Cardiff School of Computer Science and Informatics

Coursework Assessment Pro-forma

Module Code:	CM2104
Module Title:	Computational Mathematics
Lecturer:	Prof. Paul Rosin
Assessment Title:	Buffon's needle
Assessment Number:	1
Date Set:	Monday 16th November 2020 (week 6)
Submission date and Time:	Monday 14th December 2020 at 9:30am (week 10)
Return Date:	Monday 18th January 2021 (week 12)

This coursework is worth 50% of the total marks available for this module. If coursework is submitted late (and where there are no extenuating circumstances):

1. If the assessment is submitted no later than 24 hours after the deadline, the mark for the assessment will be capped at the minimum pass mark;
2. If the assessment is submitted more than 24 hours after the deadline, a mark of 0 will be given for the assessment.

Your submission must include the official Coursework Submission Cover sheet, which can be found here:
`https://docs.cs.cf.ac.uk/downloads/coursework/Coversheet.pdf`

Submission Instructions

Description		**Type**	**Name**
Cover sheet	Compulsory	One pdf file	`[Student number].pdf`
Report	Compulsory	One pdf file	`Report_[Student number].pdf`
Source code	Compulsory	One or more Matlab files packaged as a single zip file	`Code_[Student number].zip`

Any code submitted will be run on a system equivalent to those available in the Linux laboratory and must be submitted as stipulated in the instructions above.

Any deviation from the submission instructions above (including the number and types of files submitted) will result in a mark of zero for the assessment.

Staff reserve the right to invite students to a meeting to discuss coursework submissions

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Assignment

Develop a GUI implemented in MATLAB using App Designer that allows the user to carry out a Monte Carlo simulation of variations of the experiment invented by the Comte de Buffon in the eighteenth century. The traditional version of "Buffon's needle" involves dropping needles (line segments) onto the floorboards (i.e. a floor made of parallel planks of wood) from which an estimate of π can be obtained by counting the proportion of needles that cross a crack (i.e. a line between the floorboards).

Task 1 (10% weight): Write a MATLAB GUI that simulates a modified version of "Buffon's needle" that drops squares (i.e. square boundaries consisting of 4 lines rather than needles) to estimate π.

Task 2 (10% weight): Extend the above GUI with an additional function. It should simulate a modified version of "Buffon's needle" that drops squares to estimate $\sqrt{2}$ rather than π. Use the formula developed in: "Statistical estimation of some irrational numbers using an extension of Buffon's needle experiment", S. Velasco, F.L. Román, A. González, J.A. White, International Journal of Mathematical Education in Science and Technology, vol. 37, no. 6, pp. 735-740, 2006.

Task 3 (10% weight): Extend the above GUI with an additional function. It should simulate a modified version of "Buffon's needle" that drops needles on square tiles (rather than parallel planks of wood) to estimate π. Use the formula developed in: "Buffon's Needle Problem for a Rectangular Grid", Robert Fakler, The Mathematics Teacher, vol. 88, no. 3, pp. 205-208, 1995.

Note: The tasks above require the GUI to:

1. Allow the user to select which task is run.
2. Allow the user to adjust the number of needles, dropped squares, parallel planks of wood, square floor tiles from default values. The program should allow at least 1,000,000 needles/dropped squares, 10 parallel planks of wood, and 100 square floor tiles.
3. Before running the simulation allow the user to adjust the sizes of the needles, dropped squares, parallel planks of wood, square floor tiles from default values.
4. Display the parallel planks of wood and/or square floor tiles.
5. Display the dropped needles/squares.
6. Highlight in a different colour all needles/dropped squares that intersect the cracks between planks/tiles.
7. Display the value estimated by the Monte Carlo simulation.
8. Allow the user to customize elements of the displayed value (e.g. font size, colour).

Task 4 (10% weight): Extend the above GUI with an additional function:

1. It should allow the user to select a needle by clicking on or near it with the mouse. The needle will then be highlighted in a different colour.
2. The n needles with most similar orientation will then be highlighted in yet another colour. The default value is $n = 3$, and the value of n can be modified through the GUI.
3. Determine the n closest needles to the selected needle. The distance should be computed as follows: use the Euclidean distance between the selected needle and the rays (infinite lines) through the remaining needles. Highlight the following by using three colours: 1/ the selected needle, 2/ the closest rays, and 3/ the needles generating the closest rays.

NOTE: This task only requires selected needles to be highlighted, and **not** the squares in Task 2.

Task 5 (25% weight): In order to gain higher marks you need to add some novel extensions or additional features. You need only provide **two** further different **novel** extensions (such as those suggested here). There are endless possibilities here and you are encouraged to think of your own extensions. Here are a few suggestions:

- Support saving and loading back sets of needles such that previous results can be combined to produce better estimates.

- Allow a mixture of different sized needles to be used.
- Add further alternate versions of Buffon's needle to estimate π.
- Advanced GUI layout/elements to control or edit the experiment setup.
- At startup pre-generate the dropped needles, and then display the appropriate number of needles and the current estimate of π as controlled by a slider.

Please note: You are allowed to use the Geometric Processing toolbox introduced in the module and third-party libraries, as long as you clearly reference the sources in your report.

The two papers cited in this document are available for download in Learning Central under Assessment

You must supply a report on your submission which provides a short written description (1–2 pages of text plus diagrams, screenshots etc.) conveying all the appropriate information to demonstrate its operation and explaining your extension of the basic algorithm.

Learning Outcomes Assessed

1. Show a clear understanding of basic MATLAB programming environment and data structures

2. Understand the practical implementation of some general mathematical techniques via MATLAB

3. Demonstrate an awareness of basic Linear Algebra and its application to Computational Geometry concepts with MATLAB

Criteria for assessment

Credit will be awarded against the following criteria.

1. 10% – Basic MATLAB graphical user interface (window, buttons, text, etc.)
2. 15% – Graphical display of "Buffon's needle" (floorboards, tiles, needles, etc.)
3. 10% – Version of "Buffon's needle" that drops squares to estimate π (Task 1)
4. 10% – Version of "Buffon's needle" that drops squares to estimate $\sqrt{2}$ (Task 2)
5. 10% – Version of "Buffon's needle" on square tiles (Task 3)
6. 10% – Extended version of GUI that highlights selected and related needles (Task 4)
7. 25% – Design and implementation of novel extensions or additional features (Task 5)
8. 10% – Report describing the operation of your program and your extension of the basic algorithm

and the amount of credit will be awarded according to the following indicators:

1. 1st: the submission fully addresses the stated requirement for the Part,
   as well as meeting the *excellence indicators* below.
2. 2.1: the submission fully addresses the stated requirement for the Part,
   but has weaknesses in terms of the *weakness indicators* below.
3. 2.2: the submission partially addresses the stated requirement for the Part.
4. 3rd: the submission minimally addresses the stated requirement for the Part.

5. Fail: the submission does not adequately address the stated requirement for the Part.

Factor	Weakness indicator	Excellence indicator
Approach	Does not adopt a professional or defensible approach	Adopts appropriate methods with full justification for the choices made
Insight and understanding	Little or no insight and understanding	Has developed considerable insight and understanding

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Feedback and suggestion for future learning

Feedback on your coursework will address the above criteria. Feedback and marks will be returned on Monday 18th January 2021 (week 12) via email. This will be supplemented with oral feedback in the Tutorial/Q&A session.