



**FACULTY OF SCIENCE**  
**ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING**

<b>MODULE</b>	IT28X07: BIOMETRICS
<b>CAMPUS</b>	AUCKLAND PARK CAMPUS (APK)
<b>ASSESSMENT</b>	JUNE 2020 <b>MEMO</b>

**DATE:** 2020-06

**SESSION:** 08:30 - 10:30

**ASSESOR(S):**

PROF D.T. VAN DER HAAR

**EXTERNAL MODERATOR:**

PROF S. VIRIRI (UKZN)

**DURATION:** 120 MINUTES

**MARKS:** 100

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 a zip archive named in the following format.  
STUDENTNUMBER\_SURNAME\_INITIALS\_SUBJECTCODE\_ASSESSMENT e.g.  
202012345\_SURNAME\_IAM\_IT28X07\_FSAO.zip
5. Additional time for submission is allowed for as per the posted deadlines on EVE. If you are experiencing technical difficulties related to submission please contact me as soon as possible.
6. 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/u4yVG2H>).
7. This paper consists of 13 pages excluding the cover page.

## SECTION A - SHORT QUESTIONS

### QUESTION 1

#### *General Biometric Systems*

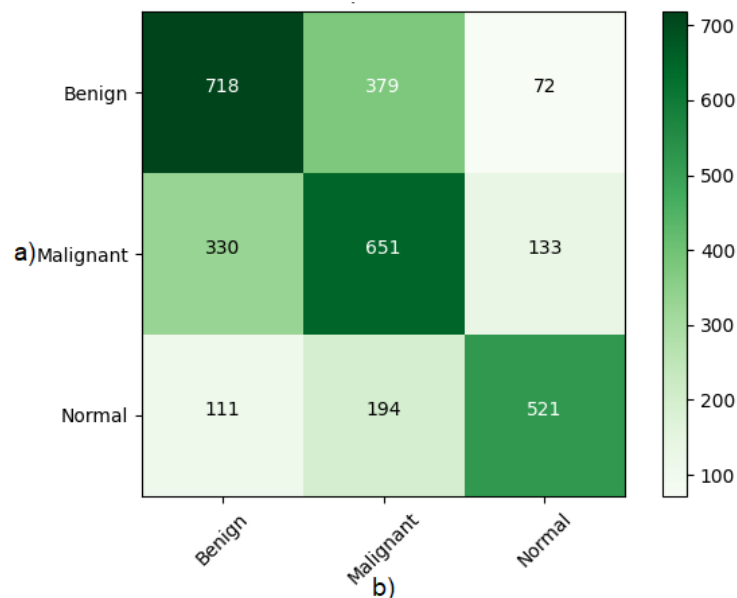
(a) Provide a score (low, medium or high) for **face recognition** against the follow four (4) **biometric requirements** for 2020 (i.e. as it stands today): (4)

1. Universality
2. Collectability
3. Acceptance
4. Circumvention

#### **Solution:**

1. Universality - High
2. Collectability - High
3. Acceptance - Medium
4. Circumvention - Medium

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



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

#### **Solution:**

1. A confusion matrix for a multi-class classification problem

2. True label
3. Predicted label
4. There is an issue with malignant and benign classes

Total: 10

**QUESTION 2**

- (a) Aside from alignment issues, list four (4) **other limitations** of hand geometry. (4)

**Solution:**

1. It is considered expensive for what you get
2. Is affected by poor lighting
3. Lacks specificity
4. Suffers from hygiene issues
5. any other valid limitation

- (b) Provide the coordinates for **four** examples of bifurcations in the fingerprint binary image below: (4)

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

**Solution:**

1. (2,2)
2. (4,6)
3. (6,7)
4. (8,5)
5. (7,2)

6. (3,6)

7. (3,9)

Total: 8

### QUESTION 3

#### *Face Recognition*

- (a) Briefly describe how appearance-based **face detection** works. (2)

#### **Solution:**

The appearance-based representation is based on recording various statistics of the pixels' values within the face image, such as intensities and histograms to determine if it complies with a face-like region.

- (b) Consider the "Eigenfaces" 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?

#### **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 analysis)
4. Appearance-based (learnt face model analysis)

- (c) List two (2) examples of **kernels** that can be used for Support Vector Machines. (2)

#### **Solution:**

They probably either say linear, Poly or RBF, but just in case:

1. Polynomial kernel.
2. Gaussian kernel.
3. Gaussian radial basis function (RBF)
4. Laplace RBF kernel.
5. Hyperbolic tangent kernel.

6. Sigmoid kernel.
7. Bessel function of the first kind Kernel. ...
8. ANOVA radial basis kernel.

Total: 8

**QUESTION 4**

- (a) Briefly describe three (3) features used in **speaker recognition** systems. (3)

**Solution:**

1. Pitch
2. Energy
3. Formant frequencies
4. Vocal tract model parameters
5. Linear prediction model coefficients
6. Cepstral coefficients
7. Mel Frequency Cepstrum
8. Intersession variability

- (b) What does the equation below represent and what **role** does it play in speaker recognition? (4)

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

**Solution:**

It represents a discrete cosine transform (2) and it is used to convert an audio signal from time to frequency domain

Total: 7

**QUESTION 5***Ocular Biometrics*

- (a) Discuss one key contribution John Daughman made within the context of **iris** recognition, along with **why** it was so important. (4)

**Solution:**

1. The use of 2D Gabor wavelets to extract phase structure of the iris, which is then encoded in a bitstream which an XOR is used to match
2. Provides real-time matching (in fact its millions of iris patterns a second on a single core)

- (b) Describe two (2) eye **ailments or diseases** that affects conjunctiva bio-metrics systems, along **why** it impacts it. (4)

**Solution:**

1. Diabetes - vascular disruptions
2. Conjunctivitis - burst vessels on the eye

Total: 8

**QUESTION 6***Palm and Behavioural Biometrics*

- (a) 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): (8)

$$\begin{bmatrix} 229 & 85 & 116 & 50 \\ 165 & 64 & 211 & 56 \end{bmatrix}$$

**Solution:**

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 229 & 0 \\ 0 & 0 & 0 \end{bmatrix} 00000000 = 0_10$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 1 & 85 & 1 \\ 1 & 0 & 1 \end{bmatrix} 00011011 = 27_10$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 116 & 0 \\ 0 & 1 & 0 \end{bmatrix} 00000100 = 4_10$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 1 & 50 & 0 \\ 1 & 1 & 0 \end{bmatrix} 00000111 = 7_10$$

$$\begin{bmatrix} 0 & 1 & 0 \\ 0 & 165 & 0 \\ 0 & 0 & 0 \end{bmatrix} 01000000 = 64_10 \\
 \begin{bmatrix} 1 & 1 & 1 \\ 1 & 64 & 1 \\ 0 & 0 & 0 \end{bmatrix} 11110001 = 241_10 \\
 \begin{bmatrix} 0 & 0 & 0 \\ 0 & 211 & 0 \\ 0 & 0 & 0 \end{bmatrix} 00000000 = 0_10 \\
 \begin{bmatrix} 1 & 0 & 0 \\ 1 & 56 & 0 \\ 0 & 0 & 0 \end{bmatrix} 10000001 = 129_10 \\
 \begin{bmatrix} 0 & 27 & 4 & 7 \\ 64 & 241 & 0 & 129 \end{bmatrix}$$

(b) Briefly describe the **ergotic** type of gesture.

(2)

**Solution:**

The gesture couples with the action of doing work

Total: 10

### QUESTION 7

**Fingerprint-palmprint** multimodal recognition-based biometric systems have the potential to have mainstream success. One of the reasons behind this can be attributed to the fact that larger sensors have become cheaper. Discuss how you would implement a fingerprint and palmprint 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).

**Solution:**

Types of fingerprint sensors (2):

- optical (using CCD and LED)
- Capacitive (Solid state)
- thermal

- ultrasonic (transducer type)

Capture(1):

- User presents finger
- It captures the sample

Preprocessing(1):

- Greyscaling
- Histogram equalisation
- CLAHE
- Gaussian Blur
- Gabor filters

Feature Extraction(2):

- Level 1: Holistic view, ridge count and orientation
- Level 2: According to minutia and on the Cartesian axis
- Level 3: Ridge edge shape and pores
- *Level 4: fingerprint molecular identification (FMID)*

Matching(1):

- RANSAC (for feature selection)
- (Euclidean, Manhattan, Mahalanobis) Distance measure
- Hough transform
- Support Vector Machine (SVM)

feature fusion is preferred (1)



**QUESTION 8***Biometric Trends and Esoteric Biometrics*

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

**Solution:**

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

1. Helix Rim
2. Antihelix
3. Antitragus
4. Lobule
5. Triangular Fossa
6. Crus of Helix
7. Concha
8. Tragus
9. Incisure Intertragica

Any valid implementation decision should suffice

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

**Solution:**

Any electronic nose sensors:

1. MOSFET (most popular)
2. Conducting polymers
3. quartz crystal microbalance
4. surface acoustic wave

Total: 6
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**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 **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
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**SECTION B - LONG QUESTIONS**

**QUESTION 10**

Near the end of last year a scientist published an article in the prestigious Cell journal on an alternative method for technique for creating a designer baby by selecting "superior" embryos by screening their DNA. The scientific and broader community has been in an uproar and recently that scientist has been sentenced to jail. However, there has been debate on the case and some scientists in South Africa are curious about the legal and ethical implications of his research. Write a report that pays special attention to the following:

- The common criticisms of DNA biometrics.
- The ethical considerations related to biometrics.
- The legal aspects related to biometrics and your opinion on the case study.

**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) (it is publicly available information?)

Total: 10
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**QUESTION 11**

The recent surge of working from home transitions for many companies (especially multi-nationals) have many line managers deeply concerned about whether their employees are doing their work. An ex-government contractor (Company Y) has decided to edge into this space by providing an employment monitoring tool that works using employee smart phones. They have tasked you with writing up a report that proposes the best solution for their employee monitoring solution, along with how to compare your solution with other potential ideas. Comprehensively discuss 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 that can scale (Fingerprint, face and iris?)
- 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)

**(15)**

Total: 15

— End of paper —