Teacher SCARLET: An Application of Artificial Neural Networks in Off-Line Blackboard-Handwritten Character Recognition for Biology Lesson Data Extraction

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***Abstract*—The study introduces Teacher SCARLET: a smart classroom assistance for rich learning environment tool. The proponents developed a blackboard-handwritten character recognition system for a biology lesson data extraction. Its features include handwritten-blackboard character recognition, multimedia approach of learning, printable documents and ready-to-go presentation materials for teaching. The study used Quasi-experimental method in determining the degree of accuracy of recognition for the developed software through experiment paper. The developed software was evaluated by two (2) groups of respondents comprising of 3rd year high school students as student respondents and science teachers as experts using survey questionnaires. The questions were categorized by accuracy, user-friendliness, functionality and appropriateness. After conducting the study, it showed that the developed system can be used by the students and the teachers to support the learning process within the classroom.**

***Index Terms*—Artificial intelligence, e-learning, image analysis and processing, pattern recognition.**

I. Introduction

The interest in developing a smart classroom application with technology and computer software and platforms has increased in the last years. Computer-Aided instruction programs had evolved to much more in terms of interactivity, connectivity and multimedia integration. Today, the concentration in smart classroom is focused on interactivity using artificial intelligence mimicking human senses to produce real-life scenarios of teaching paradigm that allows students and teachers to perform effectively and efficiently.

In the study done by Wolf, he discussed the benefits of multimedia learning, adaptive interfaces and learning style theory by constructing a novel e-learning environment. Dynamic approach for learning styles was suggested. It stated that the approach should provide an environment with media experiences for learners to have media experiences rather than static experiences. As a result, relationship with learning patterns, learning styles and learning materials to the students has its effect on the whole learning paradigm including its effectiveness. [1].

Supporting blackboard as a tool for learning, Abuloum and Khasawneh discussed the attractiveness of using Blackboard as an e-learning tool as a mode of instruction. The paper stated that traditional classroom environment together with the use of electronic learning tools such as e-blackboard has diverse advantages such as flexibility, more authority, and less boundaries to time and space. Results indicated that the students' response shows a positive attitude towards the use of Blackboard as an e-learning tool. The findings also emphasized that the flexibility and usefulness of accessing the course grades, the interest of students in acquiring additional information with the use of e-blackboard, and its usefulness in obtaining class materials, contributes to the students' acceptance of e-blackboard an e-learning tool [2].

A whiteboard that automatically identifies drawn stokes, interprets them in context, and augments drawn images with computational results, such as solutions to mathematical equations are surprisingly realistic goals for system architects. This is how the future tool in education is seen [3].

With this, the development of the whiteboard tool, introduced an architecture for a system integrating handwriting recognition algorithm and image segmentation in a form of digital whiteboard system. In the application developed by Vajda *et al.*, they provided not just the process of capturing whiteboard contents but also recognizing it in an interactive software framework. The study focused on two main aspects: first, the recognition of different on-line text and non-text components and secondly, the digital outcome of the recognition process. The study addressed the problem of whiteboard analyzer which is described by lack of interaction between the digital output of the system and the static whiteboard content [4].

A more creative way of integrating technology was developed by Kabir and Denish. They utilized Interactive Whiteboard (IWB) system which allows a projection of a custom-built whiteboard application to be manipulated and interacted within a similar manner being done with the traditional whiteboard, along with additional capabilities. It uses the technology of a Nintendo Wii Remote Control and an Infrared (IR) pen to enable such an interaction techniques on a computer screen projection [5].

On the other hand, Oksiiz demonstrated a character recognition system which combines an on-line and off-line approach. The study also aims to create learning online recognition system by using vision based handwritten character recognition method [6].

The digital whiteboard system, which was developed by Gericke *et al.*, utilizes Optical Character Recognition and Clustering Algorithm in the analysis of unstructured whiteboard contents including drawings, sketches and

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handwritten text, showed a promising solution for analyzing recorded whiteboard data and extracting meaning out of the handwritten text, which can be used in search engine applications [7].

Moreover, the study by Liwicki and Bunke talks about on-line processing whiteboard notes. The System uses Hidden Markov Model (HMM) for Character recognition which includes modules: online pre-processing, transformation to off-line data, off-line pre-processing, feature extraction, classification and post-processing. By the proposed system, the study achieved 59.5% of recognition rate and had been tested for whiteboard handwriting recognition which can be helpful in note digitalization for further data processing [8].

A technology that offers possibility of producing distance lectures as a by-product of classroom teaching was utilized by Knipping. The approach avoids the huge costs normally involved in courseware production [9].

Thus, according to Genesi, multi-media aspects and improved visuals were found to be interesting, fun and engaging to students [10].

There are some existing applications that serve as blackboard handwriting recognition system yet none of them focuses on the application of blackboard handwriting recognition to biology lesson extractor software. Therefore, researchers developed software known as Teacher SCARLET that will assist on the presentation, interaction and learning of students and teacher in the learning process through the use of character recognition.

II. The Developed Software

The system was developed using Visual C# as its front-end and MS SQL Server as its back-end. It is intended to run on a stand-alone computer and it is not web-based system.

A. System Architecture

Fig. 1 depicts Teacher SCARLET's System Architecture.

The developed software comprises of engines such as Image Filtering, ANN Character Recognition and Lexical Analysis which performs image-character recognition. The system starts with handwritten characters on the blackboard. A webcam is used to capture the image. The image will be processed, analyzed and recognized. If the recognized input matched a topic on the database, it will display the content and produce a printable document of the searched topic. The user can start writing another topic to be searched or stop.

B. Software

At the start of the program, the system will display the main menu which consists of two buttons namely: Proceed and Instructions. If the user opted to click the instruction button, the system will display the step-by-step procedures on how to access the entire program. Consequently, if the user clicked the Proceed button, it will display the working area of the program where the lessons are displayed (shown in Fig. 2).

In the working area (shown in Fig. 3), the user must click the camera button to start. The system will capture the image of the board and perform image pre-processing procedure involving image filtering and image segmentation. The handwritten characters will be recognized and arrange into words that will be used to extract the lesson on the database. The lesson will be displayed on the working area. It features a multimedia display that is located at the right side of the screen, and related topics and history panel at the left side of the screen.

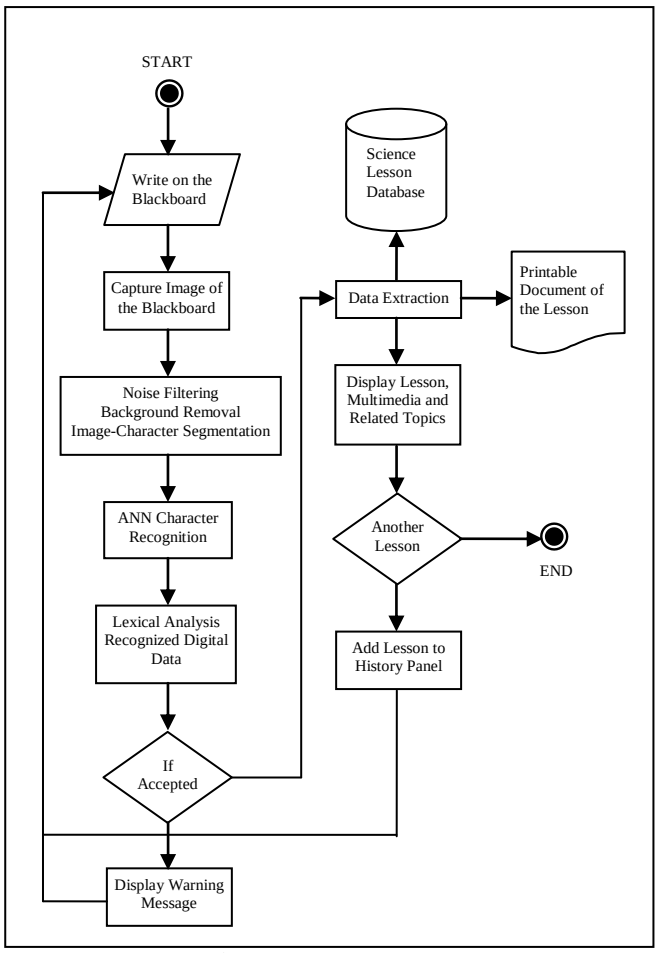

Fig. 1. Teacher SCARLET's system architecture.

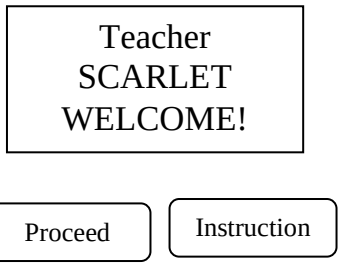

Fig. 2. Main menu of teacher SCARLET.

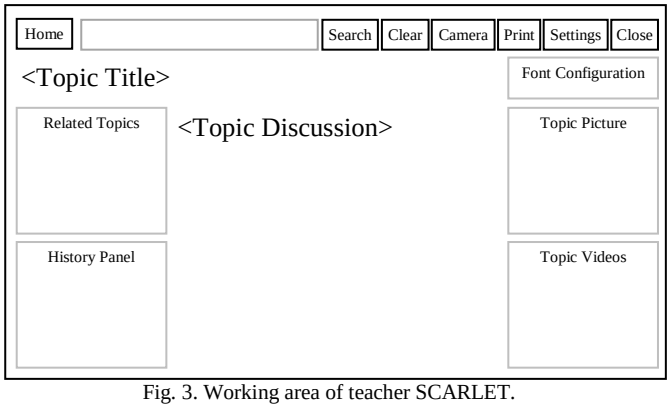

Fig. 3. Working area of teacher SCARLET.

If the user wants to print the searched lesson, the button 'Print' will perform it. 'Settings' button is for the database and recognition system configuration. 'Clear' button is to clear all searched topics. The 'Search' button is for the user to search the topic using keyboard input if the recognition is not working.

III. Research, Methods and Techniques

Researchers used Quasi-Experimental Method in the study. After the system prototype was developed, it was tested to attain the accuracy rate of recognition using experiment paper and was evaluated by the two groups of respondents: (a) experts - science teachers and (b) students – 3rd year high school students. For the expert group, purposive sampling technique was used while for the students, random sampling technique was used.

Table I shows the group of Teacher SCARLET's respondents who evaluated the developed system.

TABLE I: Groups of Teacher SCARLET's Respondents

Respondents	Total Size	Sample Size
3rd year High school Students	419	205
Science Teachers	10	5

The first group consists of 3rd year high school students of Juan Sumulong Memorial Junior College and the second group consists of the Science Teachers of the same school. The 3rd year students comprises of 419 students. Using Slovin's formula, 205 students were identified for answering the questionnaire (see Table I). Science Teachers have a total population of 10 and 50% of it was chosen to answer the questionnaire.

IV. Results and Discussion

One of the objectives of the system is to develop a software application that will assist students and teachers in the learning process of a classroom with regards to the subject Biology. To test its effectiveness, the developed software undergoes experiment testing to attain the degree of accuracy in character recognition and evaluation through survey questionnaire. With regards, to prove the hypothesis that there is no significant difference between the assessment of the two groups of respondents regarding with the developed system, researchers used T-test.

Table II shows the summary of findings in the degree of accuracy rate of recognition of Teacher SCARLET.

The developed software was tested with varying values for illumination and image resolution per character. The summary assessment in measuring the degree of accuracy of recognition of the developed software formulated from the experiment paper is 73.75% (shown in Table II).

Table III shows the comparison between the assessment of the student respondents and experts on Teacher SCARLET including computed mean for students and experts.

The statement on accuracy, the students evaluated 4.468 weighted mean while the experts evaluated 4.500 weighted means (Shown in Table III). This signifies that the system provides relevant discussion about the topic that satisfies the teacher's lesson plan which helps in providing ease to create lesson plan.

TABLE II: Summary of Findings in the Degree of Accuracy Rate of Recognition of Teacher SCARLET

Letters	Accuracy Rate of Illumination	Accuracy Rate Image Resolution	Overall Accuracy Rate
A	72.84	75.03	73.94
B	68.15	73.34	70.79
C	76.66	67.90	72.41
D	67.59	72.53	70.10
E	74.90	76.28	75.59
F	72.87	82.03	77.59
G	68.15	70.84	69.51
H	64.63	69.24	66.97
I	69.45	75.11	72.34
J	68.83	70.00	69.42
K	65.22	73.34	69.40
L	98.34	98.34	98.34
M	70.84	71.73	71.29
N	73.40	67.53	70.53
O	68.34	66.35	67.35
P	78.93	80.94	79.94
Q	68.40	73.51	71.00
R	75.11	70.99	73.08
S	85.32	75.03	80.34
T	74.32	78.40	76.39
U	80.23	71.73	76.10
V	75.03	70.03	72.57
W	75.11	63.34	69.47
X	70.84	76.84	73.90
Y	76.68	71.68	74.22
Z	71.73	65.03	68.46
Average	73.85	73.65	73.75

TABLE III: Comparison on the Assessment of the Students and Experts on Teacher SCARLET

Variables Tested	Students (X_1)	Experts (X_2)	df	Computed T-Test	Decision
Accuracy	4.468	4.500	6	-0.1435	-0.1435 < 2.447 $T_{com} < T_{val}$ Accept H_0
User-Friendliness	4.504	4.450			
Functionality	4.624	4.600			
Appropriate-ness	4.615	4.700			
Mean	4.553	4.563			

The statement on user-friendliness, the students evaluated 4.504 weighted mean while the experts evaluated 4.450 weighted means (Shown in Table III). This signifies that through the use of pleasing-to-the-eye colors on backgrounds and fonts helped the system to provide clear instructions in using the system. The system also provides buttons that performs tasks for the user to use the system effectively.

The statement on functionality, the students evaluated 4.624 weighted mean while the experts evaluated 4.600 weighted means (Shown in Table III). This signifies that the generated hand-outs of the system provide means for the students and teachers in reviewing the discussion. It provides ease in writing notes while the teacher discusses a lesson.

For the statement on appropriateness, the students

evaluated 4.615 weighted mean while the experts evaluated 4.700 weighted mean (Shown in Table III). This signifies that the system is suitable tool for facilitating communication in a learning environment. The system promotes new experience in learning Biology lessons which makes students motivated in listening to the lessons, building focus and interest in learning.

V. Conclusion and Recommendation

Based from the acquired result of the study entitled "Teacher SCARLET: An Application of Artificial Neural Network in Off-line Blackboard-Handwritten Character Recognition for Biology Lesson Data Extraction", the researchers have come-up with the following conclusions stated below.

The summary assessment in measuring the performance of the system with regards to the accurate recognition of letters through blackboard handwriting formulated from the experiment paper is 73.75% and can be considered as acceptable.

The acceptability of Teacher SCARLET based on the assessment of the 3rd year high school students of Juan Sumulong Memorial Junior College in terms of user-friendliness, functionality and appropriateness are all 'VERY SATISFACTORY' while the accuracy is interpreted as 'SATISFACTORY'.

The acceptability of Teacher SCARLET based on the assessment of the experts from Juan Sumulong Memorial Junior College in terms of accuracy, functionality and appropriateness are all 'VERY SATISFACTORY' while the user-friendliness is 'SATISFACTORY'.

According to the data gathered, analyzed and computed, the researchers showed that there is no significant difference between the assessment of the students and experts on Teacher SCARLET. Both respondents had different opinion and perception concerning the different variables tested.

After conducting the study and throughout the gathering of data from the experiment and the controlled group, the developed system can be used by the students and the teachers to support the learning process within the classroom, thus creating a new environment with enhanced interactivity and multimedia approach for learning biology lessons. Overall, the users were satisfied and recommended the use of the developed software as a tool for presenting biology lessons and deploying rich learning environment for students and as well as for teachers.

In the future, the researchers will extend the study on increasing the number of topics contained in the database. In addition, the software can be applied in different subjects such as Mathematics, Language and other textual subject such as Methods on Research. It will provide more functions, greater accuracy rate and be connected in the internet for a web-based application so everyone can access and use it.

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