Decision Function

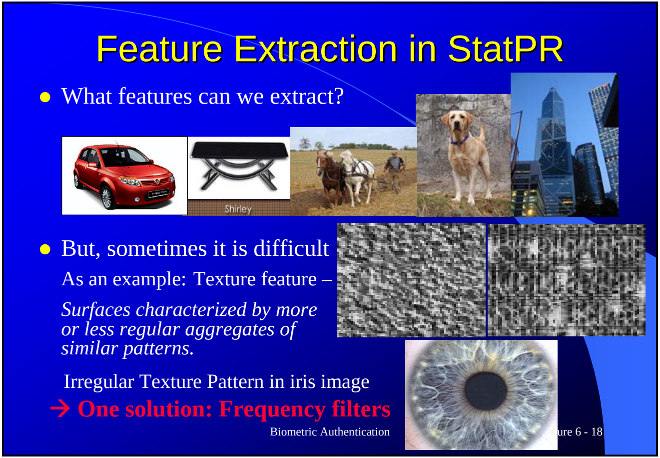


The seperating line or the seperating hyperplane on different conditions.

Problem 1.3 time domain and frequency domain

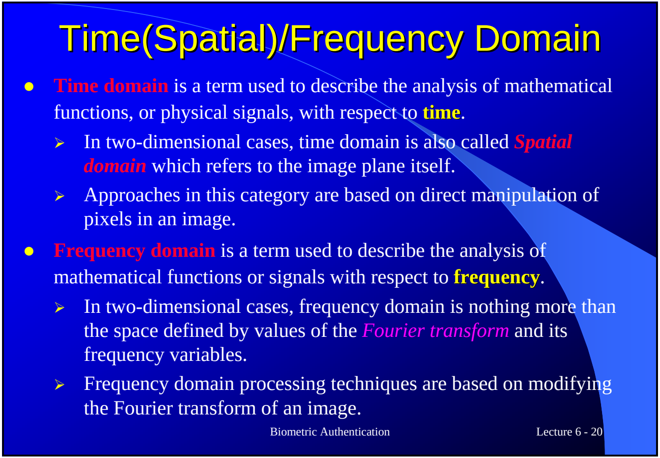
Why we need the frequency domain for feature extraction (P6:18)? What difference between time(spatial) domain and frequency domain? (P6:20-22)

Problem 1.3 time domain and frequency domain

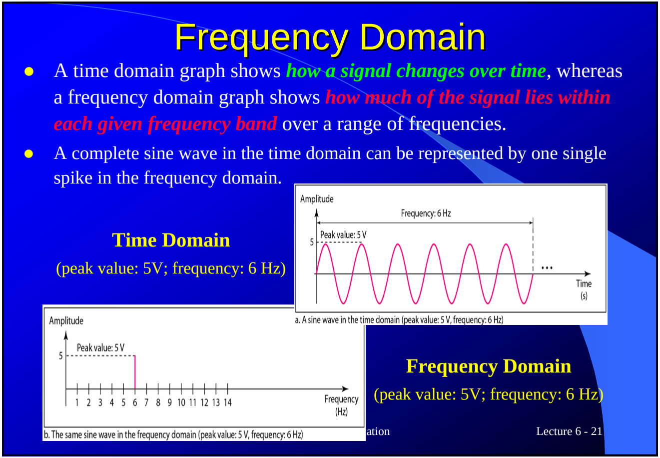


To extract features like irregular texture pattern in images

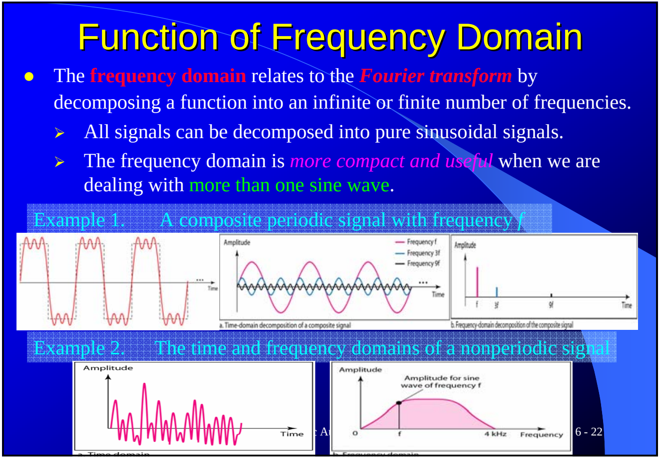
Problem 1.3 time domain and frequency domain



Problem 1.3 time domain and frequency domain



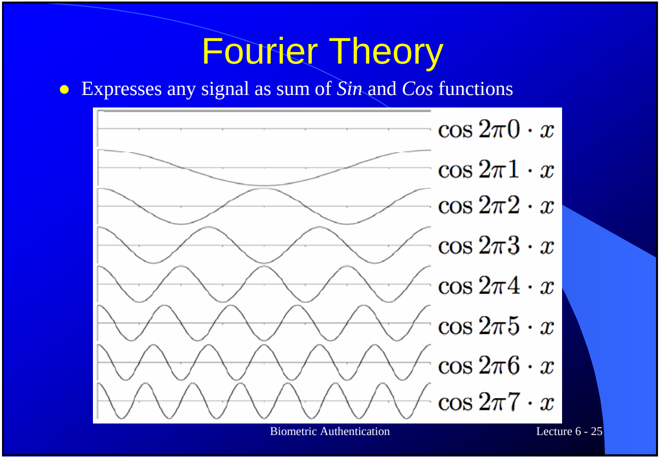
Problem 1.3 time domain and frequency domain



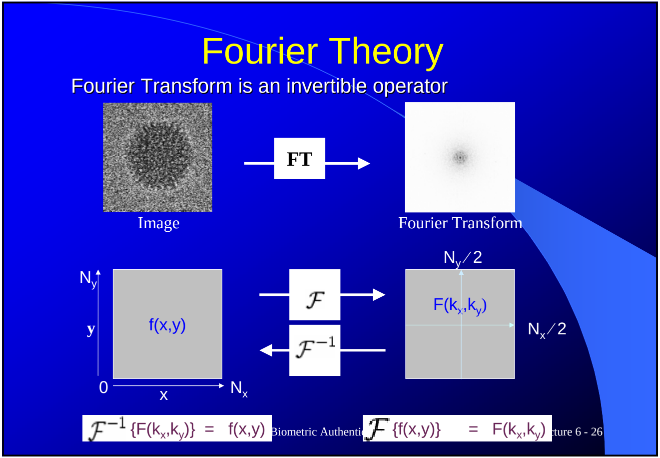
Problem 1.4 Fourier and Gabor

Understand two frequency transforms, Fourier transform (P6:25-28) and Gabor transform (P6:40)

Problem 1.4 Fourier and Gabor



Problem 1.4 Fourier and Gabor



Problem 1.4 Fourier and Gabor

1-D Fourier Transform

$$\mathcal{F}\left\{ f(x) \right\} = F(s)$$

1)
$$F(s) = \int_{-\infty}^{\infty} f(x) e^{-i2\pi xs} dx$$
$$f(x) = \int_{-\infty}^{\infty} F(s) e^{i2\pi xs} ds$$

2)
$$F(s) = \int_{-\infty}^{\infty} f(x) e^{-ixs} dx$$
$$f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(s) e^{ixs} ds$$

3)
$$F(s) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(x) e^{-ixs} dx$$
$$f(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} F(s) e^{ixs} ds$$

The same results but different formats

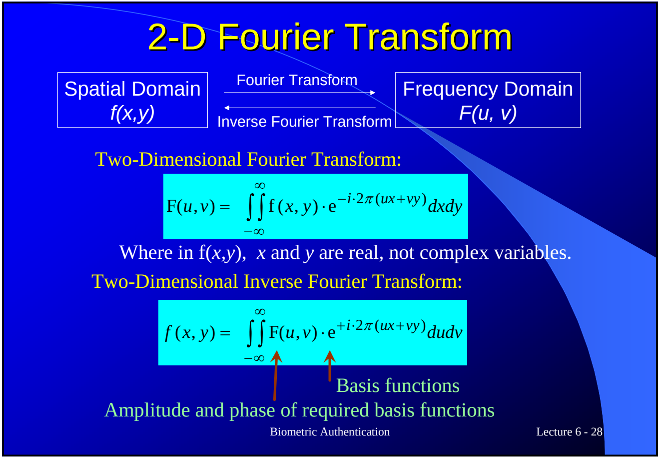
where

$$e^{ix} = \cos x + i \sin x$$

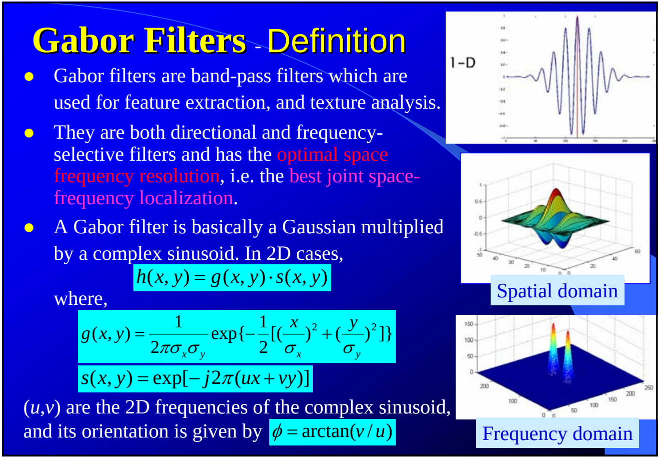
Euler's Formula

Biometric Authentication Lecture 6 - 27

Problem 1.4 Fourier and Gabor



Problem 1.4 Fourier and Gabor

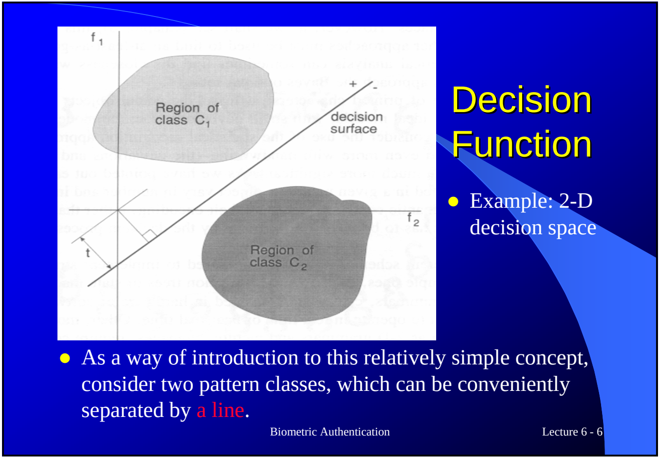


Outline

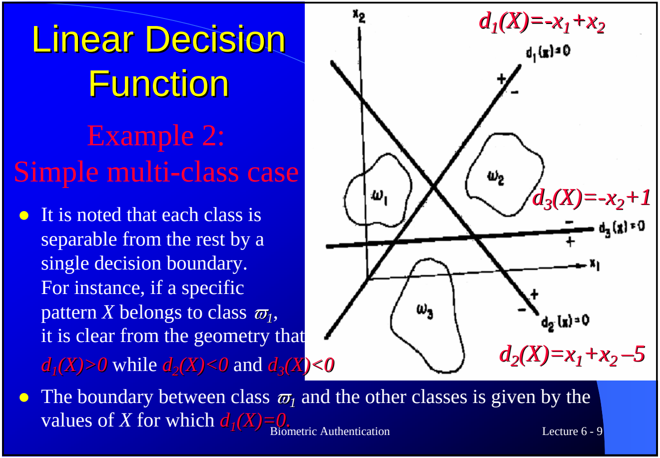
Problem 2: Indeterminate Region

Note that there are some regions in which a decision cannot be reached, which are labeled as IR (Indeterminate Region)(see P6:6). In these regions either more than one decision functions are greater than zero or all decision functions are less than zero. There are three functions which have been defined In P6:9, including d1(x), d2(x) and d3(x). Which regions can be taken as IR?

Problem 2: Indeterminate Region



Problem 2: Indeterminate Region



d1(x), d2(x) and d3(x): 000, 011, 101, 110, 111

Outline

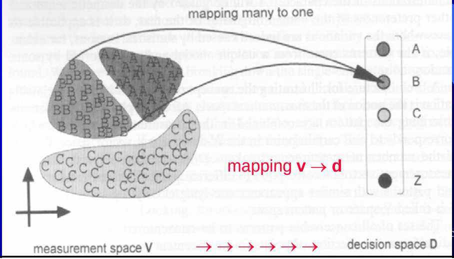
Problem 3: Classifier

There are two spaces, Measurement Space and Decision Space, which are given in P6:5. Pattern classification is defined to map measurement features to one of the classes. Could you design a simple classifier (see P4:36 and P4:39) to implement the given function?

Problem 3: Classifier

Pattern Classification

- The principal function of a PR system is to yield decisions *concerning the class membership of the patterns* with which it is confronted.
- In order to accomplish this task, it is necessary to establish some rule upon which to base these decisions. One important approach is the use of decision functions.



ture 6 - 5

Problem 3: Classifier

Inner Products

We can analyze minimum-distance classifiers easily by using a little **linear algebra**. Let **x** stand for a column vector of d features, x1, x2, ... , xd. By using the **transpose operator** ' we can convert the column vector **x** to the row vector **x**':

$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_d \end{bmatrix} \qquad \mathbf{x}' = [x_1 \ x_2 \ \ldots \ x_d]$$

The **inner product** of two column vectors **x** and **y** is defined by

$$\mathbf{x}'\mathbf{y} = x_1 y_1 + x_2 y_2 + \ldots + x_d y_d = \sum_{k=1}^{d} x_k y_k$$

Lecture 4 - 36

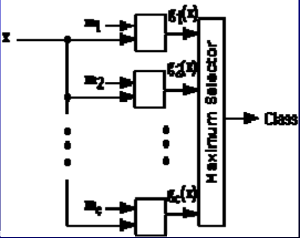
Problem 3: Classifier

Linear Discriminants (2)

Let us define the **linear discriminant function** g(**x**) by

$$g(x) = \mathbf{m}'\,\mathbf{x} - 0.5\,\|\,\mathbf{m}\,\|_2 .$$

Then we can say that a minimum-Euclidean-distance classifier classifies an input feature vector **x** by computing *c* linear discriminate functions g1(**x**), g2(**x**), ... , gc(**x**) and assigning **x** to the class corresponding to the maximum discriminant function. We can also think of the linear discriminant functions as measuring the correlation between **x** and **m**k, with the addition of a correction for the "template energy" represented by || **m**k $\|_2$. With this correction included, a minimum-Euclidean-distance classifier is equivalent to a maximum-correlation classifier.



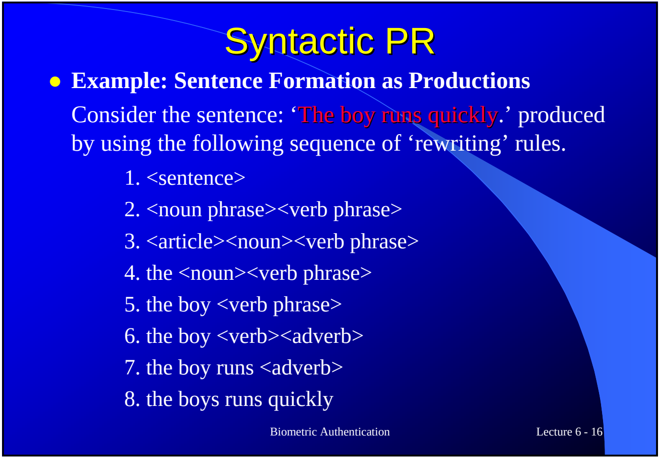
Biometric Auth

Outline

Problem 4: Syntactic PR

An example for Syntactic PR is given in P6:16 by the written (English) language, where a paragraph may be decomposed into sentences $\rightarrow$ words $\rightarrow$ letters $\rightarrow$ strokes. Consider the sentence: "The powerful computer could do many things for us." produced by using your sequence of "rewriting" rules.

Problem 4: Syntactic PR



Problem 4: Syntactic PR

- $< sentence >$
- $< noun\ phrase >< verb\ phrase >< preposition\ phrase >$
- $< noun\ phrase >< verb\ phrase >< noun\ phrase >< preposition\ phrase >$
- $< artical >< adjective >< noun >< auxiliary\ verb >< main\ verb >< adjective >< noun >< preposition >< pronoun >$
- $the\ < adjective >< noun >< auxiliary\ verb >< main\ verb >< adjective >< noun >< preposition >< pronoun >$
- $the\ powerful\ < noun >< auxiliary\ verb >< main\ verb >< adjective >< noun >< preposition >< pronoun >$

Problem 4: Syntactic PR

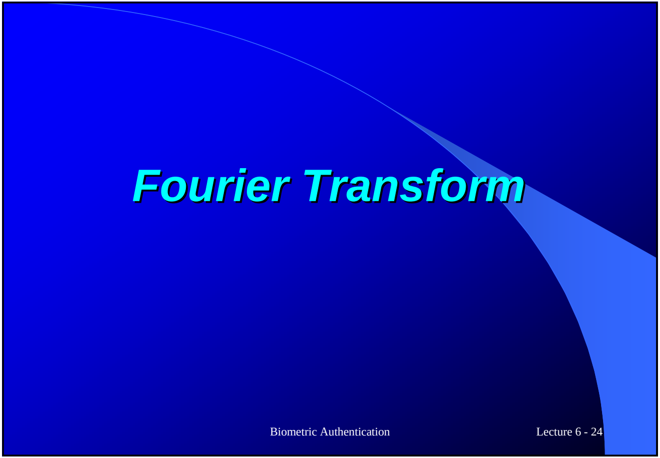
- *the powerful computer* < *auxiliary verb* >< *main verb* >< *adjective* >< *noun* >< *preposition* >< *pronoun* >
- *the powerful computer could* < *main verb* >< *adjective* >< *noun* >< *preposition* >< *pronoun* >
- *the powerful computer could do* < *adjective* >< *noun* >< *preposition* >< *pronoun* >
- *the powerful computer could do many* < *noun* >< *preposition* >< *pronoun* >
- *the powerful computer could do many things* < *preposition* >< *pronoun* >
- *the powerful computer could do many things for* < *pronoun* >
- *the powerful computer could do many things for us*

Outline

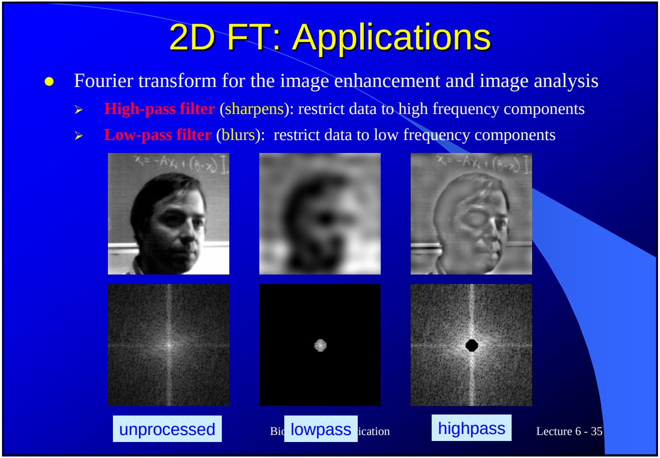
Problem 5: Frequency Transform

Frequency transform can be applied to many different applications (P6:24, 35-38, 41-45). Could you consider a new application using frequency transform in image processing and pattern recognition?

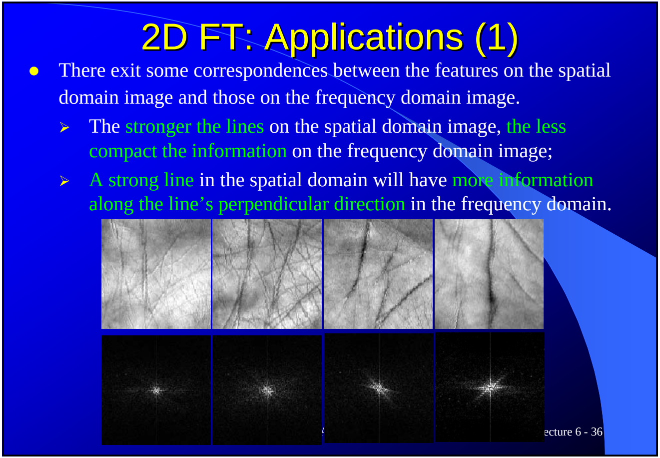
Problem 5: Frequency Transform



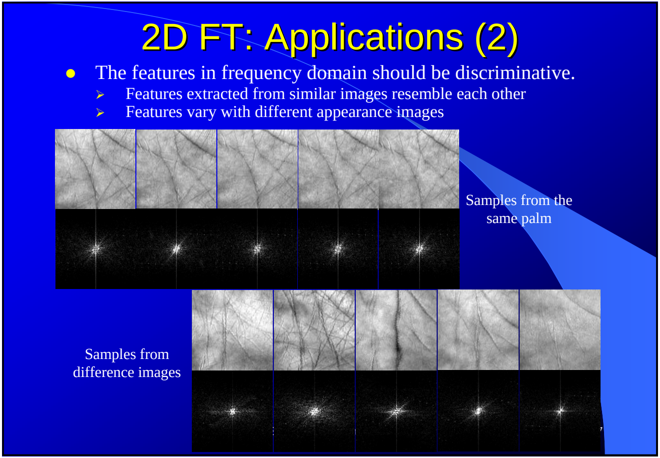
Problem 5: Frequency Transform



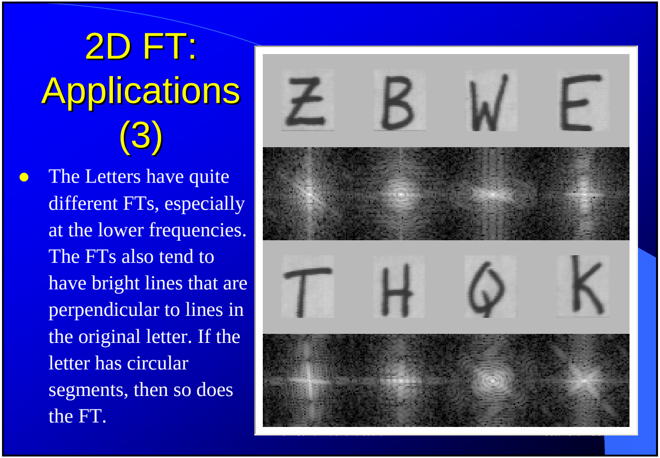
Problem 5: Frequency Transform



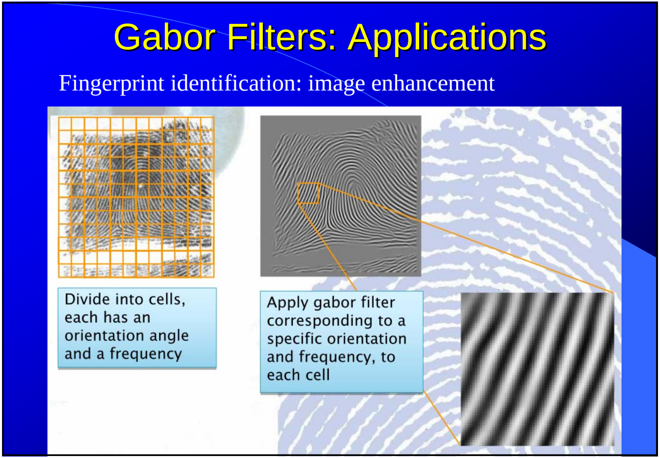
Problem 5: Frequency Transform



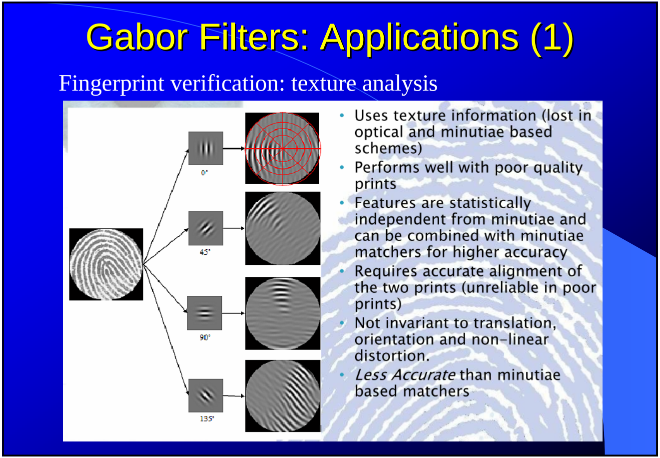
Problem 5: Frequency Transform



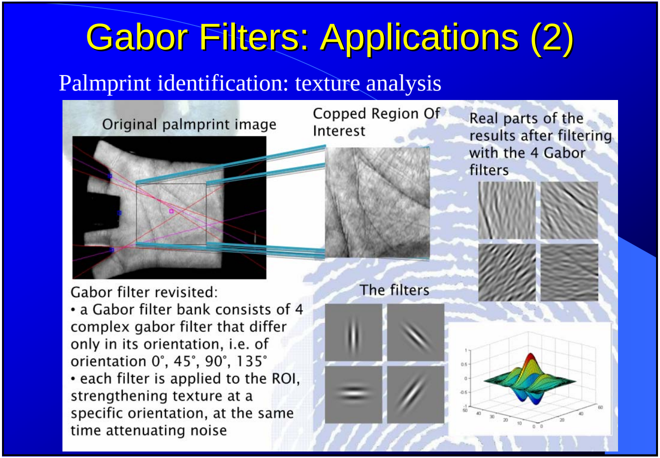
Problem 5: Frequency Transform



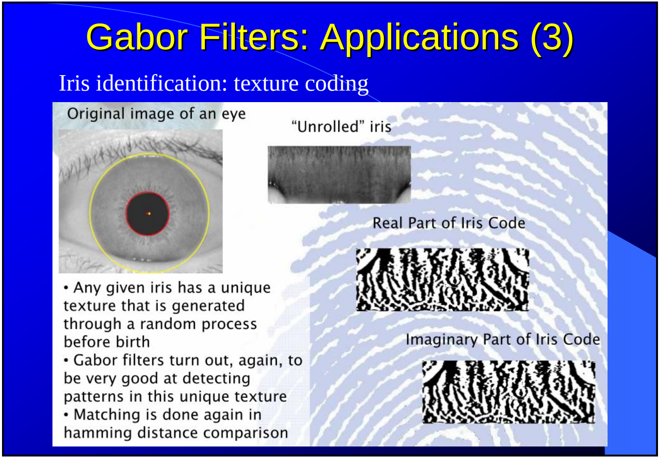
Problem 5: Frequency Transform



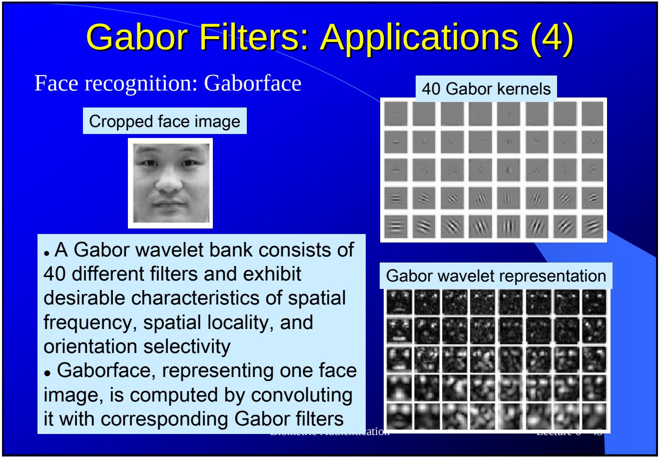
Problem 5: Frequency Transform



Problem 5: Frequency Transform



Problem 5: Frequency Transform

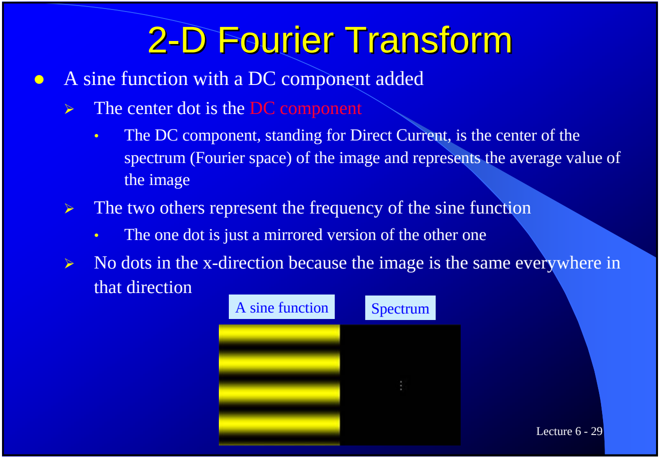


Outline

Problem 6: Frequency Transform

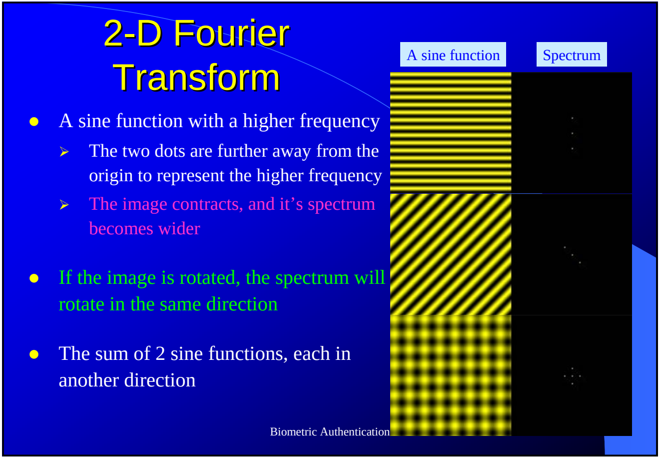
What results could you obtain from the examples using 2D Fourier Transforms in P6:29-34?

Problem 6: Frequency Transform



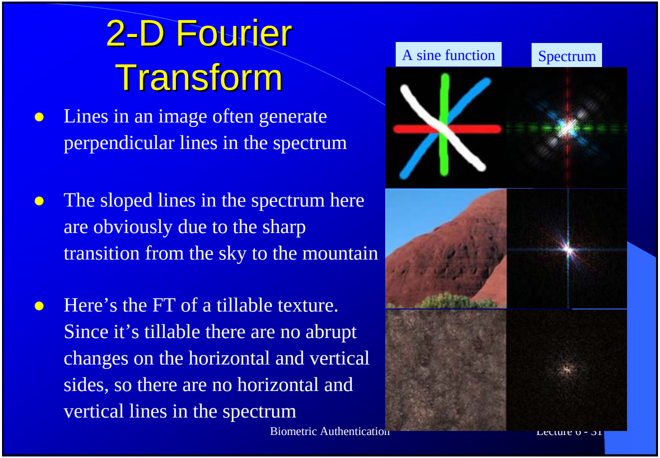
constant frequency - dot

Problem 6: Frequency Transform



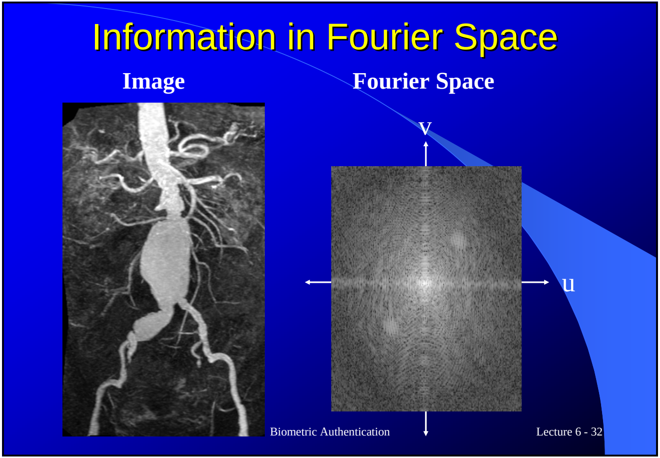
directions of the frequencys

Problem 6: Frequency Transform

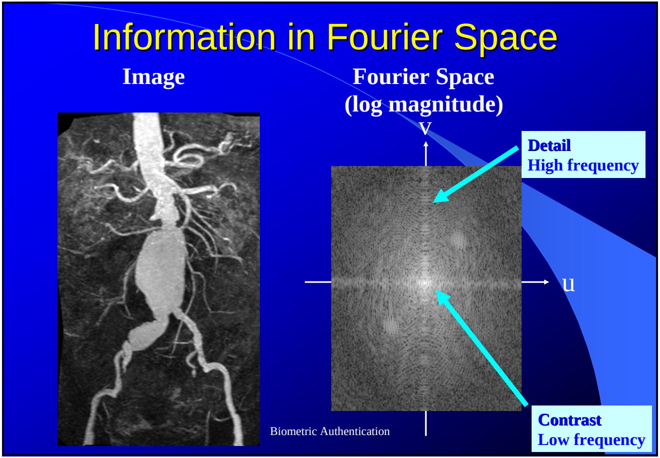


lines gets resposes in their orthogonal directions

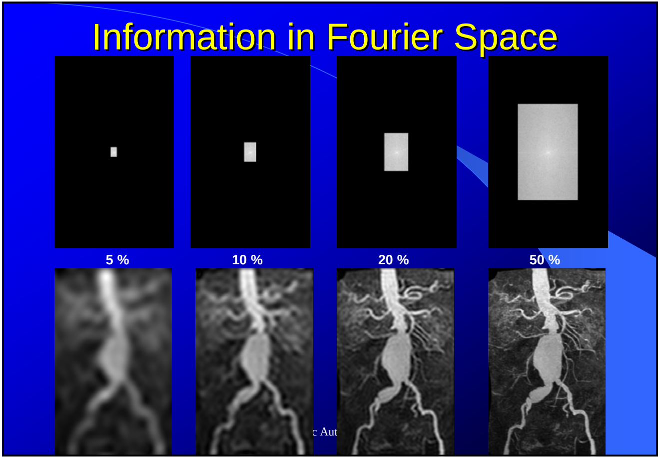
Problem 6: Frequency Transform



Problem 6: Frequency Transform



Problem 6: Frequency Transform



frequency resolution

Problems

Any questions?