FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	IT28X07
	BIOMETRICS
CAMPUS	AUCKLAND PARK CAMPUS (APK)
ASSESSMENT	JULY 2020 **MEMO**

Please read the following instructions carefully:

1. This is a time restricted open book assessment. Answer **all** the questions in a text processor or on paper, which is scanned and submitted.

2. Write *cleanly* and *legibly* on any handwritten parts (if applicable).

3. This paper consists of 10 pages.

4. Ensure that your submission to **Eve** is *complete* and done *before* the cut-off time.

SECTION A - SHORT QUESTIONS
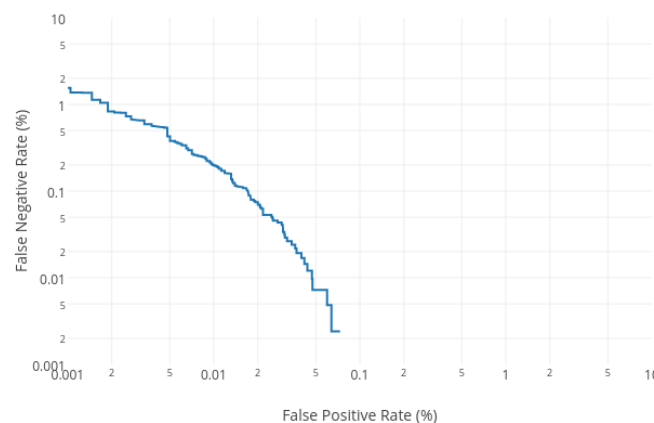
QUESTION 1
General Biometric Systems

(a) Describe two (2) **benefits** of passwords, which biometric-based au-   (4)
thenticators do **NOT** share.

> **Solution:**
>
> $$2 marks each$$
>
> 1. Cheaper
>
> 2. More familiar
>
> 3. Passwords are a secret

(b) Analyse the following image and answer the questions that follow: (6)

1. What does the image depict? (2)
2. What is the formula for calculating precision? (2)
3. What is the formula for calculating recall? (2)

> **Solution:**
>
> 1. Detection Error Tradeoff (DET) curve
>
> 2. Precision = TruePositives / (TruePositives + FalsePositives)
>
> 3. Recall = TruePositives / (TruePositives + FalseNegatives)

Total: 10

QUESTION 2
Fingerprint Recognition

(a) Provide the coordinates for **four** examples of bifurcations in the finger-print binary image below: (4)

	0	1	2	3	4	5	6	7	8	9
0	1	0	1	0	0	0	1	1	1	0
1	1	0	1	0	1	0	1	1	0	0
2	1	1	0	1	1	1	1	0	1	1
3	0	1	1	1	1	1	1	0	0	0
4	1	1	1	0	0	1	1	0	1	0
5	1	1	0	0	1	1	1	1	0	1
6	1	0	0	1	1	0	1	0	0	1
7	1	1	0	1	1	0	1	0	0	0
8	1	1	0	1	1	1	1	1	1	0
9	0	0	1	1	1	0	1	0	0	1

Solution:

1. (2,1)

2. (5,5)

3. (2,8)

4. (8,4)

5. (2,1)

6. (8,6)

7. etc.

(b) Briefly describe the capture **process**, along with which **sensors** are used for hand geometry recognition. (4)

Solution:

1. Light source

2. Pegs on a surface between fingers

3. Mirror on side for depth of hand

4. Camera to capture the outlines

Total: 8

QUESTION 3
Face Recognition

(a) List four (4) **face detection class types** that each face detection al- (4)
gorithm can be classified into.

> **Solution:**
>
> 1. Knowledge-based (top-down with level analysis)
>
> 2. Feature-based (bottom-up with invariant feature analysis)
>
> 3. Template matching (physical component, colour or edge ana-
>   lysis)
>
> 4. Appearance-based (learnt face model analysis)

(b) Analyse the equation below, describe which **method** the following (4)
equation relates to, along with the **role** it plays in face recognition:

$$G_c[i, j] = Be - \frac{(i^2 + j^2)}{2\sigma^2} cos(2\pi f(i\ cos\theta + j\ sin\theta))$$

> **Solution:**
>
> It depicts a Gabor filter (which uses a Gaussian kernel function mod-
> ulated by a sinusoidal plane wave for a respective frequency and
> orientation. It is used during preprocessing

Total: 8

QUESTION 4

(a) Briefly describe three (3) **limitations** of speaker recognition. (3)

> **Solution:**
>
> 1. Recording of sound
>
> 2. Illness
>
> 3. Time to present
>
> 4. Complexity

(b) If audio signal A is 0.1 $watt/m^2$ and audio signal B is 1.2 $watt/m^2$, what is (4)
its **power difference** (in watts dB)? Secondly, will a human experience
pain listening to audio signal B?

> **Solution:**
>
> $10log\frac{0.1}{1.2} = -10.79$watts dB
> Yes a human will experience pain listening to signal B

Total: 7

QUESTION 5

Retina recognition-based biometric systems are known to be accurate and can be used in highly secure environments. Discuss the **process** required to capture a retina sample, along with the **steps** required to process and match a sample. For each step in your discussion be sure to elaborate on the following aspects:

- The sensor that can be used to capture a sample.
- A brief description of the steps followed to process and match a sample.
- The algorithms used at each step.

Solution:

Sensor (1) either:

- Near infra red camera

Capture(2):

- Alignment so that light can reach the back of eye
- Capture around fovea

Preprocessing(2):

- Grayscale
- CLAHE

Feature Extraction(2):

- Bifurcations
- Any valid fingerprint equivalent

Matching(1):

- Support Vector Machine (SVM)
- Other classifier

Total: 8

QUESTION 6

For the greyscale pixels below derive the **local binary pattern** (*hint* use the centroid as a threshold) matrix/image (with radius=1, clockwise and zero padding parameters):

$$\begin{bmatrix} 229 & 85 \\ 165 & 64 \\ 216 & 44 \\ 70 & 132 \\ 116 & 50 \end{bmatrix}$$

Solution:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix}$$

10011011 = 155_{10} 00000101 = 5_{10} 10110101 = 181_{10} 01001010 = 74_{10}

$$\begin{bmatrix} 155 & 5 \\ 181 & 74 \end{bmatrix}$$

Total: 10

QUESTION 7

Multi-modal and Pervasive Systems

(a) Discuss **decision-level biometric fusion**, along with which methods can be used to achieve it. (4)

Solution:

In decision level fusion, each classifier operating under a binary hypothesis, applies a threshold on the match score and renders its decision regarding the presence (=1) or absence (=0) of a genuine individual. The decisions from multiple classifiers are then fused in order to generate the final decision.

- Likelihood ratio

- PSO

- Z-normalisation

- etc.

(b) Discuss what **smart textiles** are, along with their potential applications. (4)

Solution:

Clothing or material that has technology integrated within it. There are Passive smart textiles, Active smart textiles and Very smart textiles.

1. ECG

2. EMG

3. EEG

4. GSR, etc.

Total: 8

QUESTION 8

Biometric Trends and Esoteric Biometrics

(a) Discuss **brain wave recognition**, along a brief description on **how** you would implement such a system. (4)

Solution:

An EEG classification system where certain parts are taken into account:

1. 10-20 channel capture using EEG

2. Preprocessed using a band pass filter

3. Deriving energy variants

4. Classifying using a ML classifier such as SVM

Otherwise any valid implementation decision should suffice

(b) Provide a reason why **DNA** recognition has not become ubiquitous. (2)

Solution:

1. Computational overhead

2. Not exactly real-time

3. Cost

4. Privacy issues

5. etc.

Total: 6

QUESTION 9

Vulnerabilities and Countermeasures

Draw an **attack tree** that highlights the **weaknesses** that will typically be found for a **fingerprint-smart card multimodal access control** system such as the one found at the University of Johannesburg **AND** provide a discussion on two **reasons** why you would want to subvert a biometric system, **ALONG** with two ways to **safeguard** against them.

Solution:

Any attack tree that depicts common attacks (and their subsequent conditions that need to be met for that respective attack).
Drawing (2)
Root attack such as certain PAD attacks (2)
Conditions for attack (2)

The reasoning includes (any two) (2):

- Gaining false access

- Avoid identification

- Denial of Service

- Identity theft

Safeguards include (any two) (2):

- Spoof detection

- Watermarking

- Human Verification

- Multimodal Biometrics

- Passive and Active Biometrics

- Mitigating Weak Users

- Biometric Encryption

- Revocable Biometrics

Total: 10

SECTION B - LONG QUESTIONS

QUESTION 10

Following a recent surge of working from home transitions for many companies a company (Company Y) has just released an employment monitoring tool that works using employee smart phones. The application can determine whether you are busy with work sitting on your desk or whether you are busy with non-work activities such as being on social media or playing games. However, an employee who works at a South African company (company W) that uses this monitoring tool has lashed out at this tool and is taking both companies to "the highest court in the land". Write a report on the following:

- The common criticisms of biometrics.
- The ethical considerations related to biometrics.
- The legal aspects related to biometrics
- Your opionion on whether the companies should be able to use this tool.

Solution:

Criticisms of biometrics(3):

- Loss of Anonymity
- Big brother scenario
- Function Creep
- Reduction of reasonable expectation of privacy
- Cultural, Religious & Philosophical objections

Ethical considerations(3):

- Privacy
- Cultural
- Safety
- etc.

Legal impact (3)

- ECT Act - Definition of biometrics as information and its associated consent
- RICA - The authorisation process to gain access to the system

- POPI - The protection of personal information bill that protects end users from exposure of information, especially biometric attributes.

- PAIA - Restricts the access another organisation has over their information.

Their opinion on the case (2) (perhaps it not a good idea?)

Total: 10

QUESTION 11

The South African government is doing a review of the passport and they are considering the extension of the current passport to support multiple biometric attributes at the border. However, it is difficult to understand the standards for international station and vendor compliance. Comprehensively discuss **standards** in biometric systems, and your selected **biometric attributes** suitable for passports by paying special attention to the following:

- Examples of standards organisations for biometric systems and the challenges they currently face.
- Your selected biometric attributes for passports, along with a justification
- Advantages and disadvantages of your selected biometrics.
- Your opinion on whether including additional biometrics in passports is warranted.

Solution:

Standards struggle with interoperability but examples of organisations include (4):

- ISO (derived from the Greek iso)

- ANSI (American National Standards Institute)

- X9

- SABS (South African Bureau of Standards)

Selected biometrics and justification (4)

Advantages and disadvantages of biometric technology(4)

- Expands dimensions of interaction

- Susceptible to sensor-based limitations (such as sensitivity and calibration)

- Speed of gestures limited by hardware

- Requires physical space

- Requires user acceptance

Opinion(3): Any valid reason for a choice.   **(15)**

Total: 15

— End of paper —