

## COMPUTER ASSISTED LEARNING USING MATLAB GUI FOR MORPHOLOGY SIMULATION IN DIGITAL IMAGE PROCESSING: A PRELIMINARY STUDY

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### ABSTRACT

*In this study, Computer Assisted Learning (CAL) is seen through a collection of experimentation in a course software package used to understand the concepts of a particular subject. Digital image processing is one of the computer science subjects that is compulsory for computer science students majoring in artificial intelligence in the National Defence University of Malaysia. To enhance Digital Image Processing subject, Matlab Graphical User Interface (GUI) has been used as a tool for CAL. The simulation in GUI focuses on Morphology operation topic in Digital Image Processing subject. Four main techniques can be executed on the layout of the GUI which shows the effect of the techniques when applied on a particular image. The preliminary findings show that this Matlab GUI proved to be an excellent tool for CAL environment and it is user friendly due to its convenience to the students.*

**Keywords:** *Computer Assisted Learning, Digital image processing, Morphology technique*

### INTRODUCTION

Computer Assisted Learning (CAL) can be defined as a computer programme or file developed specifically for educational purposes. The technique is used throughout the world in a variety of contexts, from primary school to tertiary educational institutions. In the 1980s, the first CAL became available to university students.

Currently, the teaching method that is being used is the 'jug and mug' method or lecturing, and lectures are supported with slide presentations. However, this method is no longer effective as the slide presentations are one way communication, not interactive and do not encourage students to participate actively in the learning process. Later, classroom teaching turned to simulations. According to Dollar and Steif [1], simulations can help significantly in conveying information that is difficult to in conveying or dealing with static images as well as they can be used to explain certain concepts far more succinctly, and less ambiguously than words can. Other advantages of simulations include: they motivate students, attract their attention, and display tasks that enhance further thinking. Simulations can support and reinforce a student's independence, in turn promoting self-directed study – a fundamental requirement for a successful university education [2]. All these advantages of simulations are in line with the constructivist learning. Constructivist learning has emerged as a prominent approach to teaching during this past decade. Constructivist epistemology asserts that learners construct their own knowledge on the basis of interaction with the environment [3]. By designing and developing courseware and simulations using the constructivist learning environment, learners can construct their knowledge actively where they learn to discover principles, concepts and facts for themselves. Active learning method produces more than 75% retention rate compared to lecture 5%, reading 10%, and discussion group 50% [4].

The National Defence University of Malaysia (NDUM) is a niche institution of the higher education and is known as a Boutique University; hence the number of the students is quite small as compared to other Malaysian public universities. The whole intake every year mainly depends on the requirement by the main stakeholder which is the Malaysian Ministry of Defence (MINDEF). This semester, more than 90 students registered for the Digital Image Processing course. The course is designed to introduce students to theoretical concepts and practical issues associated with image processing. The objective of the course is to expose the students to the concept, task, technique and algorithm in digital image processing. During the course, students

will learn various kinds of digital image processing techniques and apply the techniques using Matlab digital image processing toolbox. Students will also apply digital image processing techniques to particular applications such as for image recognition.

The time allocated for this course is 3 hours a week, where it is broken into a 2 hour face to face session (students-lecturer meetings) and a 1 hour lab session.

## **MATERIALS AND METHODS**

### *A. MORPHOLOGY TECHNIQUE*

Morphological operations are used to describe the structure or form of an image. There are three primary morphological functions: *erosion*, *dilation*, and *hit-or-miss*. Mathematical morphology is a new mathematical theory which can be used to process and analyze the images [5 – 8]. In the mathematical morphology theory, images are treated as sets, and morphological transformations which are derived from Minkowski addition. Subtraction is defined to extract features in images. Mathematical morphology is developed from set theory. It was introduced by [9] as a technique for analyzing geometric structure of metallic and geologic samples and this was extended to image analysis. The basic mathematical morphological operators are dilation and erosion and the other morphological operations are the synthesization of two basic operations such as opening and closing. Erosion is a transformation of shrinking, which decreases the binary value of the image, while dilation is a transformation of expanding, which increases the binary value of the image. Erosion filters the inner image while dilation filters the outer image. Closing is the compound operation of dilation followed by erosion with the same structuring element. Opening is also a compound operation of erosion followed by dilation.

### *B. MATLAB*

Matrix Laboratory (MATLAB) is one of the well known and popular platforms for scientific and engineering computing which is developed by the MathWorks Inc. Its popularity is due to the powerful and easy to use for a beginner. MATLAB is now widely accepted as the technical computing environment for engineers and scientists in industrial and research fields. In universities, it has become the standard instruction tool for courses in mathematics, engineering and science. MATLAB is a high-level language and interactive environment for numerical computation, visualization and programming to solve practical engineering and mathematical problems. MATLAB allows mathematical computations, matrix manipulations, generation of functions and data plotting, creation of graphical user interface, and etc. Besides that, MATLAB can be interfaced with programmes written in other languages such as C, C++, Java, and FORTRAN. There are several useful toolboxes for System Identification, Control System, Neural Network, and Robust Control. Simulink is one of the MATLAB tool used to model, simulate and analyze any dynamic system. In additional, MATLAB can be used in teaching of circuit theory, electronics, control system, simulation, filter design, signal and image processing.

### *C. Graphical User Interface (GUI)*

A GUI is a user interface with graphical objects (the components of the GUI) such as buttons, text fields, sliders, and menus. The MATLAB Graphical User Interface Development Environment (GUIDE) provides a set of tools for creating GUIs. GUIDE is a set of layout tools and it generates an M-file that contains a code to handle the initialization and launching of the GUI. GUIDE has several graphical objects such as pushbutton, sliders, axes, check box, radio button, list box, edit text, and static text. Each component works in an easy and straightforward way. The M-file contains the callback function which is used for programming the GUI. Creating a GUI involves two basic tasks which are laying out the GUI components and programming the GUI components.

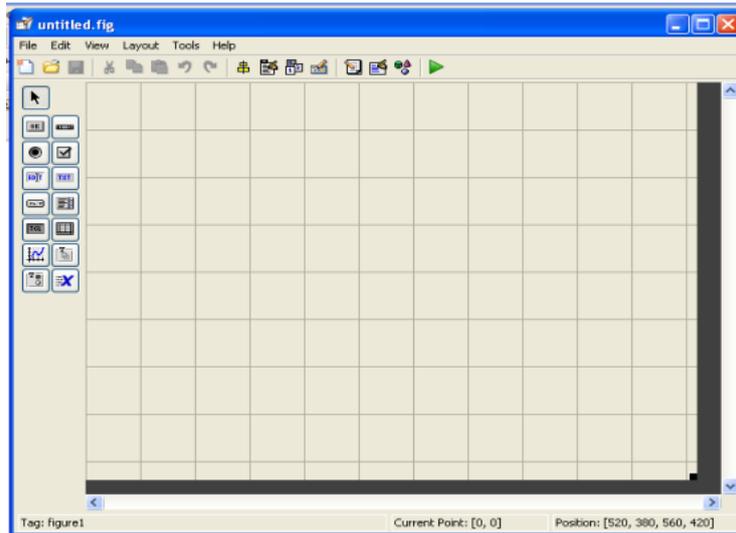


Figure 1: Layout of Matlab GUIDE

The GUI is a user friendly application as the user does not necessarily run the programme at the command window of MATLAB [10]. Every parameter can be entered in the GUI straightforward to obtain the result in numerical value or graph plotting. It is possible to convert the GUI into executable application file using compiler MATLAB in order for users to run the GUI without installing the MATLAB.

## SIMULATION AND EVALUATION RESULTS

The morphology simulation software was developed to simulate four main techniques in morphology operation which are erosion, dilation, open and close. Figure 2 and Figures 3(a) and (b) show the interface of the simulation software which is equipped with buttons to facilitate three aspects, i.e. selecting image, selecting technique, and running selected technique on the image.

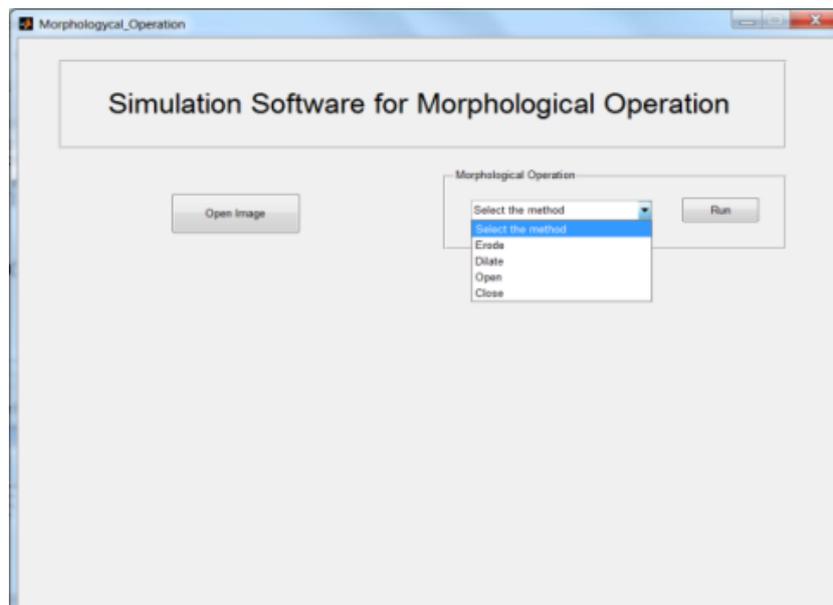


Figure 2: Interface of Simulation Software for Morphological Operation

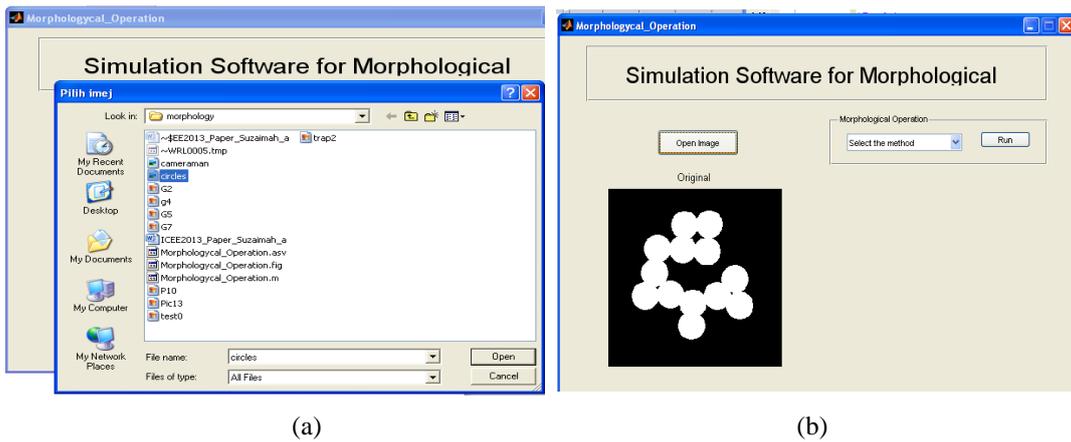


Figure 3: Interface for (a) Selecting image (b) Showing the Selected Image

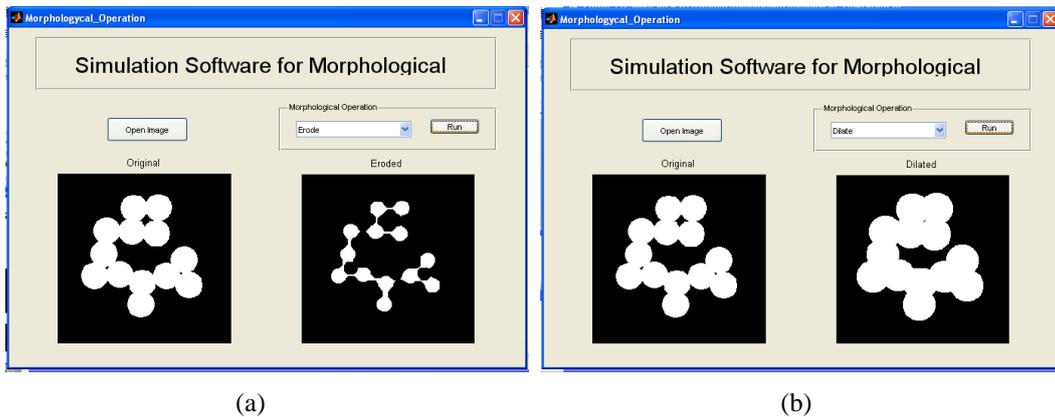


Figure 4: Interface for (a) Effect on the Original Image After Erosion (b) Effect on the Original Image After Dilation

The erosion process is similar to dilation, but pixels are turned to 'white', not 'black'. As usual, the structuring element is slid across the image and then the following steps are carried out:

- If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.
- If the origin of the structuring element coincides with a 'black' pixel in the image, and at least one of the 'black' pixels in the structuring element falls over a white pixel in the image, then change the 'black' pixel in the image (corresponding to the position on which the centre of the structuring element falls) from a 'black' to a 'white' image.

$$\text{Erosion} \quad A \ominus B = \{p | B_p \subseteq A\} \quad (1)$$

Figure 4(a) shows the effect on the original image after the erosion process. As a result of applying the erosion, all the images that are smaller than the structural element will be erased, and images connected by thin lines will be disconnected and the sizes of all images will be reduced.

The dilation process is performed by laying the structuring element B on the image A and sliding it across the image in a manner similar to convolution (will be presented in a next laboratory). The difference is in the operation performed. It is best described in a sequence of steps:

- If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.
- If the origin of the structuring element coincides with a 'black' pixel in the image, make all pixels black from the image covered by the structuring element.

Dilation 
$$A \oplus B = \bigcup_{b_i \in B} A b_i \quad (2)$$

Dilation is the opposite of erosion. Figure 4(b) shows the effect on the original image after dilation process.

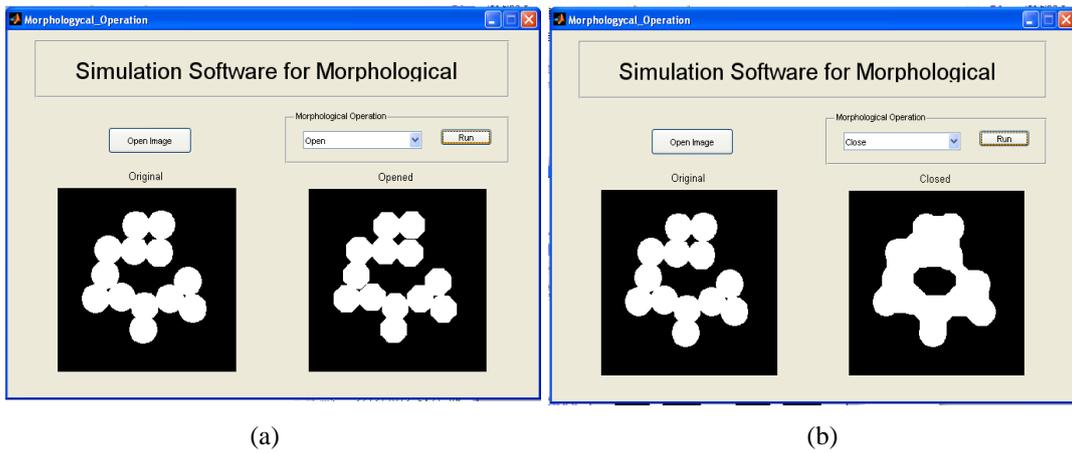


Figure 5: Interface of (a) Effect on the Original Image After Open, (b) Effect on the Original Image After Close

Closing can be used to filling holes, gaps and gulf while opening can remove bridges, branches and small protrusions. Below are the equations representing opening and closing techniques.

Open 
$$A \circ K = (A \ominus K) \oplus K \quad (3)$$

Close 
$$A \bullet K = \underline{(A \oplus K)} \ominus K \quad (4)$$

Figures 5 (a) and (b) show the effect on the original image after applying open and close techniques.

Morphological operations are usually performed on binary images where the pixel values are either 0 or 1. It is important to introduce the concepts of *segmentation* and *connectivity*.

We have performed a study to investigate the student's understanding of morphology technique by using Matlab gui to support the learning process. A set of questions have been distributed among students that taking Digital Image Processing subject. Figure 6 shows percentage of student's understanding and efficiency of the gui to support teaching and learning of morphology technique. The figure shows 88% - 92% of the students have understanding on handling the gui and the content of the gui. 79% agreed that the content of the gui is sufficient to help them learn. Likewise 84% of the students found that the workflow of the gui is easy to

understand. In terms of efficiency, 91% - 93% of the students agreed that the gui has helped them to understand and grab the knowledge instantly.

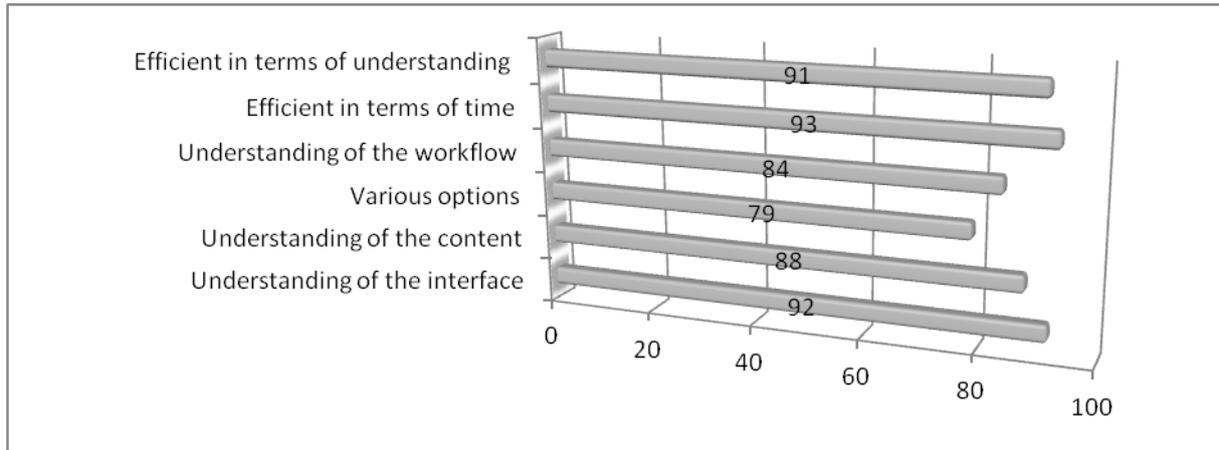


Figure 6: Percentage of the student's evaluation of the gui

## CONCLUSIONS

As a conclusion, the GUI MATLAB explained in this paper is user friendly software for simulating the morphology technique. The result obtained, shows that developing the simulation using Matlab GUI has enhanced the performance of Computer Science degree students in NDUM and increased their confidence level in learning the digital image processing course. The students can be more interactive in class compared to the previous teaching and learning method as they are capable of giving feedback throughout the simulation process. CAL is definitely a convenient way of teaching and learning tool to aid students in understanding the subject better such as by showing the effects of the various images during the application of the morphology technique. Thus, implementation of the Matlab GUI is recommended to enhance the learning process throughout the course.

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