KnE Social Sciences

ICADECS
International Conference on Art, Design, Education and Cultural Studies (ICADECS)
Volume 2021

Knowledge E
enriching | engaging | empowering

Conference Paper

Computer Based Test Using the Fisher-Yates Shuffle and Smith Waterman Algorithm

Medika Risnasari, Muhamad Afif Effindi, Prita Dellia, Laili Cahyani, and Nuru Aini

University Trunojoyo, Madura, Indonesia

ORCID:
Medika Risnasari: http://orcid.org/0000-0001-8277-199X

Abstract

Tests are used to determine a person's level of understanding of a subject. The inhibiting factors in tests are less varied questions, questions with insufficient difficulty, subjective assessments, and the length of time in their correction. This research aimed to develop a Computer Based Test (CBT) application. The type of questions in this CBT are multiple choice and essays. This CBT employs categorization of questions, randomization of the questions, and automatic assessment. Questions were categorized manually based on Bloom's Taxonomy of a lecture. Then the randomization process was carried out using the Fisher-Yates Shuffle algorithm for each question category. The Smith Waterman algorithm was used to automatically assess the essay-type questions. The steps of the Smith Waterman algorithm were preprocessing, data comparison using Smith Waterman, and percentage similarities conversion to test scores. The results of the study showed that the CBT application was able to randomize questions using the Fisher-Yates Shuffle algorithm and automatically assess answers using the Smith Waterman algorithm. RMSE was used to measure of the accuracy of the Smith Waterman algorithm: a value of 1.86 was obtained.

Keywords: Computer based test, assessment, Fisher-Yates Shuffle, Smith Waterman

Corresponding Author:
Medika Risnasari
Medika.risnasari@trunojoyo.ac.id

Published: 2 June 2021

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICADECS Conference Committee.

1. Introduction

Assessment is one of a critical issue in every education level [1] and intended to gather information about students and classroom [2]. The assessment pointed on how teacher or lecturer gathering learner progress of their learning process. The assessment could be done in several ways, such as informal setting like observation and verbal conversation. The other one is through a test.

The test itself varied such as paper and pencil test and electronic assessment. The last one had several terms, if we trace back to past resources, such as computer-based

assessment or computer-based testing (CBT) [3], computer aided test (CAT), Computer-based Formative Assessment [4], assessment using game [5]. Several studies show the engagement of student and their motivation increased by using computer-based test [1] and could give positive feedback to the students [6]. An authorized computer-based assessment also held in Indonesia, i.e. Computer Based National Assessment (UNBK)[7] and Computer Based Written Test (UTBK) [8].

Hence, works on Computer-based assessments are still needed, since the customized form of the assessments are still needed. This work focused on evaluation of computer based test tools developed. The tools which had been developed are random number generation in emerging the problems and automation in essay evaluation.

The computer-based assessment try to tackle several problems, i.e. the subjective aspects in essay grading and long time for grading since the sum of the students. The electronic assessment tool developed in this work was tested in Students of Universitas Trunojoyo Madura, in a class of 2018, in Introduction on Information Technology course. The problems set in database focusing on cognitive problems material which was considering Bloom's Taxonomy.

Fisher-Yates is one of random number generation algorithm which is stated had high performance among all other algorithms exist [9]. Several works report the success implementation of Fisher-Yates method to randomized problems collected in a Mobile Game App [10], file encryption [11], CAPTCHA generation [9], and by using Modern version of Fisher-Yates Algorithm it also applied in random interleaver utilized in digital and cellular communication system [12]. Hence, this work used Fisher-Yates to adopt in randomized the questions in database.

The rest sections are as follow. Method explained in the Second Section. Experiment and Analysis on the test result described in the Third Section. And this paper concluded in Fourth Section.

2. Methods

This study develops computer based test application (CBT). There are two stages in the design of CBT applications. The first is the division of questions automatically through the process of classification and randomization of questions. The second is automatic assessment. For automatic assessment using Smith Waterman Algorithm, only applies to questions in the form of description (essay).

Figure 1 shows the first stage and second in a CBT application. First stage is explained that the questions that will be given to students are first classified manually based on

Bloom's taxonomy and produce several categories of questions. Then the randomization process was carried out using the Fisher Yates Shuffle algorithm for each question category. After all questions in each category are randomized, the next number of questions is determined for each category according to need. The final process at this stage is the merging of questions from all categories to be ready to be tested on students.

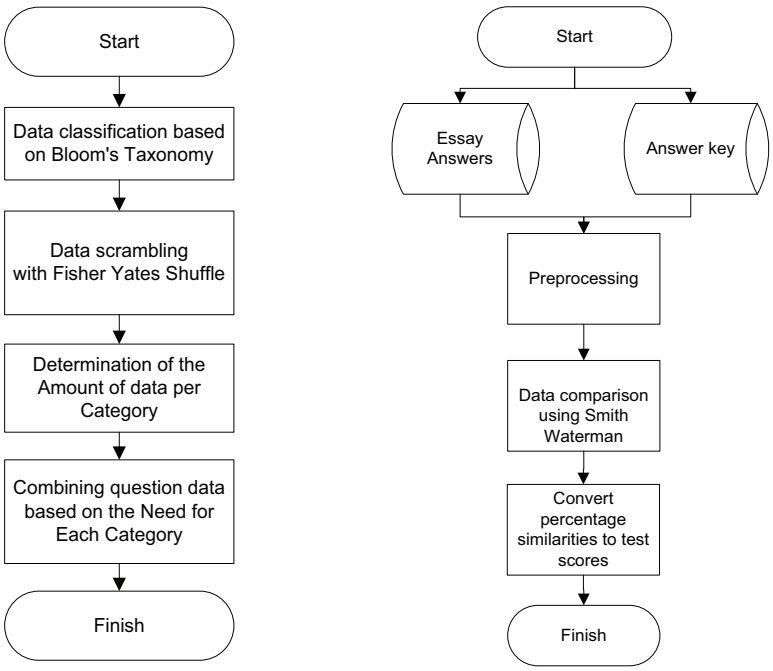

Figure 1: first and scond Stage of CBT application

Fisher-Yates Shuffle algorithm step [13]:

1. Initialize Range from 1 to (n)

   This is a range ID. Vocational Theory Questions for category C1 before being randomized using the Fisher-Yates Shuffle algorithm:

2. Choose Numbers Randomly from Range Not Moved (K)

3. Move (K) to Last Position of Range and Move the Last Number in Range to Position (K) Previously Moved

4. Repeat until all numbers have been moved

Figure 1 in the second stage of the CBT application, which is the automatic assessment. First, it is preprocessing. In this research, we are adding a porter algorithm in preprocessing. There are several steps in the preprocessing thats are case folding, tokenizing, filtering and stemming. The details of the first preprocessing step are case

folding where all letters are converted into lowercase letters and also eliminate characters other than letters and numbers. After that, the tokenizing process is carried out. Tokenizing is the process of separating sentences into single words and removing spaces, enter, tabulation, and punctuation. Then the filtering process is carried out. Filtering is the process of selecting general words that often appear and are considered important in a text. The last step of pre-processing is stemming. Stemming is the process of changing the words contained in the text into basic words.

After preprocessing, a comparison process is carried out using the Smith Waterman algorithm. The details is as follows [14]:

1. text convertion to matrix

The formula for calculating the maximum value if X (i) = Y (j) can be seen in the following equation.

$$S_{ij} = S_{i-1,j-1} + h$$

X is source document (answer key). Y is comparison documents (student answers). Sij is maximum value of substring X with substring Y at position i and j. $S_{i-1,\ j-1}$ is value of substring X with substring Y at position i-1 and j-1. h = 1 is the conformity value if substring X = substring Y. i is row position in the matrix. j is column position in the matrix

The formula for calculating the maximum value if X (i) ≠ Y (j) can be seen in the following equation.

$$S_{ij} = \max(0, S_{i-1,j} - d, S_{I,j-1} - d, S_{i-1,j-1} - r)$$

S_{ij} is maximum value of substring X with substring Y at position i and j. $S_{i-1,j}$ is value of substring X with substring Y at position i-1 and j. $S_{i,\ j-1}$ is value of substring X with substring Y at position i and j-1. $S_{i-1,j-1}$ = value of substring X with substring Y at position i-1 and j-1. d = -1 is the value to indicate the removal or insertion of a substring (index). r = -1, the value to declare substring replacement (replacement). i is row position in the matrix. j is column position in the matrix

2. Calculation of Local Similarities

$$\text{Score}_{opt(I,j)} = \max S_{ij}$$

3. Calculation of Similarity Percentage

$$\text{similarity}(x, y) = \frac{\left(\frac{t}{m}\right) + \left(\frac{t}{n}\right)}{2} \times 100\%$$

X is source document (answer key). Y is input documents (student answers). t is number of substrings traceback results. m is number of substrings in the source document. n is number of substrings in the comparison document

After the Smith Waterman algorithm is applied, the next process is converting the percentage of similarity results to test scores so that the test scores are obtained automatically. Conversion to value is done by multiplying the weight of each data.

3. Result

The resulting CBT applications are in the form of multiple choice and essay question. The data (questions) used consists of 10 multiple choice 5 essays. This application trial was conducted in the Introduction to Information Technology subject with 20 respondents. At the preprocessing stage in randomization questions include (1) entering the question bank (2) determining the question categories based on bloom taxonomy.

The questions displayed by the system are randomly questions from the question bank using the Fisher-Yates Shuffle algorithm. While the assessment system is an automatic assement performed by the system using the Smith waterman algorithm. Figure 2 shows the problem feature settings.

Figure 2: setting the test question based on bloom taxonomy

In the CBT application using the fisher-yates shuffle algorithm and the smith waterman algorithm, exam participants will be able to see the results of the scores automatically performed by the system.

The results of the assessment by the system and by lecturer of 20 participants are as in table 1. To obtain the accuracy of the results of the assessment by the system, then the assessment is done manually by a lecture.

From table 1, that show a different score by a lecture and a system. The difference in the results of the assessment between the system with the lecturer is stated in Root Mean Square Error (RMSE). Root Mean Square Error (RMSE) is a parameter to measure the performance or level of accuracy produced by a product. The RMSE results are a measure of system accuracy. The RMSE value indicates the amount of system error, the lower the RMSE value, the variation in values produced by the forecast model approaches

Table 1: Assesment by System and assement by lecturer

Id_students	Assesment by system	Assessment by a Lecturer	Id_students	Assesment by system	Assessment by a Lecturer
1	98	95	11	63	65
2	90	85	12	32	32
3	75	63	13	62	70
4	57	57	14	55	75
5	80	75	15	52	60
6	89	80	16	55	65
7	50	50	17	62	55
8	64	68	18	60	55
9	82	91	19	58	72
10	55	55	20	55	65

variation in the value of observations.

$$RMSE = \sqrt{\sum_{1}^{n} \frac{(y_i - yo_i)^2}{N}} = \frac{37,25}{20} = 1,86$$

From the test results on the CBT using the Fisher-Yates Shuffle Algorithm, it is found that the questions received by the examinees are not the same between one another. A Smith Waterman Algorithm as an automatic appraisal of the essay question found that the system is able to provide an automatic assesment. Automatic assessment using the algorithm will give a minimum difference between the system and the manual if preprocessing is done well, that is (1) the problem given is not a question of reasoning (2) the problem by asking for certain answers from a number of alternative answers, for example, mention 3 kinds of numbers. So the preparation of question and answer is an important factor in the success of the Smith waterman algorithm in assesment automatically. In the next research, we can used a another method based on semantic to get a better assessment result.

4. Conclusion

Based on research results from the CBT application using the Fisher-Yates Shuffle Algorithm And The Waterman Smith Algorithm it can be concluded that

1. Fisher-Yates Shuffle algorithm can do randomization of questions well from a lot of question that is the questions received by the examinees are not the same as each other

2. The automatic assessment results using the Smith waterman algorithm get an RMSE value of 1.86

3. The correction system is equipped with Porter algorithm to provide faster stemming results, can detect foreign languages and can provide accurate assessment.

Acknowledgement

The author would like to thank the informatics education department laboratory for a supported the in this research.

References

[1] Nikou, S. A., & Economides, A. A. (2015). The impact of paper-based, computer-based and mobile-based self-assessment on students' science motivation and achievement. *Computers in Human Behavior*.

[2] Arends, R. I. (2012). *Learning to teach* (9th ed.). McGraw-Hill.

[3] Scheuermann, F., & Bjornsson, J. (2009). *The transition to computer-based assessment: New approaches to skills assessment and implications for large-scale testing (JRC Scientific and Technical Reports)*. European Commission Joint Research Centre Institute for the Protection and Security of the Citizen.

[4] Timmers, C. F., Walraven, A, & Veldkamp, B. P. (2015). The effect of regulation feedback in a computer-based formative assessment on information problem solving. *Computers & Education*, 87.

[5] Attali, Y., & Arieli-Attali, M. (2015). Gamification in assessment: Do points affect test performance? *Computers & Education*, *83*.

[6] Munro, A., Cumming, K., Cleland, J., Denison, A., & Currie, G. (2018). Paper versus electronic feedback in high stakes assessment. *Journal of the Royal College of Physicians of Edinburgh*, *48*(2), 148–152.

[7] Kementerian Pendidikan dan Kebudayaan. (2018). *Pendidikan dan Kebudayaan, Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia nomor 4 tahun 2018 tentang penilaian hasil belajar oleh pemerintah*.

[8] Ristekdikti, K. (2018). *Peraturan Menteri Riset, Teknologi, dan Pendidikan Tinggi Republik Indonesia nomor 60 tahun 2018 tentang penerimaan mahasiswa baru program sarjana pada perguruan tinggi negeri*.

[9] Rane, S. S., & Shekokar, N. (2016). *3D socio graphical CAPTCHA based on reCAPTCHA against spammers and bots* [Conference presentation]. IEEE International Conference on Advances in Electronics, Communication and Computer Technology (ICAECCT), Rajarshi Shahu College of Engineering, Pune India.

[10] Castillo, R. E., Cheng, C. J., Agustin, J. S., & Aragon, M. C. R. (2019). *Development of an educational mobile game application for grade 5 for Knowledge Channel Inc.* [Conference presentation]. ICISS 2019, Tokyo, Japan.

[11] Hazra, T. K., Gosh, R., Kumar, S., Dutta, S., & Chakraborty, A. K. (2015). File encryption using Fisher-Yates Shuffle: Shuffling scheme employing pseudo-random permutations.

[12] Yadav, M., Gautam, P. R., Shokeen, V., & Singhal, P. K. (2017). Modern Fisher-Yates shuffling based random interleaver design for SCFDMA-IDMA systems. *Wireless Pers Communication*, *97*, 63–73.

[13] Olu, A. (2012). A simulated enhancement of Fisher-Yates algorithm for shuffling in virtual card games using domain-specific data structures. *International Journal of Computer Applications*, *54*(11).

[14] Irving, R. W. (2004). *Plagiarism and collusion detection using the Smith Waterman algorithm: Technical report*. DCS.