FACULTY OF SCIENCE
ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	IT28X07: BIOMETRICS
CAMPUS	AUCKLAND PARK CAMPUS (APK)
ASSESSMENT	JUNE 2021

DATE: 2021-06	**SESSION:** 08:30 - 10:30
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 5 pages excluding the cover page.

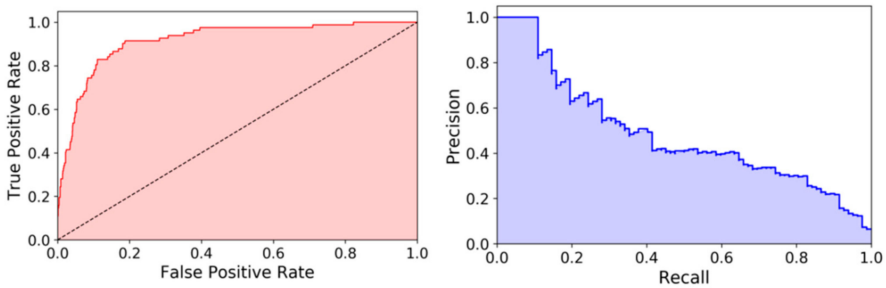
SECTION A - SHORT QUESTIONS

QUESTION 1

General Biometric Systems

(a) Provide a score (low, medium or high) for **retina recognition** against the Collectability, Acceptance and Circumvention (more is good) **biometric requirements** for 2021 (i.e. as it stands today). (3)

(b) Analyse the following image for the same system and answer the questions that follow: (3)



1. What does the above overall image depict? (1)
2. Describe a potential issue found when analysing the image (2)

Total: 6

QUESTION 2

(a) Provide the coordinates, in the format CR where C the column and R depicts the row (e.g. J0), for **four** examples of **ridge ends** 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	1	1	0	0	0	0	0	0	1	0
1	1	1	0	1	1	0	1	1	0	0
2	1	0	0	1	1	1	1	0	1	0
3	0	0	1	0	1	1	1	1	1	1
4	0	1	1	0	1	0	1	0	1	1
5	0	0	1	1	0	1	0	0	0	1
6	1	0	0	0	0	1	1	0	0	0
7	1	0	1	0	1	1	0	0	1	1
8	1	1	0	1	1	1	0	1	1	0
9	1	1	1	1	0	0	0	0	1	0

(b) Can you find any **anomalies** in the above fingerprint? If so, what are they? (2)

Total: 6

QUESTION 3

Face Recognition

(a) Consider the "Fisherfaces" approach to face recognition and answer the questions that follow: (4)

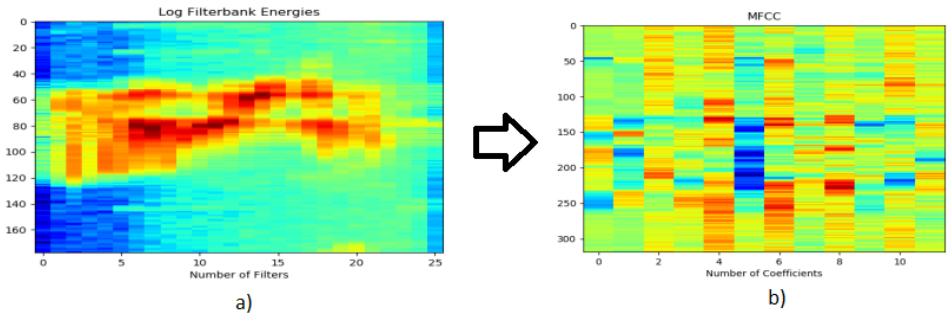
1. What are the **features** that the algorithm extracts, and how does it compute them?
2. What are the **weaknesses** of the approach?

(b) Briefly define a Gabor **wavelets** and their relation to Gabor **filters**. (2)

Total: 6

QUESTION 4

(a) Analyse the following images relevant to speaker recognition and answer the questions that follow: (3)



1. What does the above overall image depict (be sure to make reference to a and b)? (2)
2. Briefly describe the computation taking place (1)

(b) What does the equation below represent and what **role** does it play in speaker recognition? (3)

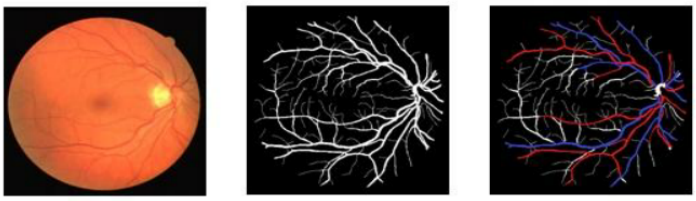
$$x_n = \frac{1}{N} \sum_{k=0}^{N-1} X_k \cdot e^{2\pi i k n / N}$$

Total: 6

QUESTION 5

Ocular Biometrics

Analyse the image below and answer the questions that follow.



(a) Discuss the ocular technology being shown and the process taking place. (4)

(b) Describe two (2) eye **ailments or diseases** that affects conjunctiva biometrics systems, along **why** it impacts it. (2)

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):

$$\begin{bmatrix} 91 & 90 & 27 & 87 \\ 39 & 167 & 59 & 114 \\ 6 & 245 & 148 & 119 \\ 91 & 179 & 172 & 178 \end{bmatrix}$$

Total: 8

QUESTION 7

Fingerprint-vein multimodal recognition-based biometric systems have have been gaining success in the east. One of the reasons behind this can be attributed to the maturity of finger vein sensors in Japan. Discuss how you would implement a fingerprint and vein multimodal biometric system, the **types** of sensors, along with various **steps** required to capture, process, match and fuse the samples. For each step in your discussion be sure to elaborate on the following aspects:

- The different sensors that can be used to capture a sample.
- A brief description of the steps followed to process, match and fuse a sample.
- The algorithms used at each step (if necessary).

Total: 8

QUESTION 8

Biometric Trends and Esoteric Biometrics

(a) Discuss **human heart rate recognition-based authentication**, along a brief description on **how** you would implement such a system. (4)

(b) What sensor is used in **odour** recognition systems? (2)

Total: 6

QUESTION 9

Vulnerabilities and Countermeasures

Draw an **attack tree** that highlights the **weaknesses** that will typically be found for a **voice assistant** system such as Amazon Alexa, Google Assistant or Apple Siri **WHERE** the attacker is not allowed to be in the same room as the listening device **ALONG** with two ways to **safeguard** against them.

Total: 8

SECTION B - LONG QUESTIONS

QUESTION 10

A recent study by Penn State University (https://bit.ly/33ZIt2B) shows when the AI system recognises the person's uniqueness that patients considers the "AI doctor" to be intrusive and less likely to follow its medical advice. It highlights key concerns about AI in society related to bias and user acceptance, which affect the ultimate roll out of biometric applications. Write a report that pays special attention to the following:

- Bias in biometric applications.
- User acceptance and usability in biometrics.
- The ethical aspects and your opinion on the case study.

Total: 10

QUESTION 11

A soft wearable sensor developed by Northwestern University can measure the itchiness suffered by a person (https://bit.ly/3ohx1sm). The sensor gauges both low-frequency motion and high-frequency vibrations from the hand to improve accuracy compared to wrist watch tools. 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.

Total: 15

— End of paper —