FACULTY OF SCIENCE
ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	IT28X07: BIOMETRICS
CAMPUS	AUCKLAND PARK CAMPUS (APK)
ASSESSMENT	JULY 2021 **MEMO**

DATE: 2021-07   **SESSION:** 08:00 - 10:00

ASSESOR(S):   PROF D.T. VAN DER HAAR

EXTERNAL MODERATOR: DR D. BROWN (RU)

DURATION: 120 MINUTES   **MARKS:** 85

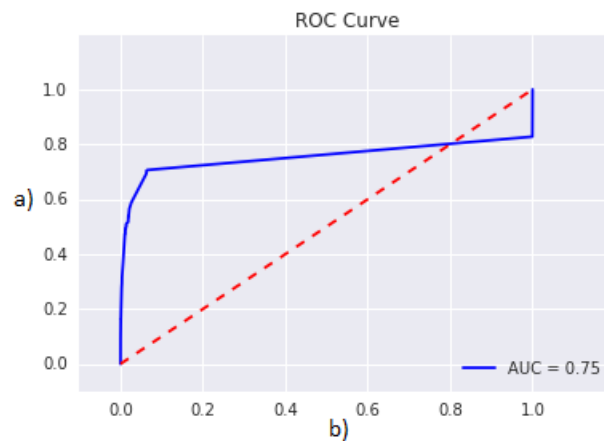Please read the following instructions carefully:

1. You must complete this assignment yourself within the prescribed time limits.

2. You are bound by all university regulations please special note of those regarding assessment, plagiarism, and ethical conduct.

3. You must complete and submit the *"Honesty Declaration : Online Assessment"* document along with your submission to EVE. No submissions without an accompanying declaration will be marked.

4. Your answers together with the declaration must be submitted in the following format. STUDENTNUMBER_SURNAME_INITIALS_SUBJECTCODE_ASSESSMENT e.g. *202012345_SURNAME_IAM_IT28X07_EXAM.pdf*

5. No communication concerning this test is permissible during the assessment session except with Academy staff members. The invigilator is available via email (dvanderhaar@uj.ac.za) and on the "UJ Biometrics" Discord server throughout the assessment (https://discord.gg/A6NQwemFqb).

6. This paper consists of 10 pages excluding the cover page.

SECTION A - SHORT QUESTIONS

QUESTION 1

General Biometric Systems

Analyse the following image depicting a ROC curve and answer the questions that follow:

1. Provide the labels for a) and b) (2)

2. What is wrong with the figure? (2)

3. How do you fix it? (2)

Solution:

1. a) TPR b) FPR

2. Poor performance / imbalanced data

3. Different method / more data or a tolerant method

Total: 6

QUESTION 2

Fingerprint Recognition

(a) Provide the coordinates, in the format CR where C the column and R depicts the row (e.g. J0), for **four** examples of **bifurcations** in the fingerprint binary image below (where 1 depicts a ridge and 0 a valley): (4)

	A	B	C	D	E	F	G	H	I	J
0	0	1	1	1	1	1	1	0	1	1
1	0	0	0	1	0	0	0	1	0	1
2	0	0	0	0	0	0	1	0	0	0
3	1	1	0	0	0	0	0	1	1	1
4	0	1	1	1	1	1	1	0	1	0
5	0	0	1	0	0	0	0	1	0	1
6	0	0	0	0	0	0	0	1	1	1
7	0	0	0	1	1	0	1	1	0	0
8	1	1	1	1	0	0	1	1	0	0
9	1	0	1	0	1	0	1	0	1	1

Solution:

1. D0

2. H1

3. I3

4. C4

5. H6

6. D8

7. E7, G3 (ends)

8. (8,6)

9. etc.

(b) Define ELBP its role in fingerprint recognition.   (2)

Solution:

Extended (although technically Entropy would be accepted and may even be a good idea!) based Local Binary Pattern. It is an alternative feature extraction method.

Total: 6

QUESTION 3
Face Recognition

(a) What are the core three (3) **contributions** in Viola and Jones' "Robust Real-Time Face Detection" article?   (3)

Solution:

1. Integral images

2. A classifier with Adaboost learning

3. Combining classifiers as cascades

(b) Briefly describe the **EigenFaces** algorithm.   (3)

Solution:

1. Used by Turk and Pentland for face classification (based on work by Sirovich and Kirby in 1987)

2. Eigenvectors derived from the covariance matrix of the probability distribution from multiple face images.

3. Multiple faces are used to create a lower dimension space that can be used for cheaper comparison.

4. The main method used to achieve this dimensional reduction is called principal component analysis (PCA).

Total: 6

QUESTION 4

(a) Briefly describe two (2) **limitations** of speaker recognition.   (2)

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
No a human will not experience pain listening to signal B

Total: 6

QUESTION 5

Iris recognition-based biometric systems are known to be accurate and can be used in highly secure environments. Discuss the **process** required to capture a iris 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.
- Examples of algorithms that can be used at each step.

Solution:

There are many variants but one example:
Sensor (1) either:

- Near infra red camera

Segmentation(2):

- segmentation
- alignment

Preprocessing(1):

- Grayscale
- CLAHE
- Rubber sheet model

Feature Extraction(1):

- barcode creation

Matching(1):

- Support Vector Machine (SVM)
- Other classifier
- Technically XOR too (Daughman)

Total: 6

QUESTION 6

For the grayscaled 4x4 pixels below derive the **local binary pattern** matrix (starting off at the top left corner with radius=1 in a clockwise direction):

$$\begin{bmatrix} 73 & 196 & 155 & 232 \\ 190 & 14 & 80 & 122 \\ 65 & 63 & 32 & 11 \\ 252 & 39 & 211 & 28 \end{bmatrix}$$

Solution:

0.5 marks per value

$$\begin{bmatrix} 00010100 & 00000000 & 00010001 & 00000000 \\ 00100000 & 11111111 & 11111111 & 11000000 \\ 01000100 & 10001011 & 01100111 & 11000111 \\ 00000000 & 11010001 & 00000000 & 10000001 \end{bmatrix} \begin{bmatrix} 20 & 0 & 17 & 0 \\ 32 & 255 & 255 & 192 \\ 68 & 139 & 103 & 199 \\ 0 & 209 & 0 & 129 \end{bmatrix}$$

Total: 8

QUESTION 7

Multi-modal and Pervasive Systems

(a) For a finger and palmprint multimodal biometric authentication system discuss which level of **biometric fusion** would be best with a justification and with which methods can be used to achieve it.   (4)

Solution:
For the most part feature level fusion is probably the best fit, because of additional accuracy and tolerance to error (with a simple feature concatenation strategy). If there is sound logic to their argument this may differ.

(b) What are the **disadvantages** of implementing a user owned based biometric system that uses smart phones?   (4)

Solution:

1. Interoperability

2. Cost

3. Computational power

4. Hygiene

5. User acceptance/buy-in

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 two limitations of **facial thermography** based recognition.   (2)

> **Solution:**
>
> 1. High cost
>
> 2. Low image resolution
>
> 3. High image noise
>
> 4. Lack of rigorous testing

Total: 6

QUESTION 9

Vulnerabilities and Countermeasures

Draw an **attack tree** that highlights the **weaknesses** that will typically be found for a **in-screen fingerprint reader** system such as the one found in many flagship smart phone handsets (and the new iPhone 13), **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)
>
> Safeguards include (any two) (2):

- Spoof detection

- Watermarking

- Human Verification

- Multimodal Biometrics

- Passive and Active Biometrics

- Mitigating Weak Users

- Biometric Encryption

- Revocable Biometrics

Total: 8

SECTION B - LONG QUESTIONS

QUESTION 10

In South African law, the POPI act has just become enforceable from 1 July 2021. Many industries say that it will have far reaching consequences and it impacts everyone. How do you think it will impact the field of biometrics in South Africa? Write a report on the following:

- Biometrics within a legal context.
- POPI and its scope
- How POPI relates to biometrics
- Your opionion on whether it will be a big impact.

Solution:

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.

POPI (3):

- Each citizen has a right to reasonable privacy
- They should have control of access to information
- Violators should be prosecuted
- etc.

Relation biometrics(3):

- Biometric data is sensitve information
- System requirements will change
- Controls in place to avoid abuse
- Liability may shift in certain service providers

Their opinion on the case (2) (It will mostly impact)

Total: 10

QUESTION 11

Studies have shown that pigs and cows that move more and eat well lead to a better quality meat product. Farmer Brown has approached you to help build a system that is built around this finding and can infer potential meat quality from certain animal candidates. Comprehensively discuss the design and implementation of an alternative way to achieve the same task (scratch detection because of itchiness). It should include which **biometric attribute** you would use, the **sensor(s)** and **algorithms** you would use and how you would **evaluate** the system. The report should pay special attention to the following:

- The biometric attribute you would use, along with the associated sensor(s)
- The algorithms you would use to implement it.
- Advantages and disadvantages of your selected biometric technology.
- The metrics that should be used to evaluate biometric systems.

Solution:

Appropriate biometric attribute with the right sensors (2)

Algorithms for(5):

- Preprocessing

- Feature Extraction

- Classification

Advantages and disadvantages if biometric technology(4)

- Any biometric

- The appropriate advantages and disadvantages

Test metrics(4):
Match accuracy: Type 1 error (FRR), Type 2 error (FAR)
Match threshold relationship - Improvement of one at the cost of the other
Failure to enrol rate (FTER)
Failure to acquire rate (FTAR)
User throughput
Matching algorithm throughput
Retrial rate (RR)
Cumulative Match Rate (CMR)

Total: 15

— End of paper —