Alternative Computing Summative Assignment

Dr Eleni Akrida and Dr Barnaby Martin

2020

Level 3 students should submit 2 PDF files:

1. a PDF file named QuantumXXXXXX for Part A of the Quantum Computing assignment, and
2. a PDF file named NaturalXXXXXX for Part A of the Natural Computing assignment,

where XXXXXX is your CIS username.

Level 4 students should submit 4 PDF files:

1. a PDF file named QuantumXXXXXX for Part A of the Quantum Computing assignment,
2. a PDF file named QuantumBXXXXXX for Part B of the Quantum Computing assignment,
3. a PDF file named NaturalXXXXXX for Part A of the Natural Computing assignment, and
4. a PDF file named NaturalBXXXXXX for Part B of the Natural Computing assignment,

where XXXXXX is your CIS username.

Quantum Computing Assignment: Dr Eleni Akrida

***** Level 3 students should undertake Part A. *****
***** Level 4 students should undertake Parts A and B. *****

Part A: Solve exercises 1 - 2. Your answers should be either written using Latex (use the settings of the Latex file provided alongside this PDF file) and compiled into pdf (only the pdf should be handed in), or handwritten and scanned (in which case you should hand in the scanned pdf). **Note: in the case where you return a scanned copy of your handwritten notes, please make sure your writing is neat and clearly legible. Marks will be deducted if your answers are not neatly written.**

1. Which of the following pairs of expressions represent the same quantum state?
   Justify your answers. **[25 marks]**

   (a) $\frac{1}{\sqrt{2}}\big(|+\rangle + |-\rangle\big)$ and $|0\rangle$.
   (b) $i\,|1\rangle$ and $\frac{1+i}{\sqrt{2}}\,|1\rangle$.
   (c) $\frac{1}{\sqrt{2}}\big(|-\rangle + |+\rangle\big)$ and $\frac{1}{\sqrt{2}}\big(|i\rangle + |-i\rangle\big)$.
   (d) $\big(\frac{\sqrt{3}}{2}\,|0\rangle + \frac{1}{2}\,|1\rangle\big)$ and $\big(\frac{\sqrt{6}+\sqrt{2}}{4}\,|+\rangle + \frac{\sqrt{6}-\sqrt{2}}{4}\,|-\rangle\big)$.
   (e) $\frac{1}{\sqrt{2}}\big(|i\rangle - |-i\rangle\big)$ and $|0\rangle$.

2. For each state and measurement basis, describe the possible outcomes of a measurement of that state with respect to that basis and give the probability of each outcome. **[25 marks]**

   (a) $\big(\frac{3i}{4}\,|+\rangle - \frac{\sqrt{7}}{4}\,|-\rangle\big)$ and $\{|0\rangle, |1\rangle\}$.
   (b) $\frac{1}{\sqrt{2}}\big(|0\rangle - |1\rangle\big)$ and $\{|i\rangle, |-i\rangle\}$.
   (c) $-\,|i\rangle$ and $\{|0\rangle, |1\rangle\}$.
   (d) $\frac{1}{\sqrt{2}}\big(|i\rangle - |-i\rangle\big)$ and $\{|+\rangle, |-\rangle\}$.
   (e) $\frac{\sqrt{3}}{2}\,|+\rangle - \frac{1}{2}\,|-\rangle$ and $\{|i\rangle, |-i\rangle\}$.

PART B: Choose one of:

1. Quantum Error Correction;
2. Quantum Supremacy.

Conduct your own research into what the topic is, its importance in the field of quantum computation, and the state of play in terms of practical implementations or designs. Write up your findings: your synopsis should include your references and should be written using Latex (use the settings of the Latex file provided alongside this PDF file) and compiled into pdf (only the pdf should be handed in); the report should be no more than 2 pages in length (excluding references). You will be given marks for clarity and quality of explanation. **[25 marks]**

Natural Computing Assignment: Dr Barnaby Martin

The Artificial Bee Colony (ABC) algorithm

This assignment is all about the Artificial Bee Colony algorithm as devised by Karaboga and Basturk (and expounded in [1]; this paper has around 5,000 citations on Google Scholar).

***** Level 3 students should undertake Part A. *****
***** Level 4 students should undertake Parts A and B. *****

Part A: Provide a synopsis of [1]. **[50 marks]**

You should read the paper and present a condensed version of it so as to provide:

- relevant background material [5 marks]
- a detailed pseudocode description of the ABC algorithm [15 marks]
- a natural language description of the ABC algorithm [10 marks]
- details of the experiments [15 marks]
- an overview of the results. [5 marks]

You should define all concepts used and give a very brief overview of the comparator algorithms and the benchmark functions used in the experimental section. Your synopsis should be written using Latex (use the settings of this Latex file) and compiled into pdf (only the pdf should be handed in); there should be a section for each of the 5 bullet-points above (your pseudocode and natural language descriptions should cross-reference one another); and the report should be no more than 4 pages in length (excluding references). After reading your report, a reader should be able to implement the ABC algorithm. You will be given marks for clarity and quality of explanation.

Part B: The ABC algorithm was extended in [2] and [3] so as to solve the Travelling Salesman Problem. Provide a synopsis of [2] and explain the concept of path-relinking from [3]. **[25 marks]**

Read the papers [2] and [3].

- You should proceed with paper [2] as in Part A, although there is no need to repeat what you have written above. You should focus on the key differences in the application of the ABC algorithm to the Travelling Salesman problem as opposed to the benchmark functions in [1]. [15 marks]
- You should outline the concept of path-relinking from [3] and how it is incorporated within the ABC algorithm. [10 marks]
- Your pdf report should use no more than 2 pages (and be produced from Latex as above).

References

[1] D. Karaboga and B. Basturk, A powerful and efficient algorithm for numerical function optimization: artificial been colony (ABC) algorithm, *J. Glob. Optim.* 39 (2007) 459–471.

[2] D. Karaboga and B. Gorkemli, A combinatorial artifical bee colony algorithm for Travelling Salesman problem, *Proc. of Int. Symp. on Innovations in Intelligent Systems and Applications* (*INISTA*), IEEE Press (2011) 50–53.

[3] X. Zhang, Q. Bai and X. Yun, A new hybrid artificial bee colony algorithm for the Traveling Salesman Problem, *Proc. of 3rd Int. Conf. on Communication Software and Networks* (*ICCSN*), IEEE Press (2011) 155–159.