ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
FACULTY OF COMPUTER AND MATHEMATICAL SCIECNCE
DEPARTMENT OF COMPUTER SCIENCE

Design and Implementation of Automatic Student Evaluation Form Processing System Using Image Analysis Techniques

By

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1. Dr. Yaregal Assabie (Advisor) ----------------------
2. Dr. ----------------------
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Abbreviation/Acronym

AAU = Addis Ababa University

OCR = Optical Character Recognition

OMR = Optical Mark Reading/Recognition

AAUSEFP = Addis Ababa University Student Evaluation Form Processing

Abstract

Addis Ababa University (AAU) is one of the largest universities in Ethiopia. It has more than sixty thousand students and more than two thousand academic staffs. To know the teaching effectiveness of the academic staff and to get the student views regarding the teaching performance of instructors, the university has prepared a questionnaire form, which contains about 36 statements that will be filled by students. These forms are processed manually in such a way that the values given by the students for each statement are added and the average values are computed. Then these values are divided by the total number of students to get the total average values given by all the students.

Processing the student evaluation form manually for a large number of students makes the processing of the forms tedious, time taking and error prone. To alleviate this problem a mechanism has to be developed by using different form processing techniques. In this project a digital image analysis technique is used to process the form.

For this project, MATLAB is used as a programming tool since it is high-performance language for technical computing that integrates computation, visualization, and programming where problems and solutions are expressed in mathematical notation. The system is designed to recognize only the values encircled by the students against each statement. After the document is scanned a template image is taken from the normalized gradient field of the image. Gradient is the change in gray level with direction. This can be calculated by taking the difference in value of neighboring pixels, producing a vector for each pixel. Thus, the gradient field of the image is normalized with a certain threshold value. Noise is removed while computing the gradient field of the image. Template matching image analysis technique is used, to detect regions which contain choices against each statement. Then, values encircled by the students are detected by finding relative circles having a range of radius in the detected region. The coordinate values of the detected circles are used to recognize values encircled by the students.

Finally, recognized values for each statement are added and the average values are computed. Then these values are divided by the total number of students to get the total average values given by all the students.

Keywords: Addis Ababa University, Student evaluation form, Template matching, Recognition.

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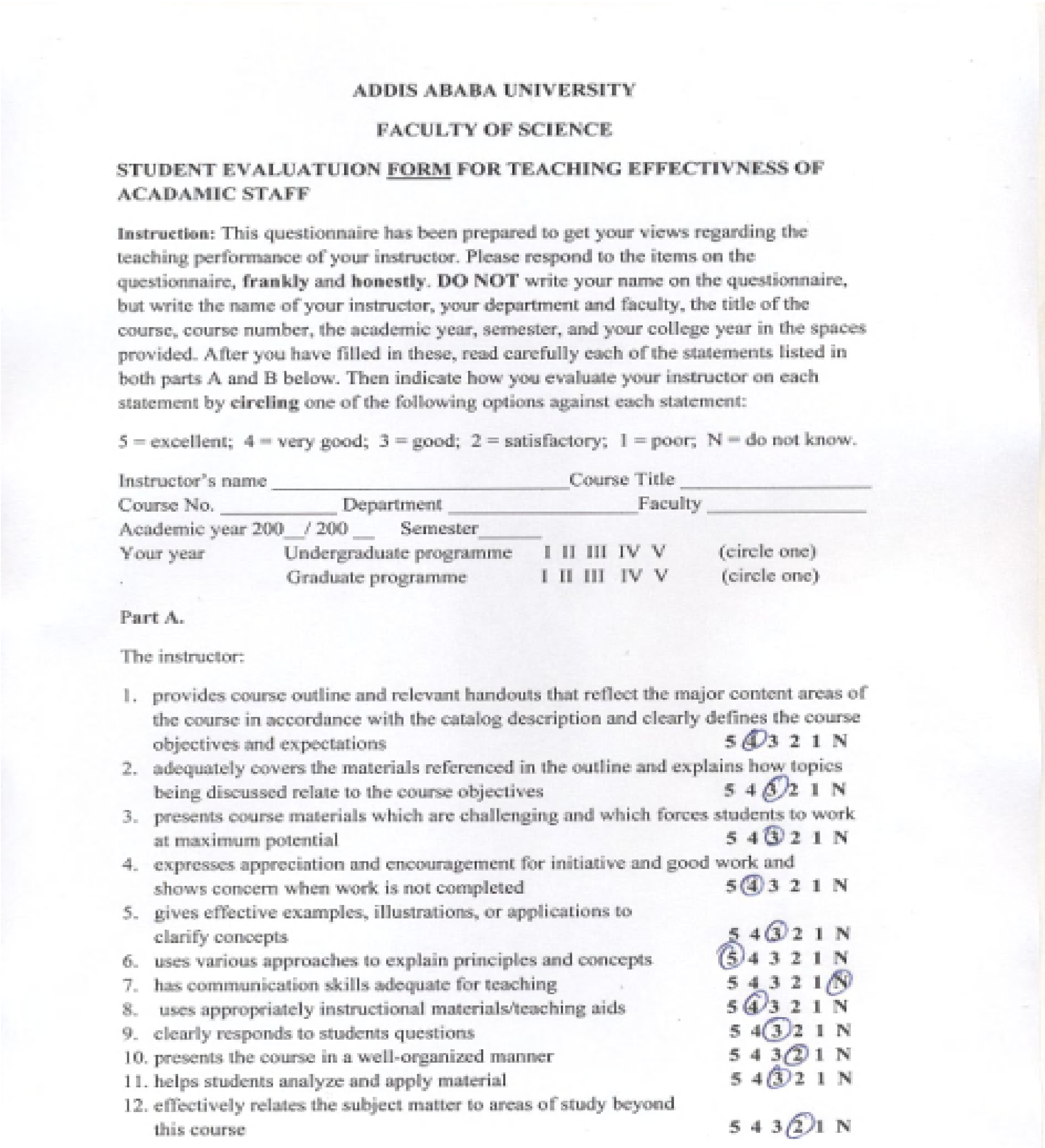
Chapter 1
Introduction

1.1. Background

Currently Addis Ababa University has about fourteen institutions and programs and there are more than sixty thousand students enrolled in different programs such as: regular, evening and summer programs in different fields of studies. It has also more than two thousand academic staff having different ranks ranging from graduate assistants to full professors [1].

Effectiveness in teaching or research of an academic staff is measured by the evaluation of the staff's work by his/her students, colleagues or professional peers and the department head or director at the end of each semester or academic year. The contribution of each of the components of the system of evaluation to the overall rating of the teaching/research effectiveness of an academic staff is: evaluation by students (45%), evaluation by colleagues (25%), and evaluation by head of department or the dean/director (30%). The different courses the academic staff has taught since his/her last promotion is indicated with the corresponding students' evaluation on the delivery of these courses [2].

Instructors are evaluated by their students at the end of each semester by using the student evaluation form for teaching effectiveness of academic staffs. The student evaluation form has been prepared to get student views regarding the teaching performance of instructors. As Figure 1.1 shown on the next page, students are not expected to write their names instead they are expected to write the name of the instructor, their departments and faculty, title of the course, course number or course code, academic year, and semester. The students also select their college year by circling one of the options against each statement. This part of the form is used to know: the instructor (who is going to be evaluated by their students), the course he/she is giving, the department and faculty of the students, academic year and semester and students college year (whether they are in undergraduate program I, II, III, IV, V or graduate program I, II,III,IV).


ADDIS ABABA UNIVERSITY

FACULTY OF SCIENCE

STUDENT EVALUATUION FORM FOR TEACHING EFFECTIVNESS OF ACADAMIC STAFF

Instruction: This questionnaire has been prepared to get your views regarding the teaching performance of your instructor. Please respond to the items on the questionnaire, **frankly** and **honestly**. **DO NOT** write your name on the questionnaire, but write the name of your instructor, your department and faculty, the title of the course, course number, the academic year, semester, and your college year in the spaces provided. After you have filled in these, read carefully each of the statements listed in both parts A and B below. Then indicate how you evaluate your instructor on each statement by **circling** one of the following options against each statement:

5 = excellent; 4 = very good; 3 = good; 2 = satisfactory; 1 = poor; N = do not know.

Instructor's name ____________________________ Course Title __________________

Course No. ___________ Department _________________ Faculty _______________

Academic year 200__/ 200 __ Semester______

Your year Undergraduate programme I II III IV V (circle one)

Graduate programme I II III IV V (circle one)

Part A.

The instructor:

1. provides course outline and relevant handouts that reflect the major content areas of the course in accordance with the catalog description and clearly defines the course objectives and expectations 5 4 3 2 1 N
2. adequately covers the materials referenced in the outline and explains how topics being discussed relate to the course objectives 5 4 3 2 1 N
3. presents course materials which are challenging and which forces students to work at maximum potential 5 4 3 2 1 N
4. expresses appreciation and encouragement for initiative and good work and shows concern when work is not completed 5 4 3 2 1 N
5. gives effective examples, illustrations, or applications to clarify concepts 5 4 3 2 1 N
6. uses various approaches to explain principles and concepts 5 4 3 2 1 N
7. has communication skills adequate for teaching 5 4 3 2 1 N
8. uses appropriately instructional materials/teaching aids 5 4 3 2 1 N
9. clearly responds to students questions 5 4 3 2 1 N
10. presents the course in a well-organized manner 5 4 3 2 1 N
11. helps students analyze and apply material 5 4 3 2 1 N
12. effectively relates the subject matter to areas of study beyond this course 5 4 3 2 1 N

Figure 1.1 Student evaluation form of AAU

After filling the first part, the students will go to the second part of the student evaluation form. In this part, the evaluation form contains about thirty six (36) statements divided in to two parts: Part A and Part B, each containing eighteen statements. Statements under Part A are focused on the performance of the instructors regarding to the course and the approaches he /she used, whereas, statements under Part B focused on the relationship between the instructor and their students. Students are expected to carefully read each of the statements listed in both parts, and then they will indicate how they evaluate their instructors on each statement by circling one of the options against each statement. The options are represented as numbers ranging from 5 down to 1, and N where option "5" represents "excellent", "4" represents "very good", "3" represents good, "2' represents "satisfactory", "1" represents "poor" and "N" represents "do not know". For both parts, the students will select one of the check boxes as an overall judgment of the instructor.

Finally the choices made by a student are added and the average choices are computed for the student. Then, the total average choice is computed by adding the average choice of each student and dividing the value by the total number of students. This value is used for decision making processes. However this manual processing of the student evaluation form is tedious, time taking, error prone and exhausting since one instructor is evaluated by a large number of students.

On the other hand, processing of the student evaluation form can be automated by using different image analysis techniques which enable to extract information from an image [3]. Examples include neural networks, structural image analysis, statistical and syntactic analysis, template matching and probabilistic image analysis. Now a days image analysis such as object detection and object recognition are used in different organizations and in different educational sectors to facilitate their activities [4]. For example, applications such as optical character recognitions and optical mark recognitions (OMR) are used in educational sectors. In optical mark recognition (also called optical mark reading) human marked data from document forms such as surveys and tests is processed and captured, and this is mostly used to analyze answer sheets in multiple choice question examinations in such a way that students mark their answers or other personal information by darkening circles marked on a pre-printed sheet. Afterwards the sheet is analyzed by OMR for grading. This enables to accomplish the task in a short period of time with low error rates.

Likewise, processing of the student evaluation form can be automated by scanning the student evaluation form and applying image analysis techniques. Scanning the student evaluation form by an ordinary scanner is time taking. However, currently there are high speed scanners (like

AXIOME AXM980 (USB Ready) scanner) that can scan 7000 sheets per hour and store in computer memory [5]. This will facilitate processing of the student evaluation forms, makes easy and simple and less error rates. Therefore, the proposed system can be taken as a new insight to automate processing of the student evaluation forms of Addis Ababa University.

1.2. Statement of the Problem

Currently there are more than sixty thousand students enrolled in Addis Ababa University. It has also more than two thousand teaching staff having different ranks [1]. Instructors are evaluated by their students at the end of each semester to promote instructors, to get feedback from students about instructors, delivery of courses and more. However, finding all values encircled by the students for such number of students, and computing the sum, and average values manually is time taking, tedious, error prone and exhaustive since one instructor is evaluated by a large number of students.

Thus, to address these problems there is a need of designing and implementation of Addis Ababa University student evaluation form processing using image analysis techniques where the evaluation form is scanned and saved as an image. This makes processing of the student evaluation forms to be completed within a short period of time, easily and with less error rates. In general this helps to facilitate the decision making processes which is made based on the result of student evaluations.

1.3. Objective of the Project

The general and specific objectives of the project are described below.

General Objective

The general objective of the project is to design and implement an automatic Student Evaluation Form Processing (SEFP) system for Addis Ababa University (AAU) using image analysis techniques.

Specific Objectives

The specific objectives of the project are:

- ✓ Collect and scan sample evaluation forms filled by students.
- ✓ Study image analysis techniques for automatic processing of forms.
- ✓ Implementing the system.

1.4. Scope of the project

As described in the introduction part of this document, the student evaluation form of Addis Ababa University has two parts. The first part (identification of the form) contains instructor name, course title, course number, department, faculty, academic year, and semester. To analyze this part, the characters need to be recognized and thus an optical character recognition (OCR) system is required. The second part contains the choices for each statement through which instructors are evaluated and the students are expected to encircle their choices.

The application developed in this project processes and analyses the choices given by the students against each statement to compute the final result. However, it will not include analysis of the first part which needs an OCR. In addition to this, it will not include analysis and evaluation of comments if there are.

1.5. Methodologies

In developing SEFP system, the following state of the art development methodologies are applied.

Literature Review

Review of works on form processing using image analysis techniques has been done. Additionally, a literature review has been done on image processing and the analysis techniques. The literature review is described in Chapter 2 of this paper.

Data Collection

Designing and implementation of automatic SEFP system for AAU using image analysis techniques is the general objective of the project. To achieve this objective and other specific objectives of the project, evaluation forms filled by students are needed. Thus, these forms are collected from Addis Ababa University. The forms are distributed to AAU Computer Science second year graduates students to fill it.

System Implementation

Different image analysis techniques have been studied to identify an appropriate technique to process and analyze such kind of forms.

The tools used and main activities that were conducted to achieve the objectives of this project were the followings.

- Template matching is used to detect regions which contain choices against each statement.
- Microsoft word is used to prepare the document and Rational Rose is used as a UML tool to depict system analysis and design since this tool has fully object oriented feature that helps to show relationships, functional dependencies and others.
- MATLAB is used for writing the source code of the system since MATLAB is high-performance language for technical computing that integrates computation, visualization, and programming where problems and solutions are expressed in mathematical notation.

1.6. Organization of the Document

This document contains six chapters. Chapter 1 provides the overall introduction about the project. Chapter 2 provides literature reviews and describes about the related work on form processing using image analysis techniques. In Chapters 3 and 4, the analysis and design of the developed system is presented respectively. Chapter 5 presents the implementation of the project, and finally conclusion and future works are explained in Chapter 6.

Chapter 2

Literature Review

Addis Ababa University (AAU) is one of the largest higher learning institutions in Africa that was established at the end of the 1940s. Formerly known as Haile Selassie I university, AAU was established by ministry of education in 1949 as a trinity college with 71 students and 9 academic staffs. Currently, AAU has more than sixty thousand students enrolled in regular, evening, and summer programs [1].

As like to other educational sectors, AAU has its own objectives. Some of them are:

- To provide education that fully develops the personality and strengthens the respect for understanding, friendship, and tolerance free from ethnic, nationality, sex, religious, and other prejudices.
- To Search for, cultivate, preserve, and transmit knowledge.
- To conduct research and studies, in an objective and dispassionate way and free from any bias, on different fields and disseminate fruitful results.

To achieve its objective the teaching effectiveness of academic staff has been evaluated by their students at the end of each semester. Evaluating the academic staff by their students is also used to know students' views about their instructors performance, and the overall values given by the students is also used as a criteria to do promotions to higher ranks for the instructor. For instance, for promotion to the rank of assistance professor effectiveness in teaching or research weights from 37.5-50 %, publication from 35-45 % and participation in university affairs and/or professional and/or related public services weights 12.5-25 % [2].

Student evaluation form processing involves computing the average values given by the students on the student evaluation form against each statement listed on the evaluation form. Processing such forms for a small number of students may be easy but for a large number of students processing such forms manually is tedious, time taking, and the probability of occurring errors is so high.

Thus, automating the manual processing of the student evaluation form using image analysis techniques plays a great role in simplifying the job of processing the student evaluation form. In this technique students fill hard-copy questionnaire, and the questionnaire papers are scanned and marked answers are extracted from the digitalized images.

Implementation of a web based application for processing the student evaluation form of AAU, is may be taken as an alternative. However, there are certain facts that advocate hard-copy: the number of active users of computer and internet in our country is small, the number of computer skilled persons is even smaller, and the number of computers available for the students and the number of students is not balanced in the university. Furthermore the hard-copy questionnaires are more familiar for the students in the university.

2.1. Digital Image Processing

In common usage, an image or picture is an artifact that reproduces the likeness of some physical object. They are typically produced by optical devices such as cameras. They are rich in information and convey different implications.

Image technology is relatively a young technology which has got wide applications in different disciplines such as medical diagnosis, multimedia system, security – biometrics, geographic information system (GIS)- remote sensing, industrial automation- robot control, and very recently processing of forms [7].

In its early time, image-processing algorithms were computationally intensive. They require high processing speed and large memory size but in current trends of digital technology, computer capacity is increasing from time to time. For instance, there are faster microprocessors, larger memory size and faster and wider buses. This advancement of technology made image analysis affordable.

Image analysis is concerned with the extraction of measurements, data or information from an image by using image processing techniques. In the literature, this field has been called computer vision, image data extraction, scene analysis, image description, automatic photo interpretation, image understanding and a variety of other names [8].

Image analysis is distinguished from other types of image processing, such as segmentation and enhancement, in that the ultimate product of an image analysis system is usually numerical output rather than a picture. Image analysis also diverges from classical pattern recognition in that analysis systems are not limited to the classification of scene regions to a fixed number of categories, but rather are designed to provide a description of complex scenes [7, 8].

There are different stages of image analysis [8]. The first step towards designing an image analysis system is digital image acquisition. Most commonly a digital image is acquired by using cameras but we can also get a digital image by scanning preprinted sheets or papers. Currently there are more powerful scanners that can scan thousands of pages within a short period of time and they store the image in the computer memory for further processing. Sometimes, we may receive noisy images that are degraded by some degrading mechanism. In such cases, we need appropriate techniques of refining the images so that the resultant images are of better visual quality, free from aberrations and noises.

After the enhancement of the image to the desired quality, the next step is detection or segmentation of objects of interest within the image. Detection is the process of finding smaller regions of interesting image data which can be further analyzed by more computationally demanding techniques to produce a correct interpretation, for instance selection of a specific set of interest points.

After detecting objects of interest in the image the next step is recognition. In object recognition one or several pre-specified or learned objects or object classes can be recognized, usually together with their two dimensional (2D) positions in the image or three dimensional (3D) poses in the scene.

Image analysis is the process of extracting information from the given image by using different image analysis techniques. There are different image analysis techniques that are used to detect and/or recognize objects and extract information from the given image.

2.1.1 Template Matching

Template matching is a technique for finding small parts of an image which match a template image [8]. It slides the template from the top left to the bottom right of the image, and compare for the best match with template. The template dimension should be equal or smaller than the reference image. It is used in various applications such as face recognition, object tracking, medical image processing, etc. Template matching can be subdivided into two approaches: feature-based and template-based matching.

The feature-based approach uses the features of the search and template image, such as edges or corners, as the primary match-measuring metrics to find the best matching location of the template in the source image. If the template image has strong features, a feature-based approach may be considered; the approach may prove further useful if the match in the search image might be transformed in some fashion. Since this approach does not consider the entirety of the template image, it can be more computationally efficient when working with source images of larger resolution, as the alternative approach, template-based, may require searching potentially large amounts of points in order to determine the best matching location.

The template-based, or global, approach uses the entire template, with generally a sum-comparing metric (using SAD (Sum_of_absolute_differences), cross-correlation, etc.) that determines the best location by testing all or a sample of the viable test locations within the search image that the template image may match up to. For templates without strong features, or when the bulk of the template image constitutes the matching image, a template-based approach may be effective. As aforementioned, since template-based template matching may potentially require sampling of a large number of points, it is possible to reduce the number of sampling points by reducing the resolution of the search and template images by the same factor and performing the operation on the resultant downsized images (multiresolution, or pyramid, image processing), providing a search window of data points within the search image so that the template does not have to search every viable data point, or a combination of both.

This method is normally implemented by first picking out a part of the search image to use as a template: We will call the search image **S(x, y)**, where **(x, y)** represent the coordinates of each pixel in the search image. We will call the template **$T(x_t, y_t)$**, where **(x_t, y_t)** represent the coordinates of each pixel in the template. We then simply move the center (or the origin) of the template **$T(x_t, y_t)$** over each **(x, y)** point in the search image and calculate the sum of products between the coefficients in **S(x, y)** and **$T(x_t, y_t)$** over the whole area spanned by the template. As all possible positions of the template with respect to the search image are considered, the position with the highest score is the best position. This method is sometimes referred to as 'Linear Spatial Filtering' and the template is called a filter mask.

2.1.2 Neural Network

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information [9]. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in union to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process.

An important application of neural networks is pattern recognition. Pattern recognition can be implemented by using a feed-forward neural network. In which the network is trained to associate outputs with input patterns. When the network is used, it identifies the input pattern and tries to output the associated output pattern. Generally this can be done in the following procedure: present the network with training examples, which consist of a pattern of activities for the input units together with the desired pattern of activities for the output units, determine how closely the actual output of the network matches the desired output, then change the weight of each connection so that the network produces a better approximation of the desired output. In addition to this neural network is used for medical image analysis.

2.1.3 Structural Methods

In this technique image patterns are analyzed/ recognized based on its structural relationships inherent in a pattern's shape [6]. The structural relationship includes: matching shape numbers; in which the degree of similarity, k, between two region boundaries (shapes) is defined as the largest order for which their shape numbers still coincide, string matching: in which matching is done symbol by symbol, for example suppose two region boundaries, a and b, are coded into strings denoted a_1, a_2, a_n and b_1, b_2, ..., b_n respectively. Let α represent the number of matches between the two strings, where a match occurs in the k^{th} position if $a_k = b_k$. The starting point on each boundary is important in terms of reducing the amount of computation.

There are also other image analysis techniques like syntactic pattern recognition which provides a unified methodology for handling structural recognition problems. Basically, the idea behind syntactic pattern recognition is the specification of a set of pattern primitives, a set of rules (in the form of a grammar) that governs their interconnection, and a recognizer (called an automaton), whose structure is determined by the set of rules in the grammar.

Neural network, syntactic and structural techniques of image analysis need some regular pattern as inputs but in the case of AAU student evaluation forms, the students may encircle their choices in different forms. Thus template matching is preferred for such type of application.

Depending on the quality of the image, the image analysis techniques use different image enhancement mechanisms as a preprocessing to suppress noises. Gaussian filter, mean filter, median filter, laplician, etc. are some of image enhancement mechanisms.

2.2. Related Works and Systems

There are a large number of various works on form processing using different image analysis techniques. To support the idea of this project, similar works and systems on the area have been assessed.

Optical Mark Reading (OMR) is a technology that has been around for decades. A common application of OMR is in standardize testing [10]. In these testes, respondents indicated their answers to question by filling in, or marking, bubbles (response bubbles) or marks on a pre-printed form with a dark (number two) pencil. The interpreted filtered raw scores of filled or unfilled must be fully translated in combination with additional bubbles into meaningful output results. There are two types of OMR systems: hardware-based and software-based OMR systems.

Hardware-based OMR systems typically rely on specifically printed forms utilizing drop-out colors (i.e. colors that are not read by the reader), and dedicated scanning machine called OMR readers. Forms typically have to be completed using a number two pencil or in some cases a colored pen (e.g., blue, or black). OMR forms have a timing track made up of dark timing lines on the edge (or sometimes the top) of the page. These timing lines are detected by the reader as it moves the piece of paper (the form) past a read head. The read head contains a series of sensors (typically 48 across the page) that measure the amount of light returned from the page.

Forms designed for OMR readers are often printed using special drop-out colors because they are readable by the human eye, but drop-out or disappear when scanned so as to not affect the output data. A number two pencil is used to mark the form because the pencil lead does not reflect the light back to the sensor. When a timing line is found, the reader polls each of its sensors and creates a read level for each. Each sensor provides a read level value between 0 and the maximum, N. there is a value, T, between 0 and N which is deemed to be the recognition threshold. Usually any sensors returning a value at or above (darker) the recognition threshold will be considered filled bubbles and any below the threshold will be unfilled. Even though the reader may be calculating read levels, the output of the OMR reader for each bubble will usually be correct because the difference in read levels is enough to eliminate all ambiguities that a user made the black dot symbol inside the bubble or not. However such systems capable of processing these forms traditionally relay on expensive, dedicated hardware and require the purchase of expensive, preprinted forms.

Software-based OMR systems work with image scanners and easily created plain paper forms. Such systems use sophisticated software algorithms to eliminate the need for the timing lines on a form, thereby allowing the forms to be created with common office tools like a word processor and laser printer. Software- based OMR systems use a self-registering algorithms where in the bubbles that are to be recorded as either filled or not are in and of themselves used in a search algorithm to locate the bubbles on the page that are to be identified, thereby eliminating the need for the special paper and typical timing, framing or other form registration marks that are found on the traditional OMR systems. Self registering OMR means that the bubble must be sufficiently well separated from each other and from the text and graphics on the form thereby taking up precious additional space on the form. However this software-based OMR system has limitation, since it can’t process forms that contain questions and answers in one sheet [11].

There are also different projects on form processing using image analysis techniques that have already implemented for evaluation of university/ faculty. The SIZENA (System for Faculty/University Evaluation) [12] developed for processing evaluation forms. This system uses e-copy and hard-copy questionnaires. In the first case, students fill e-copy questionnaire using their own computers outside the teaching facilities or using computers in faculty computer center. In the second case, students fill hard-copy questionnaire during lecturing hours. Later on the questionnaire papers are scanned and marked answers are extracted from digitalized pictures of scanned questionnaires. The questionnaire participators can answer on questions either by marking offered answers or writing open answers. In SIZENA, answering questions in hard-copy questionnaire is restricted on marking offered answers. Restriction is made because Optical Character Recognition (OCR) of hand written text in their verbal region is a huge problem and a great challenge.

Even if the evaluation form of this project and AAU student evaluation form is different, this project can be used as a bench mark to accomplish the project.

Chapter Three

System Analysis

In Chapter 2, we have seen the different image analysis techniques and the main processes involved and some related works on form processing. In this chapter the functional and non functional requirements of the system will be described and modeled using UML models.

3.1. Proposed System

3.1.1 Overview of the System

The student evaluation form processing system is designed and implemented to overcome the problems that exist on the manual processing of the form using image analysis techniques. The system should allow the user to provide the student evaluation form as an input that is scanned and stored as an image.

The diagram in Figure 3.1 shows the schematic representation of the system and the steps to go through to recognize the values encircled by the students against each statement.

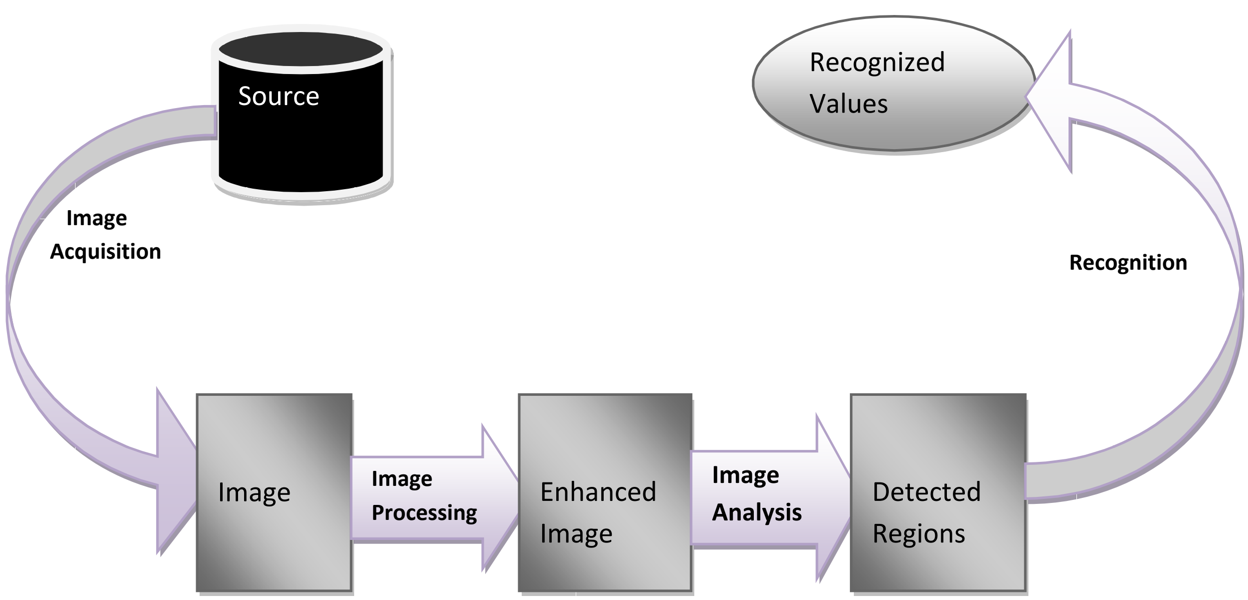


Figure 3.1 Schematic representation and steps in student evaluation form processing of AAU

As depicted in Figure 3-2, student evaluation form processing of AAU involves the following activities.

I. Image acquisition of a student evaluation form filled by students

Image analysis starts with image acquisition. As described in section 2.1, this involves all aspects that have to be addressed in order to obtain images of the objects of interest. For this project images are found by scanning the student evaluation form after filled by AAU computer science second year graduate students. The cleanness of the paper has to be considered carefully since this will have an impact on the quality of the image when it scanned.

II. Image processing

Image processing techniques is applied on the acquired image to enhance the quality of image so as to remove noises. Since the student evaluation form may be degraded by different noises, and this may have an impact on the image analysis techniques, enhancing the image to the better quality will improve the result. One of the most commonly used filters for image processing are Gaussian filters and derivatives of Gaussians. Gaussian filter is frequently used as a low-pass filter for noise suppression and Gaussian derivatives are used to detect and localize edges along with determining their orientation [13]. The use of Gaussian kernels for image processing has become popular, among others, due to (i) their separability in the x and y directions, and (ii) directional isotropy, i.e. circular symmetry [13]. Mathematically, a 2 D Gaussian kernel is defined as

$$g(x,y) = \frac{1}{2\pi\sigma^2}\ \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \qquad (1)$$

where is the standard deviation. Because of its separability property, the 2D Gaussian is more efficiently computed as convolution of two 1D Gaussians, g(x) and g(y), which are defined as follows.

$$g(x) = \frac{1}{\sqrt{2\pi\sigma}}\exp\left(-\frac{x^2}{2\sigma^2}\right) \qquad (2)$$

$$g(y) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left(-\frac{y^2}{2\sigma^2}\right) \qquad (3)$$

For this project the gradient and the direction field of the image are used to separate the foreground image from the background, and noises are removed while computing the gradient and direction field of the image.

Gradient field

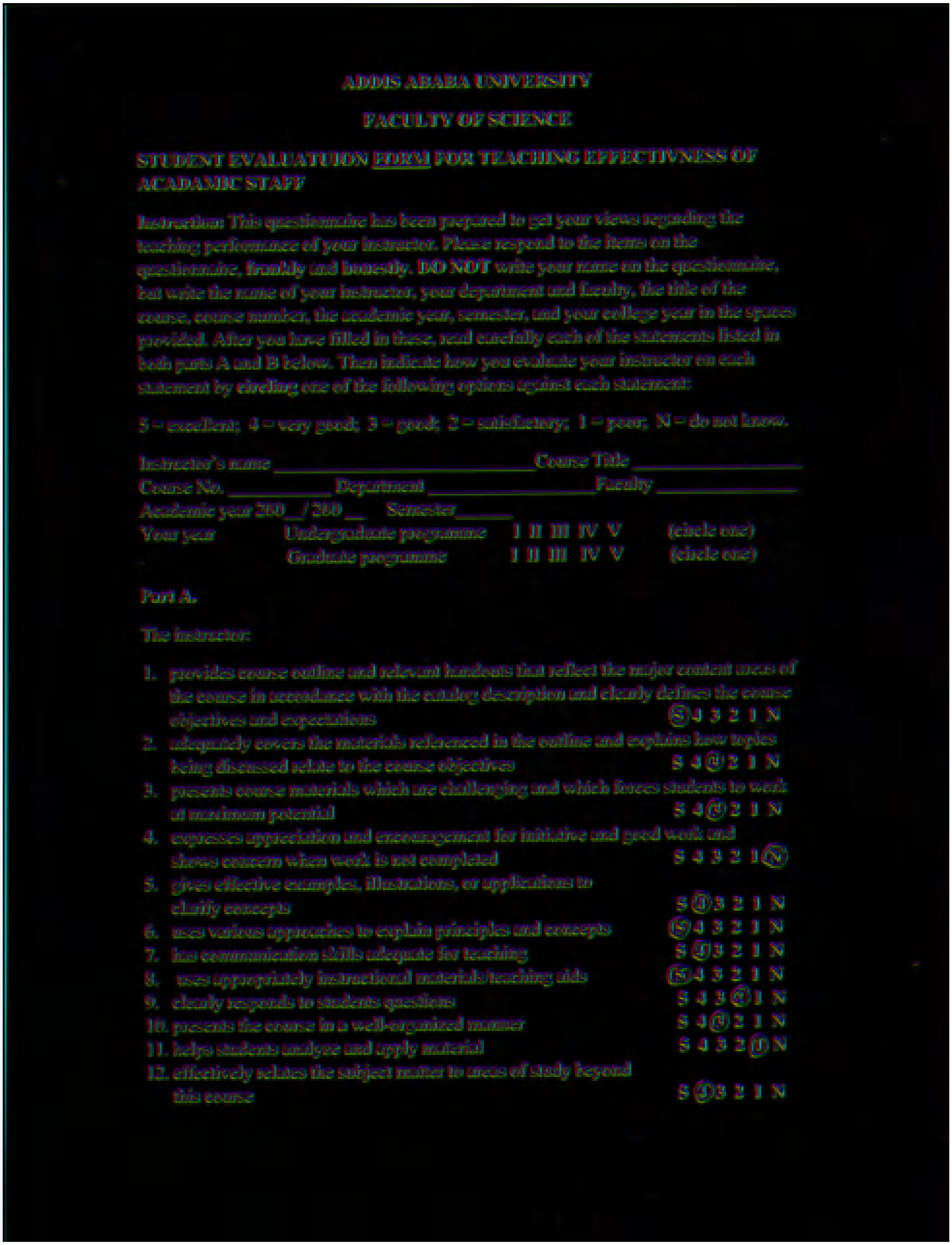
Gradient is the change in gray level with direction. This can be calculated by taking the difference in value of neighboring pixels, producing a vector for each pixel. The magnitude of the vector at each pixel measures the amount of changes in intensity, and the angle of the vector shows the direction of intensity changes of pixels expressed in the range of [0..360] degrees. For a local neighborhood *f(x, y)* of an image *f*, the gradient field ∇*f* is computed for each pixel in the entire image using Gaussian derivative operators D_x and D_y [13].

$$\nabla f(x,y) = D_x + iD_y f(x,y) = \sum_j f_j (D_x + iD_y) g\left(x - x_j, y - y_j\right) \qquad (4)$$

and sampling the image at (x_j, y_j), It amounts to a convolution with a derivative of Gaussians. The complex partial derivative operator Dx+ iDy is defined as:

$$D_x + iD_y = \frac{\partial}{\partial x} + i\frac{\partial}{\partial y} \qquad (5)$$

The gradient image can be displayed in color as shown in Figure 3.2. The hue of the color represents direction of pixels expressed in the range of [0...360] degrees, where pixels with directions of zero are represented by the red color.



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5 = excellent; 4 = very good; 3 = good; 2 = satisfactory; 1 = poor; N = do not know.

Instructor's name ____________________ Course Title ____________

Course No. __________ Department ______________ Faculty ____________

Academic year 200__/ 200 __ Semester______

Your year Undergraduate programme I II III IV V (circle one)

Graduate programme I II III IV V (circle one)

Part A.

The instructor:

1. provides course outline and relevant handouts that reflect the major content areas of the course in accordance with the catalog description and clearly defines the course objectives and expectations 5 4 3 2 1 N
2. adequately covers the materials referenced in the outline and explains how topics being discussed relate to the course objectives 5 4 3 2 1 N
3. presents course materials which are challenging and which forces students to work at maximum potential 5 4 3 2 1 N
4. expresses appreciation and encouragement for initiative and good work and shows concern when work is not completed 5 4 3 2 1 N
5. gives effective examples, illustrations, or applications to clarify concepts 5 4 3 2 1 N
6. uses various approaches to explain principles and concepts 5 4 3 2 1 N
7. has communication skills adequate for teaching 5 4 3 2 1 N
8. uses appropriately instructional materials/teaching aids 5 4 3 2 1 N
9. clearly responds to students questions 5 4 3 2 1 N
10. presents the course in a well-organized manner 5 4 3 2 1 N
11. helps students analyze and apply material 5 4 3 2 1 N
12. effectively relates the subject matter to areas of study beyond this course 5 4 3 2 1 N

Figure 3.2 Gradient image of student evaluation form

Direction field

A local neighborhood with ideal local direction is characterized by the fact that the gray value remains constant in one direction (along the direction of lines), and only changes in the orthogonal direction. Since the directional features are observed along lines, the local direction is also called Linear Symmetry (LS). The LS property of an image can be estimated by analyzing the direction field tensor [13]. The direction tensor, also called the structure tensor, is a real valued triplet, which is a tensor representing the local directions of pixels. For a local neighborhood of an image f (x, y), the direction tensor, also called the structure tensor S, is computed as a 2 x 2 symmetric matrix using Gaussian derivative operators D_x and D_y.

$$S = \begin{pmatrix} \iint (D_x f)^2 dxdy & \iint (D_x f)(D_y f) dxdy \\ \iint (D_x f)(D_y f) dxdy & \iint (D_y f)^2 dxdy \end{pmatrix} \tag{6}$$

Linear symmetry exists among others at edges where there are gray level changes and an evidence for its existence can be estimated by eigenvalue analysis of the direction tensor or equivalently by using complex moments of order two which are defined as follows:

$$I_{20} = \iint \ ((D_x + iD_y)f)^2 dxdy \tag{7}$$

$$I_{11} = \iint \ |(D_x + iD_y)f|^2 dxdy \tag{8}$$

The value of I20 is a complex number where the argument is the local direction of pixels in double angle representation (the direction of major eigenvector) and the magnitude is a measure of the local LS strength (the difference of eigenvalues). The scalar I_{11} measures the amount of gray value changes in a local neighborhood of pixels (the sum of eigenvalues). Direction field tensor, which is a tensor field defined over local images for all points in the entire image, can also be conveniently represented by the 2D complex I_{20} and 1D scalar I_{11}.

The complex image I20 can be displayed in color as shown in Figure. 3.3 where the hue represents direction of pixels in double angle representation. Pixels with directions of zero are represented by the red color.

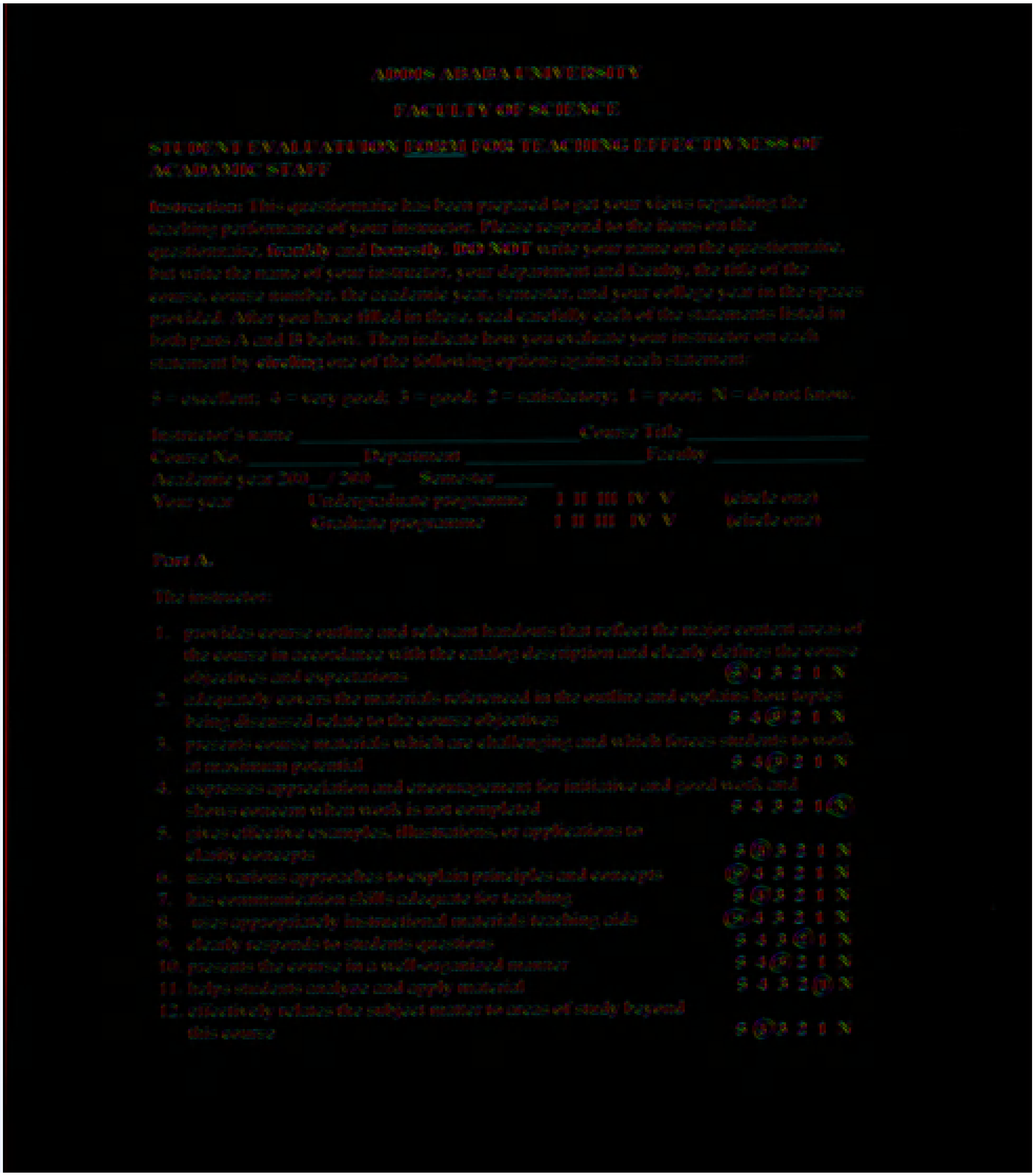
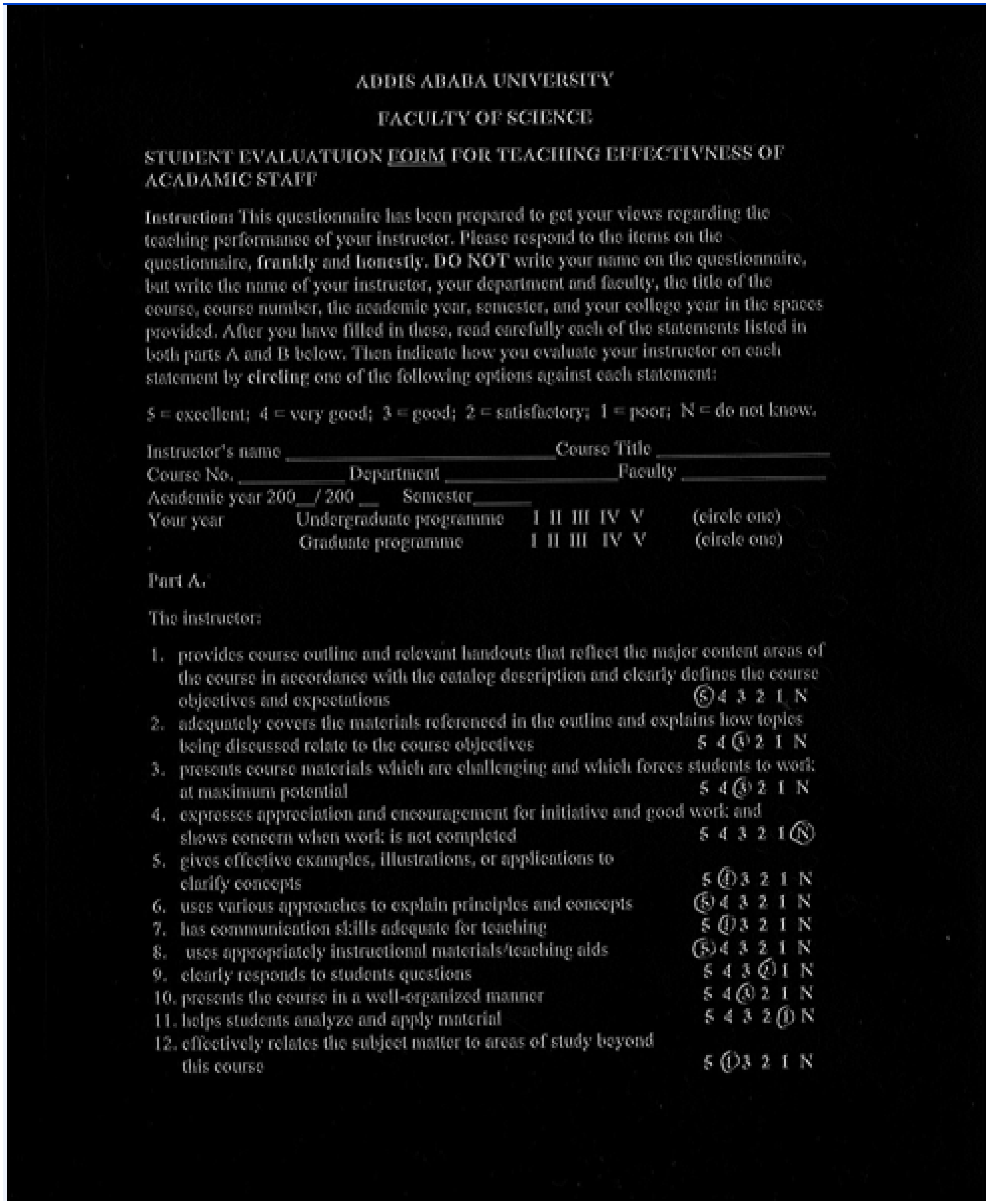


Figure 3.3 Direction field image of student evaluation form

In this work, we used ∇f for image processing and analysis. Since, ∇f has an advantage such that, its argument is computed with directions of pixels expressed with [0 ...360) degrees, representing the left and right edges (black-white, white-black transitions) differently [13].

After computing the Gradient image, pixel values that has magnitude of less than 0.005 set to zero. This is used to suppress noises. Figure 3.4 shows the result of this normalization.



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Instructor's name ______________________________ Course Title ________________

Course No. __________ Department ________________ Faculty ______________

Academic year 200__/ 200 __ Semester______

Your year Undergraduate programme I II III IV V (circle one)

Graduate programme I II III IV V (circle one)

Part A.

The instructor:

1. provides course outline and relevant handouts that reflect the major content areas of the course in accordance with the catalog description and clearly defines the course objectives and expectations 5 4 3 2 1 N
2. adequately covers the materials referenced in the outline and explains how topics being discussed relate to the course objectives 5 4 3 2 1 N
3. presents course materials which are challenging and which forces students to work at maximum potential 5 4 3 2 1 N
4. expresses appreciation and encouragement for initiative and good work and shows concern when work is not completed 5 4 3 2 1 N
5. gives effective examples, illustrations, or applications to clarify concepts 5 4 3 2 1 N
6. uses various approaches to explain principles and concepts 5 4 3 2 1 N
7. has communication skills adequate for teaching 5 4 3 2 1 N
8. uses appropriately instructional materials/teaching aids 5 4 3 2 1 N
9. clearly responds to students questions 5 4 3 2 1 N
10. presents the course in a well-organized manner 5 4 3 2 1 N
11. helps students analyze and apply material 5 4 3 2 1 N
12. effectively relates the subject matter to areas of study beyond this course 5 4 3 2 1 N

Figure 3.4 Normalized gradient image

III. Detecting value regions

Detecting region which contain values ('5', '4', '3', '2', '1', 'N') against each statement is a crucial step in this project. Thus these regions are detected by using template matching image analysis techniques. A template image is taken from the normalized gradient image as shown in figure 3.5 below. A template image is a smaller part of the original image that is needed to be detected in the source image. We then simply move the center (or the origin) of the template image over each **(x, y)** point in the search image and calculate the sum of products between the coefficients in the search image and template image over the whole area spanned by the template. As all possible positions of the template with respect to the search image are considered, the position with the highest score is the best position. For the first page of the student evaluation form of AAU, 12 regions are detected. While, for the second page 24 regions are detected. Regions detection is used to detected values encircled by the students. Within each detected regions, the values encircled by students will be detected by finding a relative circle that has a range of radius.

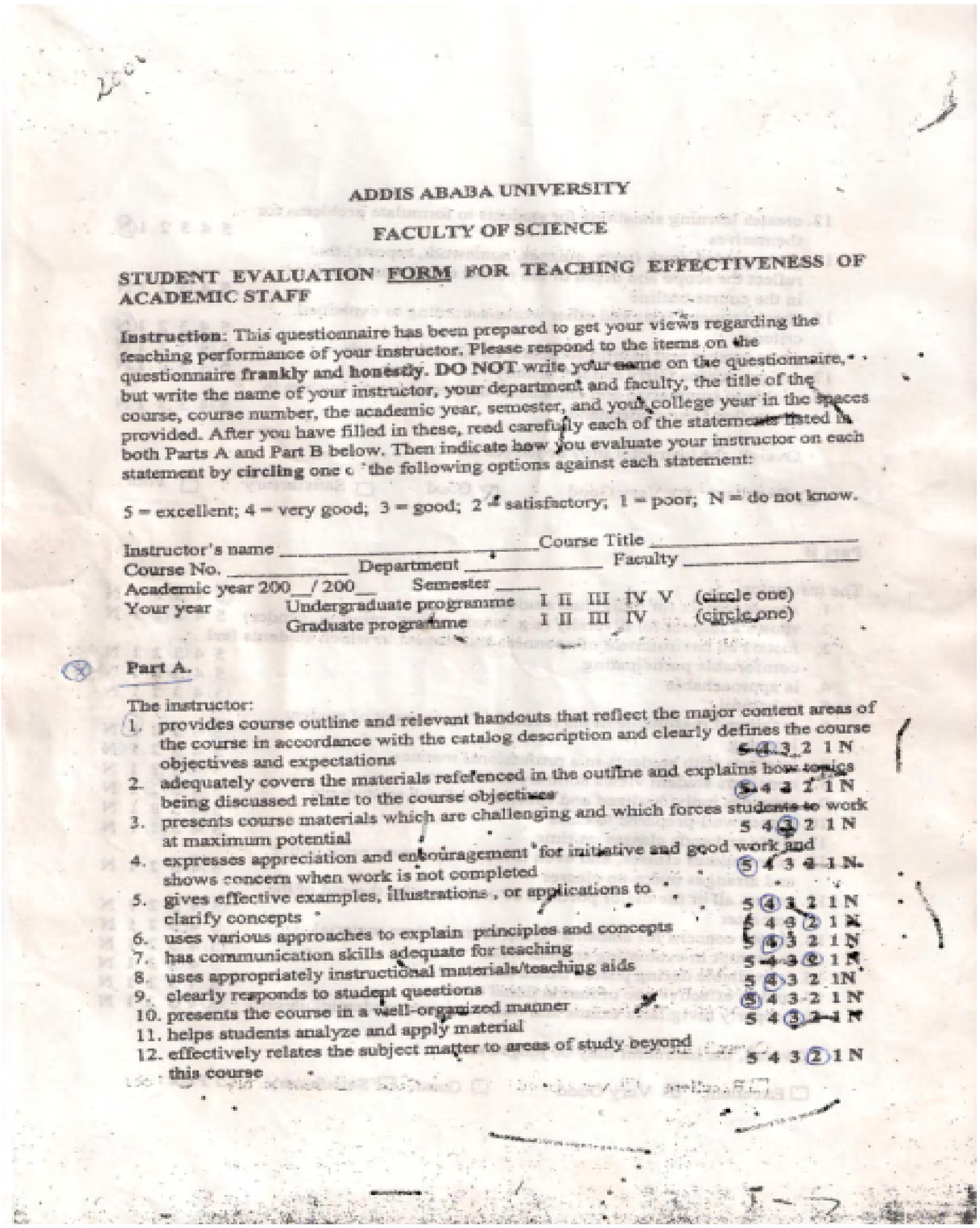
Figure 3.5 Template image

IV. Recognition

As it is explained in section 2.1 of this document, the ultimate product of image analysis system is usually numerical outputs rather than a picture. Object recognition is a high level processing stage in many computer vision systems. At this stage the input is typically a small set of data, for example a set of points or an image region which is assumed to contain a specific object [3]. The remaining processing deals with, for example:

- Verification that the data satisfy model based and application specific assumptions.
- Estimation of application specific parameters, such as object poses or objects size.
- Classifying a detected object in to different categories.

Recognition result of form processing in general highly depends on the quality of the form. Thus for highly noised images, Figure 3.6 shown the system may not recognize values correctly.



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Instructor's name ____________ Course Title ____________
Course No. ____________ Department ____________ Faculty ____________
Academic year 200__/ 200__ Semester ____
Your year Undergraduate programme I II III IV V (circle one)
Graduate programme I II III IV (circle one)

Part A.

The instructor:

1. provides course outline and relevant handouts that reflect the major content areas of the course in accordance with the catalog description and clearly defines the course objectives and expectations 5 4 3 2 1 N
2. adequately covers the materials referenced in the outline and explains how topics being discussed relate to the course objectives 5 4 3 2 1 N
3. presents course materials which are challenging and which forces students to work at maximum potential 5 4 3 2 1 N
4. expresses appreciation and encouragement for initiative and good work and shows concern when work is not completed 5 4 3 2 1 N
5. gives effective examples, illustrations, or applications to clarify concepts 5 4 3 2 1 N
6. uses various approaches to explain principles and concepts 5 4 3 2 1 N
7. has communication skills adequate for teaching 5 4 3 2 1 N
8. uses appropriately instructional materials/teaching aids 5 4 3 2 1N
9. clearly responds to student questions 5 4 3 2 1 N
10. presents the course in a well-organized manner 5 4 3 2 1 N
11. helps students analyze and apply material
12. effectively relates the subject matter to areas of study beyond this course 5 4 3 2 1 N

Figure 3.6 Noisy student evaluation form

For this project the need is to recognize values encircled by the students. Thus, the coordinate values of both the detected region and the detected circles are used to recognize values.

3.1.2 Functional Requirements

The developed system is expected to provide the following functionalities:

- The system should be able to accept the scanned student evaluation form as an input.
- The system should be able to enhance the image to filter the noises
- The system should be able to detect the regions and recognize values encircled by the students.
- The system should be able to displays the values being recognized against each statement
- The system should be able to compute the sum of recognized values and store on the temporary storage.
- The system should be able to count the number of forms being processed.
- The system should be able to compute the total average values in such a way that, dividing the total sum by the product of number of students and number of statements.
- While computing the total average, the system should be able to subtract those statements where the students encircle “N”.

3.1.3 Non Functional Requirements

There are also non-functional requirements expected from the system and the following lists these requirements.

- The system must be easy to use
- The system must respond the result quickly.

3.2 Analysis Model

To produce a model of the system which is correct, complete and consistent we need to construct the analysis model which focuses on structuring and formalizing the requirements of the system. Analysis model contains three models: functional, object and dynamic models. The functional model can be described by use case diagrams. Class diagrams can describe the object model. Dynamic model can also be described in terms of Sequence, state chart and activity diagrams. For the purpose of this project we have described the analysis model in terms of the functional model and dynamic models using use case, sequence diagrams and activity diagram.

3.2.1 Use case Diagram

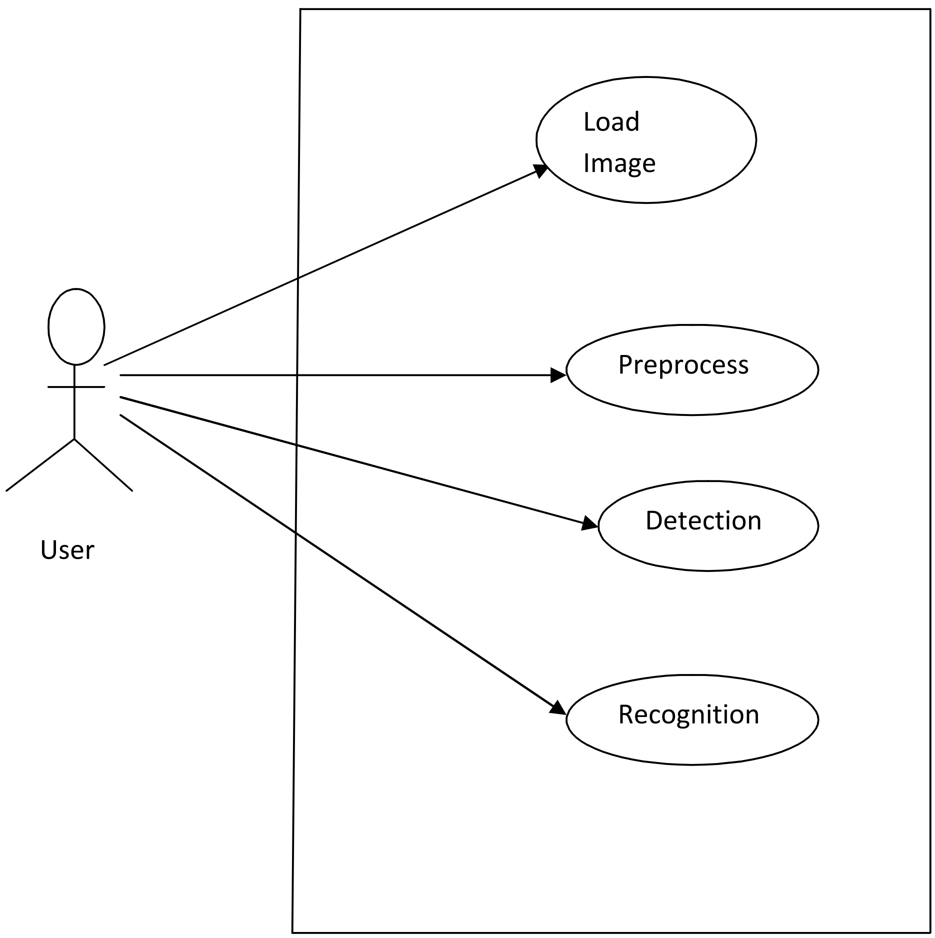

Figure 3.7 Use case Diagram of the system

3.2.1.1 Use case Descriptions

The following four tables (Table 3.1, Table 3.2, Table 3.3, and Table 3.4), show the summary of use case description for Load Image, Preprocess, Detection, and Recognition.

Use Case Name	Load Image
Participating Actor:	User
Description:	A use case that allows the user to load an image for further processing
Pre –condition:	The user initiates the system
Flow of Events:	1. The user clicks on the file menu 2. Under the file menu the user clicks on load image 3. The system displays window that contains image files 4. From the displayed window the user selects the image and clicks on open 5. The system displays the image on the user interface
Post condition:	The selected image will be displayed

Table 3.1 Use case description for Load Image

Use Case Name	Preprocess
Participating Actor:	User
Description:	A use case that allows the user to preprocess the image for noise filtering
Pre –condition:	The image for preprocessing must be loaded
Flow of Events:	1. The user clicks on the preprocessing menu 2. Under the preprocessing menu the user clicks on get preprocessed image 3. The system preprocess the given image and displays a filtered image
Post condition:	The filtered image will be displayed

Table 3.2 Use case description for Preprocess

Use Case Name	Detection
Participating Actor:	User
Description:	A use case that allows the user to detect the region which contains choices and the specific region encircled by the students
Pre –condition:	The filtered (preprocessed) image for detection must be loaded
Flow of Events:	1. The user clicks on the detection menu 2. Under the detection menu the user chooses either page 1 or page 2 based on the displayed filtered image 3. The system detects the required regions and displays the image where the detected region is bounded by white rectangle.
Post condition:	The image with detected regions bounded by rectangles will be displayed.

Table 3.3 Use case description for Detection

Use Case Name	Recognition
Participating Actor:	User
Description:	A use case that allows the user to get the actual values encircled by the students
Pre –condition:	Regions that contains values must be detected
Flow of Events:	1. The user clicks on the recognition menu 2. Under the recognition menu the user chooses either page 1 or page 2 based on the detected region 3. The system process on the detected region and displays each values, sum and average
Post condition:	Values against each statement and the sum and average values will be displayed

Table 3.4 Use case description for Recognition

3.3. Sequence Diagram

The dynamic behavior of the system is depicted by using sequence diagrams. The sequence diagrams facilitate the specification of formalization to accommodate behavioral modeling which is responsible to show and capture the interaction between participating objects in a given use case. They are also helpful to identify the missing objects that are not identified in the analysis object model. The following diagrams describe the direct translation of identified use cases in to the sequence diagram.

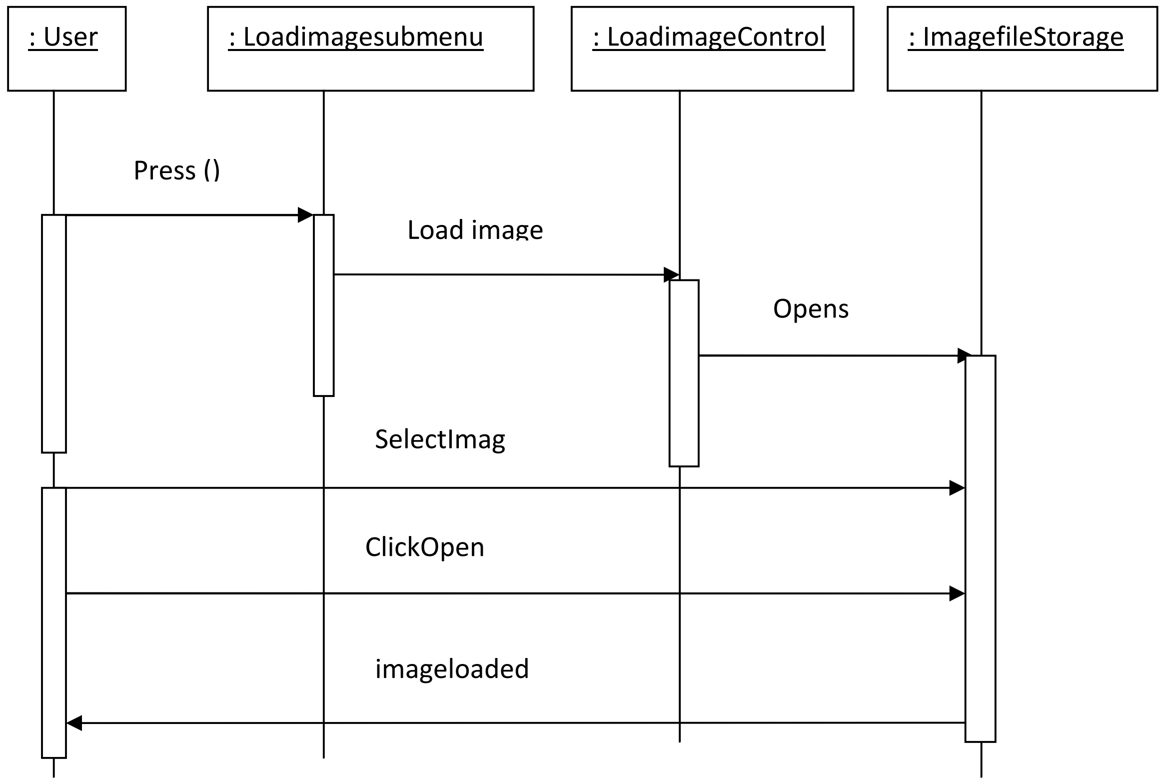

Figure 3.8 Sequence diagram for Load image

As shown in figure 3.8, shows the instance of loading scanned image by interacting with the load image sub menu, then the load image controller will open image file storage. Then the user selects the image and clicks open button. Then the image will be loaded for preprocessing.

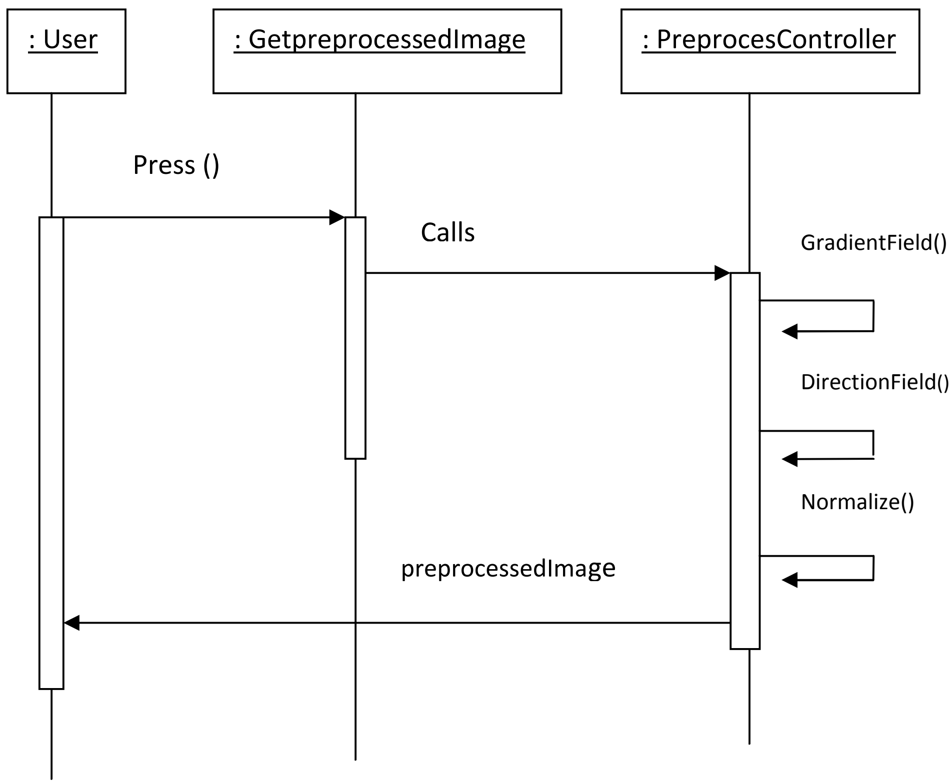

Figure 3.9 Sequence diagram for Preprocess use case

As shown in figure 3.9 once the selected image is loaded, the user clicks the get preprocessing image sub menu and this will initiate the preprocessing controller to compute the gradient field, direction field, and normalize it then the preprocessed image will be displayed.

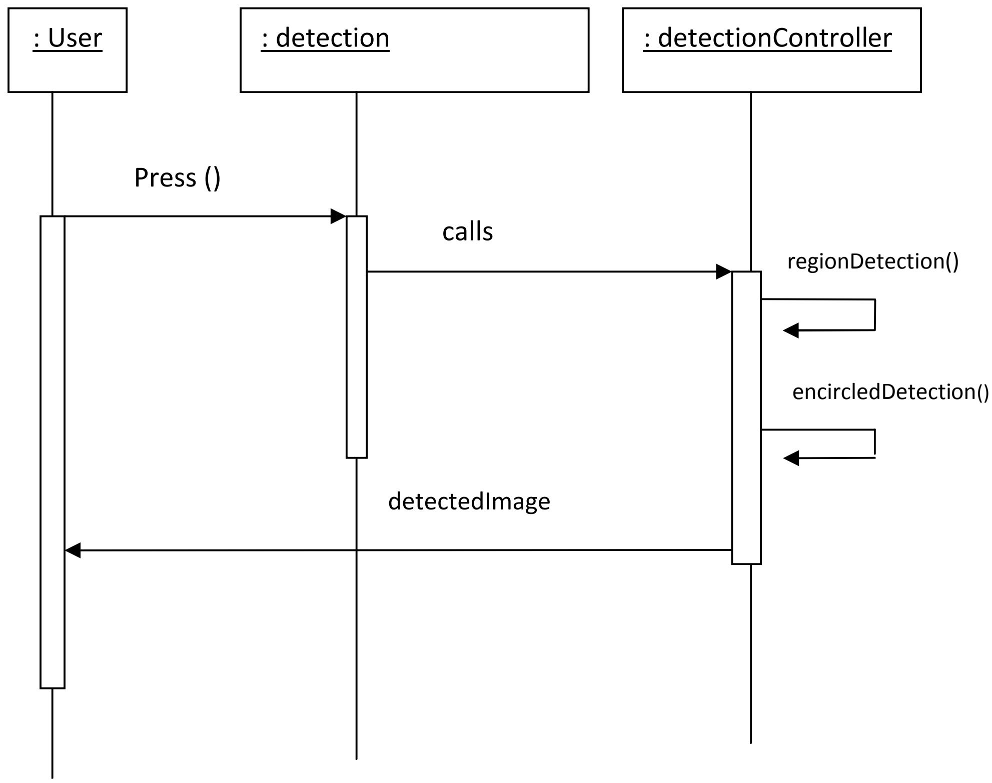

Figure 3.10 Sequence diagram for Detection use case

As shown in figure 3.10 once the image is preprocessed the user clicks the detection menu then the detectionController is initiated and here the regions where the values are found are detected by using template matching algorithms and the specific value encircled by the students will also be detected by finding relative circles in each detected regions. Finally image with detected regions will be displayed to the user.

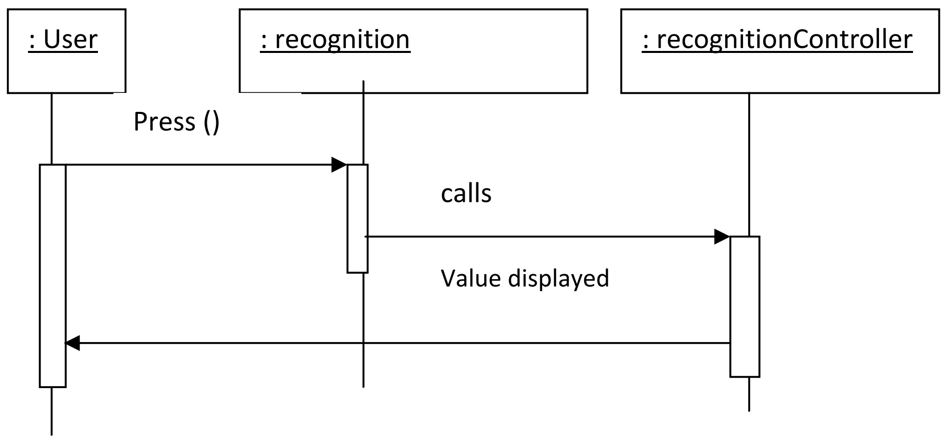

Figure 3.11 Sequence diagram for Recognition use case

As shown in figure 3.11 above based on the detected region and the specific value encircled by the user, when the user press the recognition menu the values encircled by the students against each statement for both pages (page 1 and page 2) will be displayed in addition to this the sum and average values will also be displayed.

3.4. Activity diagram

Figure 3.12 shows the activity diagram of the system that can describe the set of operations executed and the order of execution of these operations.

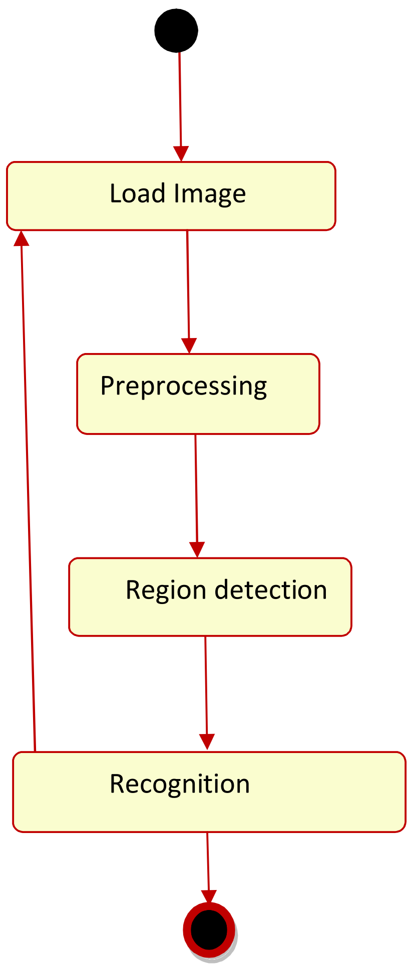

Figure 3.12 Activity diagram of the system

Chapter 4

System Design

In the previous chapter, the functional and nonfunctional requirements of the system were considered and analysis model was constructed. This chapter presents the design of the system by setting the design goals, and the architecture of the system.

4.1. Design Goals

The design goals represent the desired qualities that the system should have and provide a consistent set of criteria that should be taken into account when making design decisions. It describes the qualities of the system that developers should optimize.

4.1.1. Performance criteria

Performance may include the speed and memory requirements of the system. Processing speed is the main constraints, since Image analysis algorithms like template matching needs high processing speeds especially for large sized images to satisfy the response time requirements so, when one need to design an application using such type of image analysis techniques, mechanisms that reduce the response time should be considered.

One of the performance criteria that should be considered in designing the system having in mind the computational intensiveness of such image analysis techniques is response time. Using the template matching algorithms directly for the system can take more than 40 minutes to process the two pages. But the system is designed to process the images without noticeable delay by modifying the algorithm.

4.1.2. Maintenance criteria

The maintenance criteria deal with the difficulty of changing the system, adding new functionality, revising existing functionality, portability of the system.

Extensibility: the system should enable the addition of new functionality without affecting its current functionality.

Modifiability: the system should enable the change in interface configuration with minimum effort if the need arise.

4.1.3. End User Criteria

The end user criteria includes qualities that are desirable from a users' point of view and have not yet been covered under the performance and dependability criteria

Usability: The system shall be developed so as to be easy for user understanding by providing a simple user interface that requires minimum learning curve for novice users.

4.2. Architecture of the system

The general architecture of the system is shown on figure 4.1. From the architecture of the system we can observe that the system has five layers. The user interface layer is responsible to pass user's input data to the preprocessing and subsequently to the region detection and displays recognized values. The preprocessing and region detection activities can be considered as a layer that can perform pre-activities for the main functional activities of the system, recognition of values.

The recognition layer takes the region detected images as an input and displays the values encircled by the students to the user.

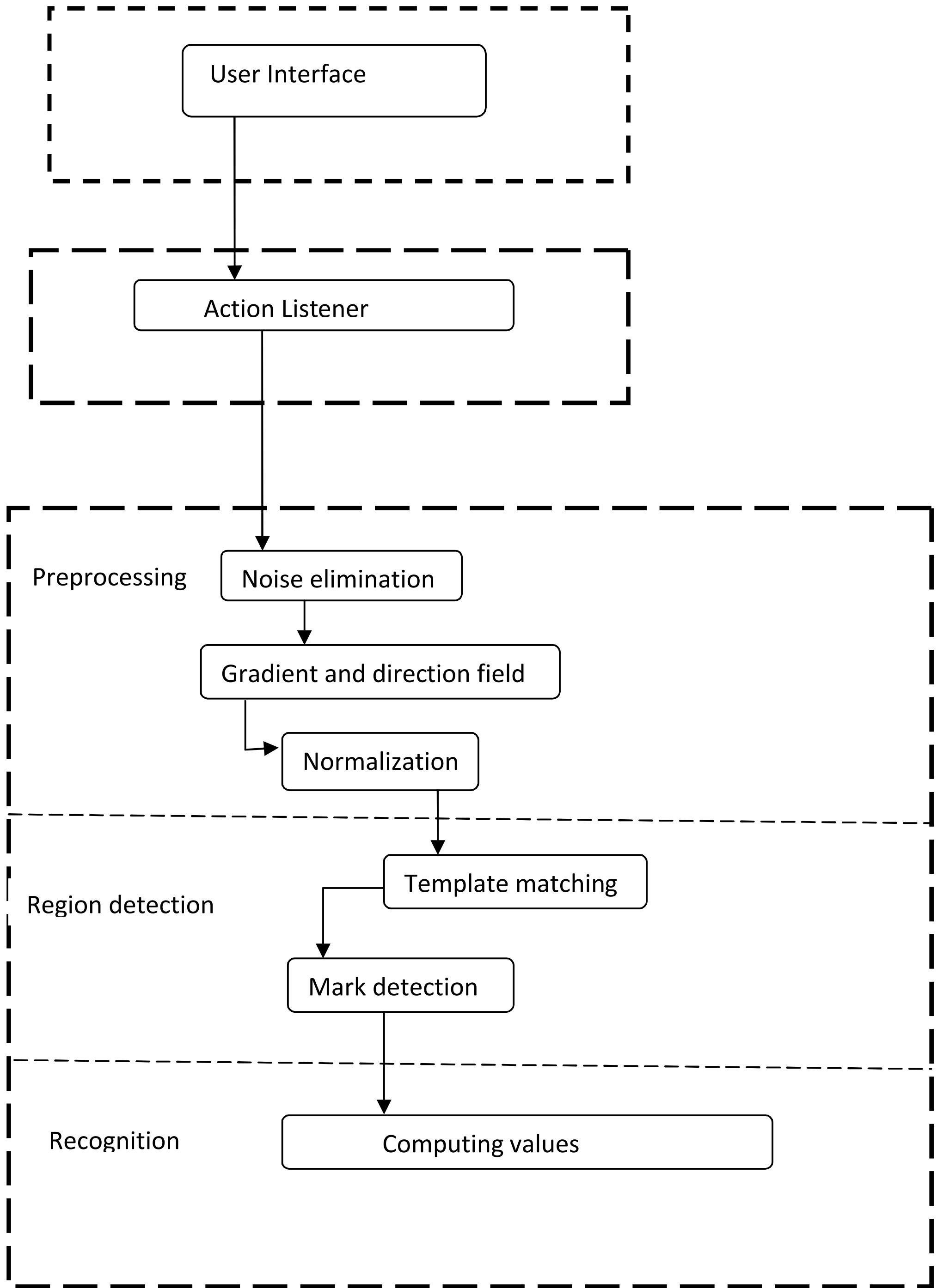

Figure 4.1 The general architecture of the system

Chapter 5

Implementation

This chapter describes the implementation of the student evaluation form processing of AAU, which was specified in detail in the previous chapter. As described in section 3.2.1, student evaluation form processing of AAU using image analysis techniques has four components. They were image acquisition, image preprocessing, region detection and recognition.

Image acquisition is the process of recording images. Student evaluation form images were taken by scanning the form after filled by the students of AAU 2nd year computer science masters students.

Next to image acquisition, image preprocessing techniques were applied on the recorded images. Image preprocessing was used to enhance the image, and then the image will have better quality.

From the enhanced image, regions which contain alternative values against each statement and the values encircled by the students will be detected. These detected regions are used to recognize values encircled by the students.

In the following section, the development environment of the implemented system and the tools used are presented

5.1. The system development environment

Our system is developed and tested on a PC of Intel® Pentium® IV CPU with 2.40GHZ speed, 256 MB of RAM, 40GB of hard Disk capacity, with Microsoft Windows XP Professional operating system.

5.2. Development tools

The implementation is developed using MATLAB version 7.1.0246(R14) service pack 3. MATLAB is high-performance language for technical computing that integrates computation, visualization, and programming where problems and solutions are expressed in mathematical notation. Typical uses include Math and computation, algorithm development; signal processing, modeling, simulation, prototyping, and the like.

5.3. AAUSEFP

The system developed as a prototype in this project work is named as AAUSEFP an abbreviation for Addis Ababa University Student Evaluation Form Processing. This project work is aimed to show the implementation of AAUSEFP by using image analysis techniques. The technique used to recognize the values encircled by the students is by arranging four menus on the user interface. After the user loads the image he/she must press the preprocessing menus to filter the noises and he /she has to press page1 or page2 sub-menu under the detection menu based on the loaded image finally he/she has to press the values submenu under the recognition menu.

Here the discussion is all about how to go through those steps to recognize the values encircled by the students on the student evaluation form of Addis Ababa University by taking particular scenario.

When the system is being activated, the user interface of the system is displayed as shown in figure 5.1.

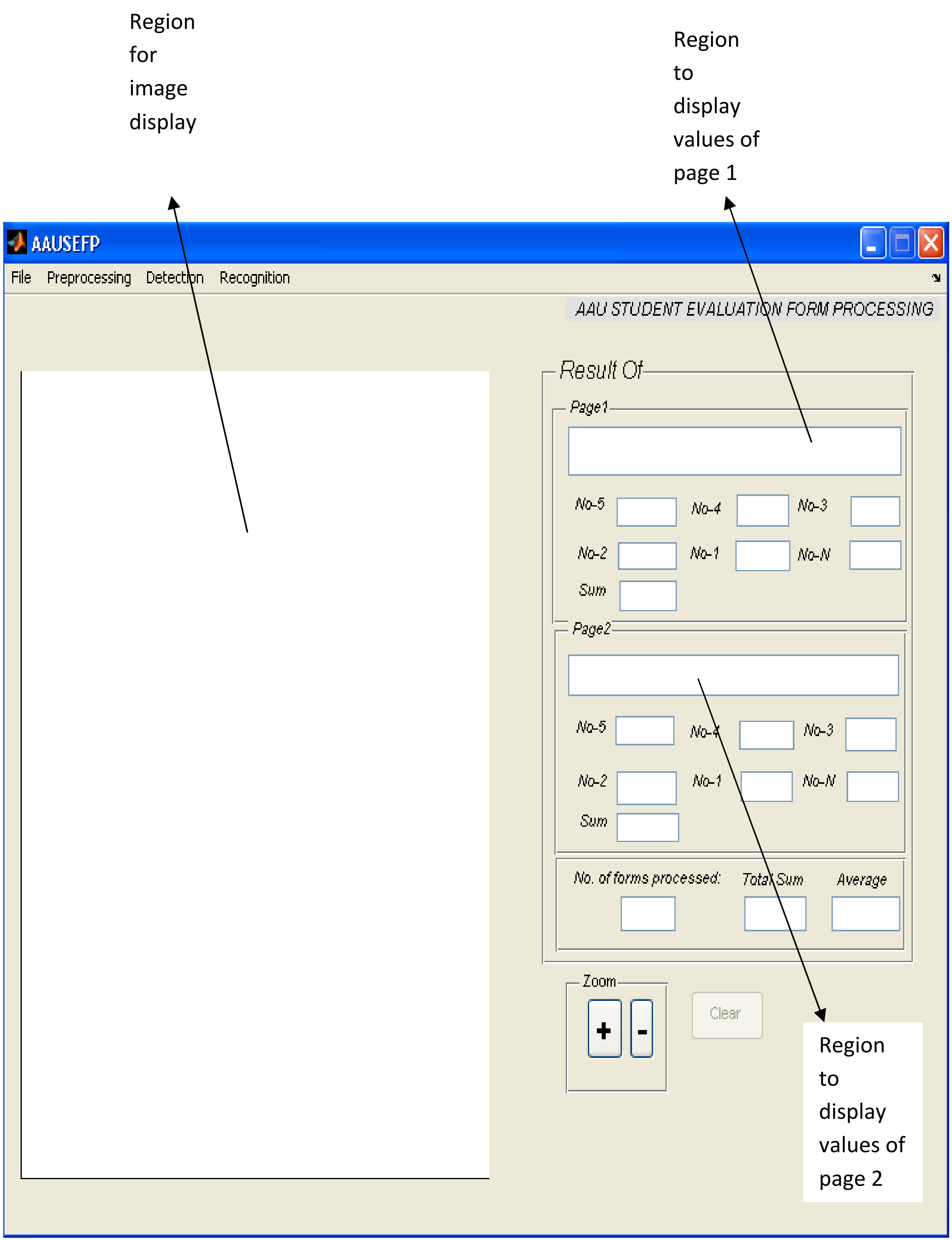

Figure 5.1.User interface of the system

The user has to load the image first by pressing the load image sub menu under the file menu. Then the image will be displayed on the white place on the left side of the user interface as figure 5.2 shown below.

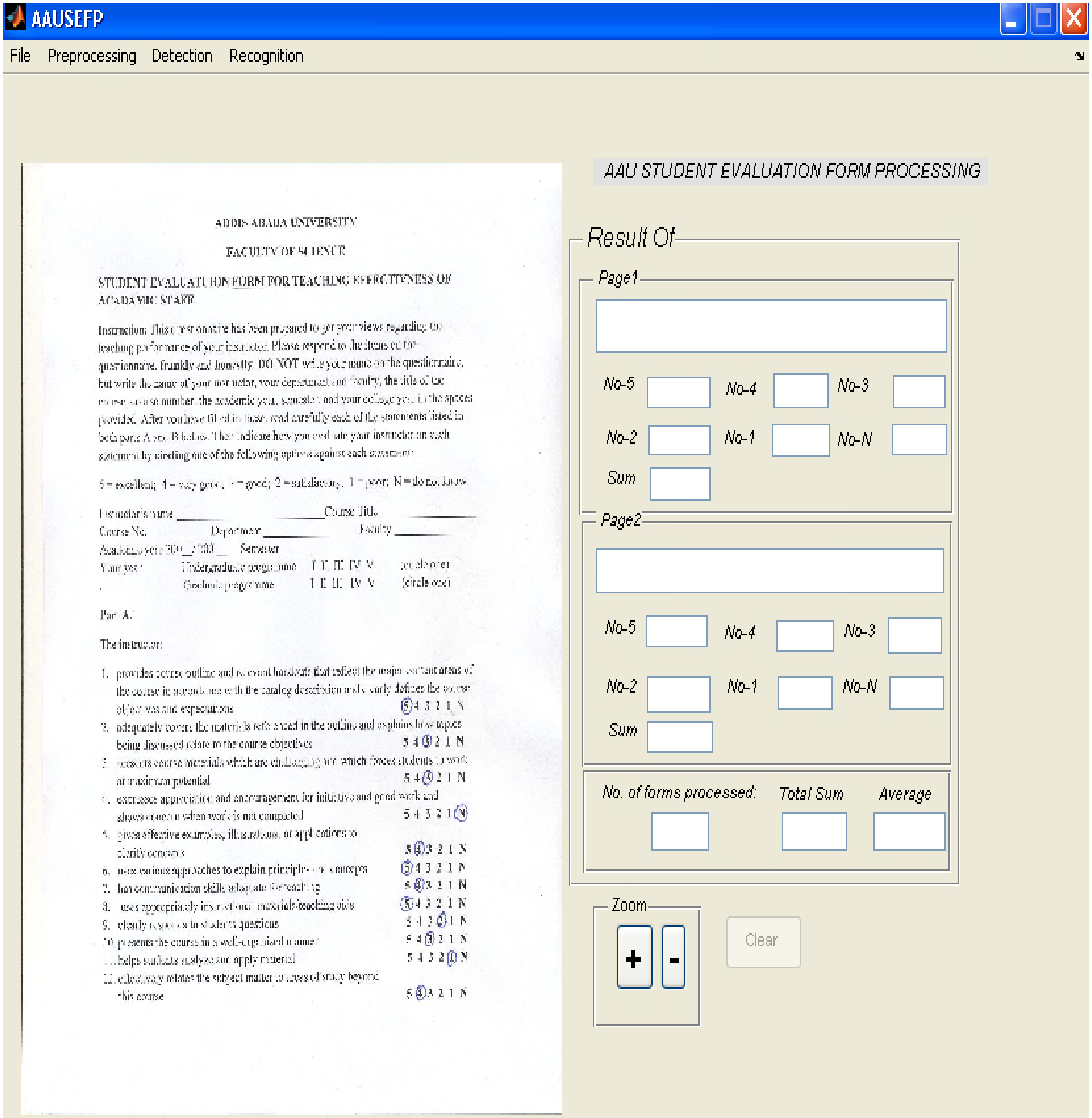

Figure 5.2.User interface of the system after loading the image

Since the image is found by scanning the student evaluation form after encircled by the students the probability of being noised is high so the user has to preprocess the image to remove the noises before detecting the regions which contains the values against each statement. Figure 5.3 shown below shows the result of the image after the user presses the preprocessing menu.

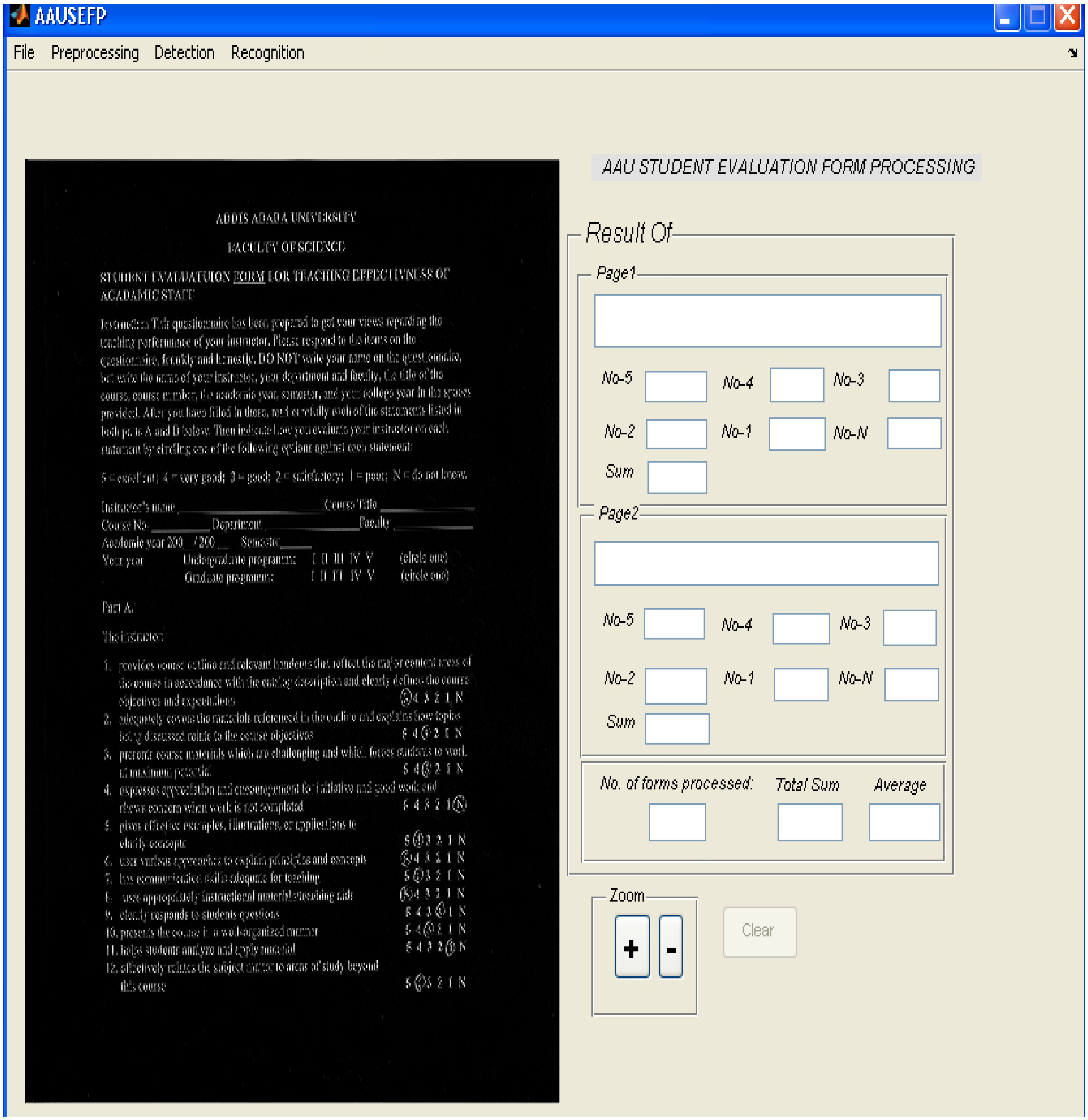

Figure 5.3 User interface of the system after preprocessing the image

The next step to recognize the values is detecting the regions which contain values against each statement and then in each region the specific regions which contain the encircled values are detected and the result after detection is shown on figure 5.4 shown below.

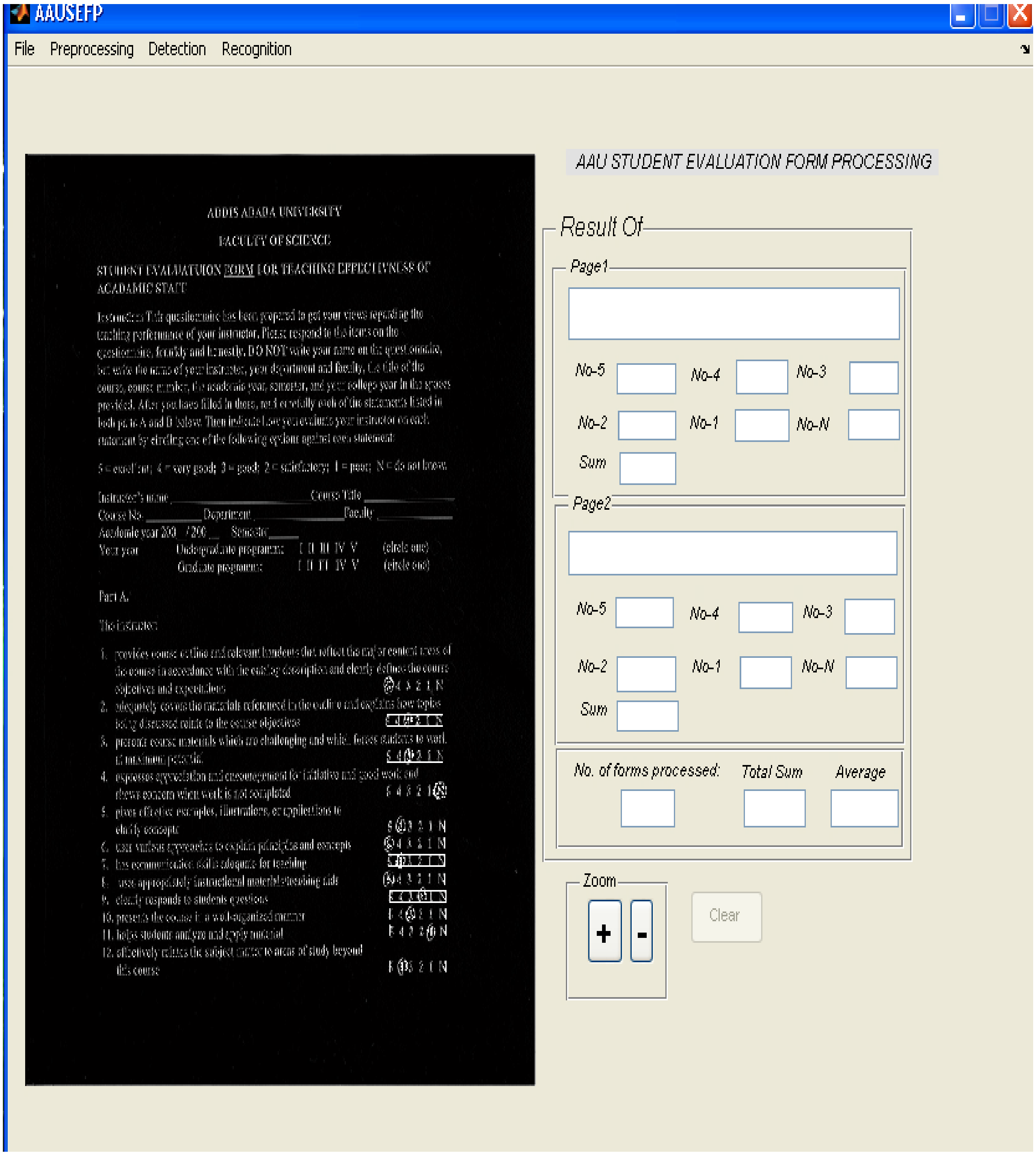

Figure 5.4 User interface of the system with region detected image

As figure 5.4 shows regions which contain alternative values against each statement is detected is shown under a white rectangle and in each rectangle the values encircled by the students are detected and displayed with white dots around the encircled values. Figure 5.5 shows the detected regions clearly if the user zooms in the specific areas in the image.

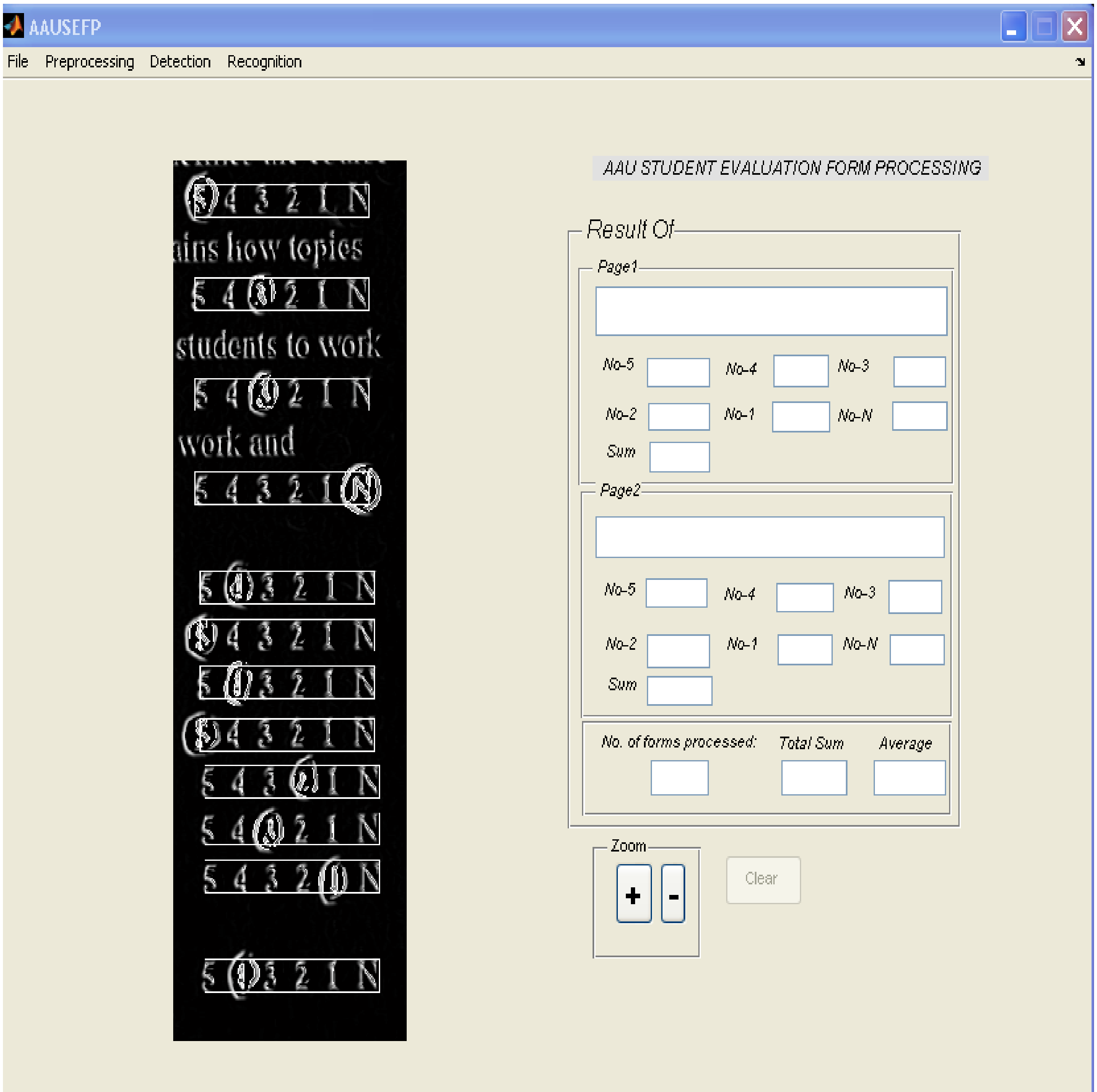

Figure 5.5 User interface of the system after the user zoom in the regions

Finally when the user presses values sub-menu under the recognition menu the values encircled by the students will be displayed. If the image is page 1 then the values are displayed under the page1 as shown in the figure 5.6.

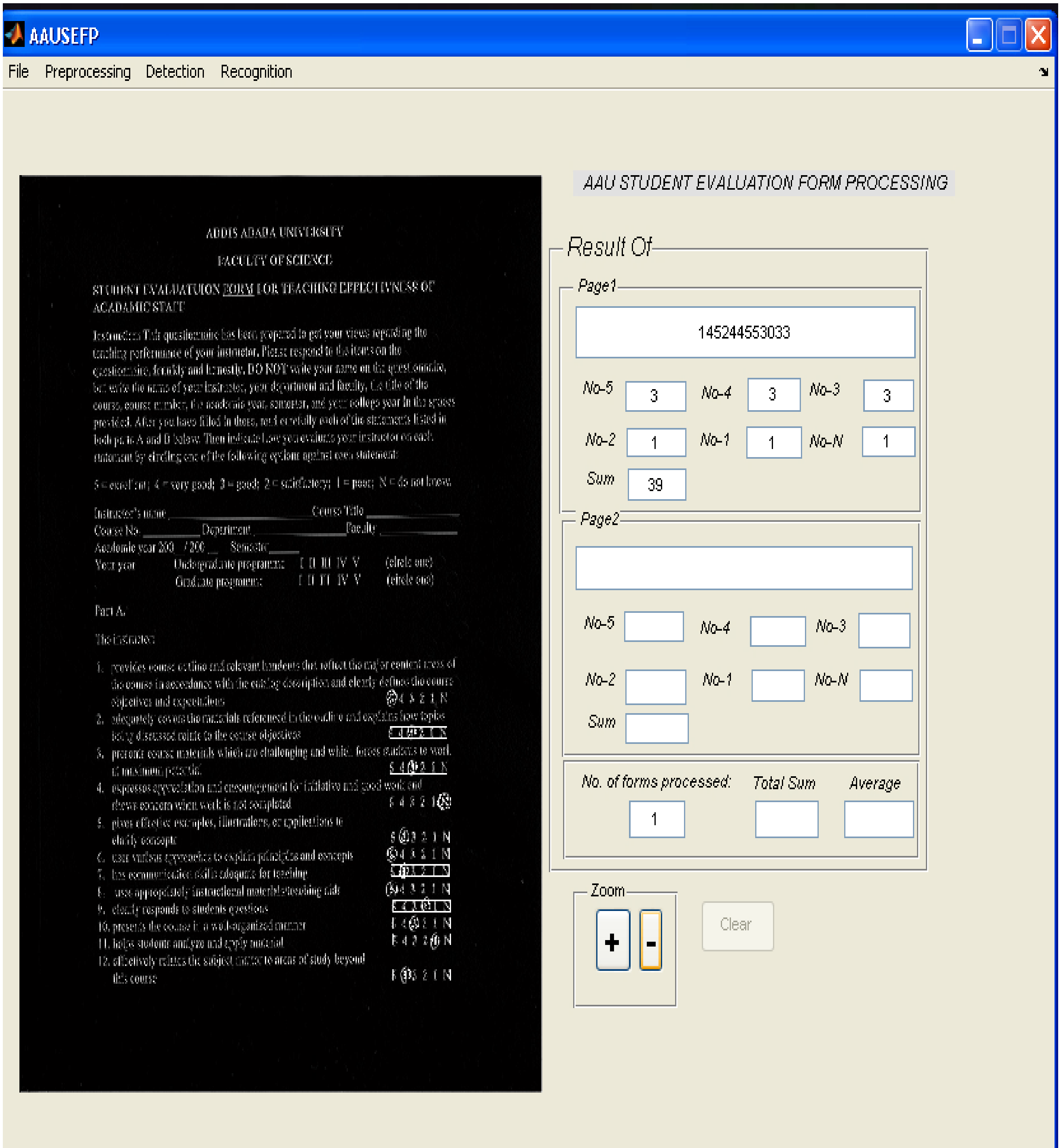

Figure 5.6 User interface of the system with recognized values of page 1

As figure 5.6 shows on the right top side the whole values together are displayed and under that the number of each value is computed and displayed and on the right bottom side the number of forms processed is counted and displayed.

The same step is applied for recognizing values encircled by students for page 2 and the values are displayed in the same way as page 1.

As figure 5.7 shown below the number of forms processed will increases by one and when the value of the second page is displayed total sum of the first page and the second page and the average values will be computed and displayed and it will continue like this.

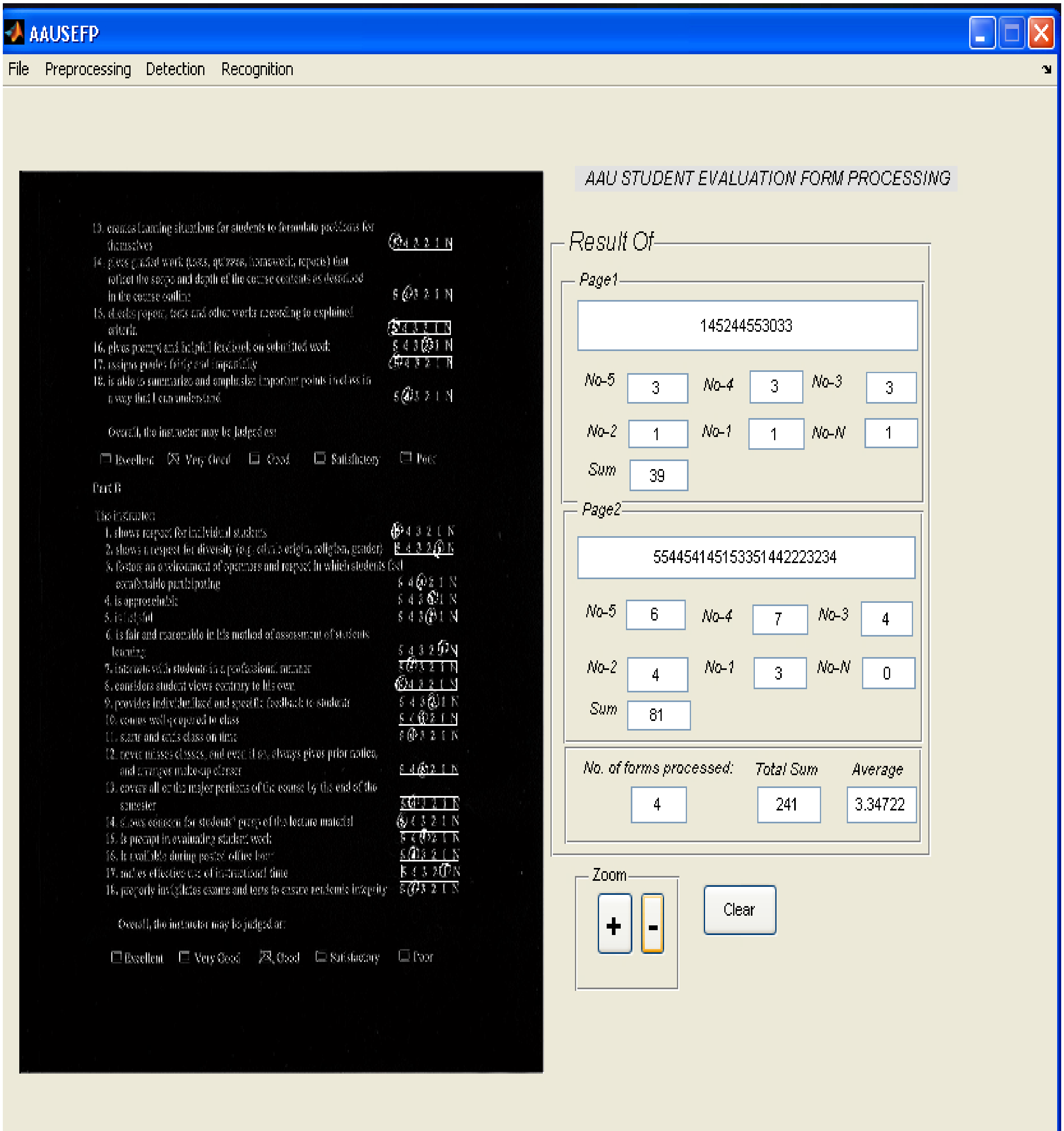

Figure 5.7 User interface of the system with recognized values of page 2

5.4. Discussion

In section 5.3 the general activities performed to recognize the values encircled by the students are described. This section describes the performance of the system regarding to error rates, usability and effectiveness of the system.

The developed system is tested with student evaluation forms which have different visual quality and that were filled by thirty students. Out of thirty students, twenty five students filled student evaluation forms which have a better visual quality, and four students filled student evaluation forms which have medium visual quality whereas, the remaining student filled a student evaluation form which is very noisy.

For those forms which have better and medium visual quality, the system recognizes the values encircled by the students correctly. However, for highly noised image, regions which contain alternative values against each statement are well detected, but the values encircled by the students are not recognized correctly. More than 96% the system is able to recognize the values correctly. This shows that the cleanness of the student evaluation form has an impact to recognize the values as they are encircled by the students.

As it is described in Chapter 3, image acquisition is the first step in image analysis systems. For a single student evaluation two pages of student evaluation form is needed to be scanned and processed two get the values. However, this adds an additional worth of cost and time. Thus, this decreases the usability of the system, but it is possible to decrease the number of pages to one either by modifying the page or by preparing an external answer sheet.

Chapter 6

Conclusion and Future works

The last chapter of this report summarizes the work of the project and some future works concerning the Student Evaluation Form Processing of Addis Ababa University. These are detailed in the following two sections:

6.1. Conclusion

The teaching effectiveness of academic staffs is evaluated by their students. This helps to know the student views regarding the teaching performance of their instructors. The number of students enrolled in Addis Ababa University is now increasing this makes processing the student evaluation form processing manually being tedious and time taking. Throughout this project, we have seen that implementing student evaluation form processing System is important for facilitating the works of processing these forms.

In line with this, to process the student evaluation form, we have used an image analysis technology which has been got recently its application in processing forms. Currently the availability of high speed scanners made preferable to use image analysis techniques for form processing.

In this project work, AAUSEFP was developed which would recognize the values encircled by the students on the student evaluation form. The system uses template matching image analysis techniques to detect the regions which contain the alternative values against each statement. For filtering noises the image must be first preprocessed. For highly noised images the system may not recognize values correctly so it is recommended to have a printable paper. In addition to this the following are written as recommendation that needs to be considered to do future works.

- Reducing the number of pages to one for a single student evaluation by rewriting the evaluation form or by preparing external answer sheets.
- In the current evaluation form students encircle the values in the way they are needed, but this makes the recognition of the values difficult. Instead of encircling, it is possible to prepare the form in such a way that, in front of each statement we can put circles and

the students will darkening the circles, this makes the processing of the student evaluation form easy and effective.

- In the current form statements and their alternative values are not separated, especially for the first page, this also makes the analysis so difficult. Thus, it is better to separate the texts from its alternative values.

Due to time limitation the work did not include the OCR part of the form, and recognition of check boxes which is used to know the overall judgment given to the instructors by their students. The work can be taken as a new insight to process the student evaluation form processing of Addis Ababa University using image analysis techniques.

6.2. Future Works

Developing systems using image analysis techniques needs to consider the performance of the techniques used regarding to speed. In order to improve the performance and quality of the system developed in this project and extend it, the following should be considered.

- Using better detection techniques will improve the performance of the system
- The scope of this work was to get the values encircled by the students against each statement: but it could be extended to recognize the name of the instructor, course title, course no department faculty academic year semester student's year and the recognition of overall judgment.

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Declaration

I, the undersigned, declare that this project is my original work and has not been presented for a degree in any other university, and that all source of materials used for the project have been duly acknowledged.

Declared by:

Name: ____

Signature: ____

Date: ____

Confirmed by advisor:

Name: ____

Signature: ____

Date: ____

Place and date of submission: Addis Ababa, June 2011.