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Application of Representation and Fitness Method of Genetic Algorithm for Class Scheduling System

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Abstract*: This paper introduced aimed to solve the poor management of schedule, one of the major problems at Isabela State University-Main Campus. Scheduling is a process conducted before a certain event would be executed. The study used and adopt the Representation and Fitness Methods of Genetic Algorithm to formulate a solution. The study showed that the adaptation of the two methods is well fitted for use in solving the stated problem. The representation method creates and generates the pre-scheduling template to be used for the plotting of schedules, and fitness method is how the pre-scheduling template generated and created. The researchers used some criterion of ISO 9126 Standard as an instrument to determine its functionality and usability. Results showed that the representation and fitness methods of the genetic algorithm make the scheduling process more accurate and reliable schedules, lessen the time-consumed and lessen the time-conflicts in the plotted schedules. For future studies to be conducted reformulation of fitness function to include the other components and variables of scheduling like individual schedules for both regular and irregular student and campus extension integration and considering the other indicator of the instrument used are significantly suggested.

***Index Terms*: Representation, fitness, Genetic algorithm, Class scheduling algorithm**

I. INTRODUCTION

Scheduling of classes has been one of the most important factors that school needs to prepare before enrolment plays a vital role in providing an idea of the students in managing their time. As times passes, several issues arise dealing with the scheduling process of schools and universities like time spent in providing solutions for the time conflicts; assigning of faculty, students, rooms and laboratory schedules takes a number of days and even weeks to prepare; and as a result, the scheduled start of classes was not followed. These problems greatly affect the student's eagerness to attend their classes, the time frame of the faculty in delivering the topics and entails negative feedbacks on the top – level management. With the birth of Information and Communication Technology, there were several studies presented and published that provide effective solutions and strategies in dealing with problems in scheduling one of which is integrating data mining concepts like genetic algorithm.The College of Computing Studies, Information and Communication Technology (CCSICT) is an Educational Institution committed to its three (3) pronged vision of continually sharing knowledge and expertise through teaching, engaging in Information Technology research and product development, and rendering service in communities is in need.Initially, the traditional scheduling process is performed after planning and determining of the need assessment by the top management [1]. The staff in charge from the CCSICT uses spreadsheet as a tool in creating schedule, the first step is to plot the minor subjects because the faculty whose teaching minor subject came from other colleges, the second step is the plotting of schedule for the major subjects, the plotted schedule depends on the nature of the major subject if it is with or non-laboratory subject, then check the number of student per section and lastly, checking of the number of students enrolled per subject. As far as the workload policy is a concern, the number of student in the lecture should have the maximum fifty students (50) and when in the laboratory it will be divided into two (2) for the reason that, the existing laboratories have 30 computer units which can only accommodate 30 students. The created schedule for the faculty, students, rooms and laboratory will be submitted for inputting in the Student Information and Accounting System (SIAS). From this, the proponents observed and identified problems encountered in the existing processes performed by the staff in charge of scheduling these are as follows: 1.) Overlapping of schedules 2.) Time conflicts on rooms, laboratory and faculty schedule, 3.) Availability of rooms, and 4.) Addressing the schedule of irregular student's takes a long period of time. It is in the light, that the proponents primarily aim to develop a system entitled "Application of Representation and Fitness Methods of Genetic Algorithm for Class Scheduling. The Genetic Algorithm is a method for solving both constrained and unconstrained optimization problems that are based on natural selection, the process that drives biological evolution. The integration of the representation and fitness methods in the design and development of the system believes to speed up the process of scheduling classes and lessen the overlapping of scheduled subjects and it specifically aims to (1) Develop the program interface of the Class Scheduling System; (2) Test the functionalities of the system for; (2.1) Pre-scheduling template using the representation method of genetic algorithm and (2.2)

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Generation of class, faculty, rooms and laboratory schedules; and (3)

Evaluate system external and internal quality in the use of the system using ISO 9126 in terms of Functionality and Usability. The context of considering the criterion functionality and usability in evaluating the system functionalities is to ensure that the system's features function as designed that is to provide a class schedule. The remaining criterion of the ISO 9126 will be considered once the system is deployed and use for its intended purpose.

II. RELATED LITERATURE

A. Genetic Algorithm

Artificial intelligence is one of the flourishing technologies for man-machine interaction, is helpful in solving many problems such as optimum broadcast scheduling (OBS). Since the OBS problem requires multiple optimization factors, Genetic algorithm has the capabilities of handling maxima and minima factors at the same time. That results from this literature caused a major inclination in employing the Genetic Algorithm approach for OBS problem [2]. Evolutionary techniques are also known as nature-inspired techniques as these types of techniques have stolen the idea from nature. Genetic algorithm (GA) is one of the most commonly used evolutionary techniques which is used to solve different NP-hard computational problems. GA is based upon the principle of human genetic. Past research shows that it has been effectively used to solve the different problems from the domain of Computer Science viz. software cost estimation, task scheduling, clustering, natural language processing, query optimization, image processing, etc. [3].

Genetic Algorithm is a heuristic search method used in artificial intelligence and computing. It is used for finding optimized solutions to search for problems based on the theory of natural selection and evolutionary biology. These Genetic Algorithms are excellent for searching through large and complex data sets. They are considered capable of finding reasonable solutions to complex issues as they are highly capable of solving unconstrained and constrained optimization issues, it is based on the human evolution theory of Charles Darwin that has four(4) methods Representation, Fitness, Crossover, and Mutation [4].

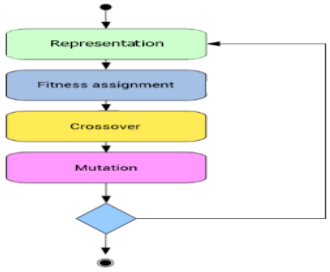

Fig. 1: Genetic Algorithm

- Representation - It is a process that the pre-scheduling template will create as a tool to be used in scheduling. Before creating the pre-scheduling template vector, the size of time-slot-space may be initialized using the formula vector, size = number of rooms * working days * working hours. And getting the value of time-granules. Time-granules is using for hashing the time-space-slot. If the assigned class will consume 3hours duration then 3 time-space-slot of the room will be occupied [5].

$$S = NR * WD * WH \quad \text{Eq (1)}$$

Where:

S - Size…
NR – Number of Rooms
WD – Working Days
WH – Working Hours

- Fitness - It is a process of scoring a class based on their fitness to the schedule. Each class can have 0 to 7 points. In calculating and scoring the fitness value of each class a lot of rules maybe consider. The rules are based on the assigned process of scheduling. If the class did not violate the assigning process, then its score will be incremented. If the class violated the assigning process, then no increment of the score will happen. The fitness value is calculated as; *schedule_score / maximum_score,n, and maximum_score* is the total score of schedule score which is 7 [5].

$$FV = SS / MS \text{ of } n \quad \text{Eq (2)}$$

Where:

FV – Fitness Value
SS – Schedule Score
MS of n – Maximum Score of every Template

The fitness value is used for the generation of the pre-scheduling template. The pre-scheduling template is based on the classroom, so the number of the template is the number of created classroom. The generation of the pre-scheduling template is one-by-one rules validation every classroom and it is also how the scheduled score is incremented. The fitness value is range 0 to 1 [5]. And if the fitness value is equal to 1 then the template will be generated.

Fitness functions are of paramount importance. Chromosomes are an abstract representation of a candidate solution. The fitness function is used in quantifying the desirability of the solution, which is closely correlated with the objective of the Algorithm or optimization process. The fitness level is used in evaluating candidate solution, that is, the values being generated characterize the solutions [6].

The fitness function, on the other hand, is to make a decision as to whether the value is appropriate for the determined solutions [7].

B. Greedy Algorithm

Greedy Algorithms take all of the data in a particular problem, and then set a rule for which elements to add to the solution at each step of the algorithm. In the animation above, the set of data is all of the numbers in the graph, and the rule was to select the largest number available at each level of the graph. The solution that the algorithm builds is the sum of all of those choice [8]. In a class-scheduling system that will allow collaborative preparation of schedules among several users. The system integrated five components: the data management module, course assignment module, scheduling module, result storage module, and the report module. It has an engine that uses the greedy algorithm for creating schedules and detecting conflicts. The algorithm mainly executes this sequence of processes; selecting an available time, finding available room, and looking for an appropriate faculty while considering different constraints and preferences set by users (Kurniawane, 2015) [9], [10].

C. Scheduling

In the most general terms, scheduling can be described as the constrained allocation of resources to objects being placed in space-time in order to minimize the total cost of a set of the resources used.According to [11], poor scheduling practices would cause double-assignations of lecturers, prolonged postponement and cancellations of presentations as well as an inefficient use of time and resources. This method will follow pre-assigned logic rules and Algorithm to fit the optimization criteria's. The proposed system performs satisfactorily in term of accuracy, data handling and adaptability on helping the faculty to arrange presentations more easily, and yield a reliable record and increase efficient use of resources. This was the first paper to consider the now well-known special relationship between the various scheduling problems. With the help of the Gotlieb approach (1963) both Becker (1964) and Baraclough (1965) simulated their respective implementations with "hand" calculations. Typically these papers were based on a heuristic approach. Due to this work, many other papers followed which discussed the problem but had very little new work in them [11]. Traditional scheduling methods include bar charts that have evolved from paper-based to computer-based whereas modern scheduling methods are those departed from the traditional scheduling concepts (Hajdu, 2011). The examples of traditional methods are Gantt chart, CPM and PERT; whereas modern scheduling methods are LPS (Ballard, 2000) and Critical chain project management (CCPM) (Goldratt and Cox, 1984) for instance [1].Scheduling, on the other hand, was defined as logical sequencing of activities which include its durations (Yang, 2007). This can only be done after planning and it is usually were handled by different people [1].

III. METHODOLOGY

The phases of the Rapid Application Development (RAD) Methodology were used as a guide of the researchers to develop the system prototype. The Conceptual Framework of the study as presented in fig. 2 where it categorizes into three satisfying the objectives of the project. The first operational framework composed of the software methodology, software development tools, concepts of representation and fitness methods; and hardware; the second operational framework is the testing of the major functionalities using the output of the faculty need analysis, the data is used to simulate the processes of generation of the schedule template and reports for faculty, rooms, laboratory and class schedules and; the third operational framework illustrates how the system will be evaluated using the ISO 9126 standards in terms of functionality and usability.

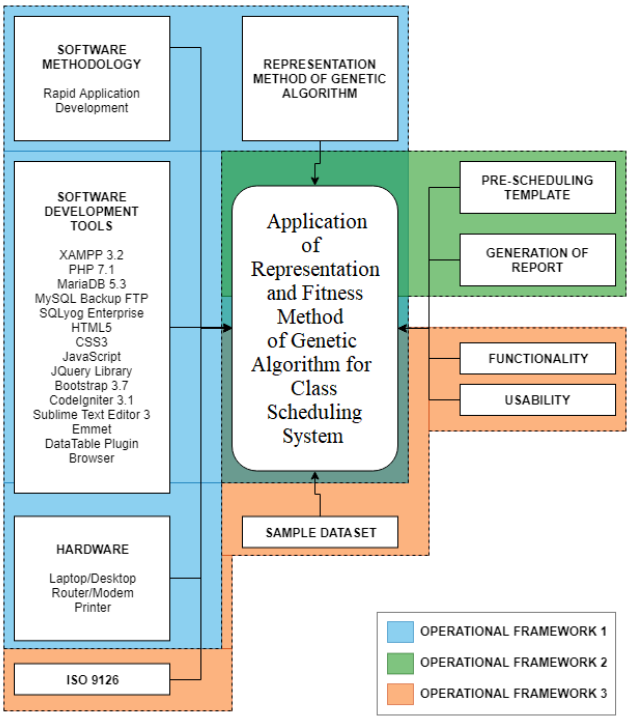

Fig. 2: Conceptual framework of the Project

A. Development Tools

Data Flow Diagramming was used to conceptualize the process flow of the system as presented in fig. 3. It has a detailed presentation on the process flow of transactions from the Registrar or College Secretary to the system and vice versa. Also, shows the relationships of the modules and tables of the database. The hardware specifications used to develop the system's interface are Intel Celeron N3050 Dual Core @ 1.6 GHz for processor, 4GB DDR3 for RAM, 500GB for HDD, Intel Graphics for GPU, Resolution of 1366 x 768, and at least installed with Windows 10 operation system and the software used in the design of the interface are as follows

- **XAMPP 7.1.1** - The proponents used XAMPP to manage database locally and local application-server of the system during the duration of the development.
- **MySQL 10.1** -The proponents use MySQL for creating and managing the database and connects them to software because of its quick processing, proven reliability, ease and flexibility of use.
- **Hypertext Preprocessor (PHP 7.1)** The proponents use PHP language to develop the system especially its functionalities.
- **Sublime Text 3** The proponent used this for creating the interface of the system and for creating a connection between the system and the server.
- **Emmet** The proponent used this Sublime Text Editor Plugin to code easily and accurately.
- **Cascading Style Sheets (CSS3)** The proponents use this to add design flexibility and interactivity the system. And also to have greater control over the layout to make precise section-wise changes.

- **Hypertext Markup Language (HTML5)** is used by the proponents as the building blocks in creating the interface of the system. HTML defines or describe the content of the system.
- **Ajax (Asynchronous JavaScript and XML)** –The proponents used AJAX to make the system very stable and do not crash easily. Even if the page is heavily loaded, the system runs smoothly until some external application interferes in its working like, some kind of fictitious spam applications which gets attached to the system when hosted on the net.
- **Bootstrap 4** The proponent used this CSS framework for the front-end design of the system.
- **JQuery 3.7** The proponent used this JS Library for both front-end and back-end of the system and to simplified the JavaScript code.
- **DataTable 3.7** The proponent used the Plugin in front-end design for tabulating the table element of the system.
- **SweetAlert** The proponent used this Plugin in front-end design to customized, animate the popup alert box of system.
- **Code Igniter 3.1** The proponent used this PHP Framework to develop projects much faster than writing code in a scratch and by minimizing the amount of code needed in a given task.

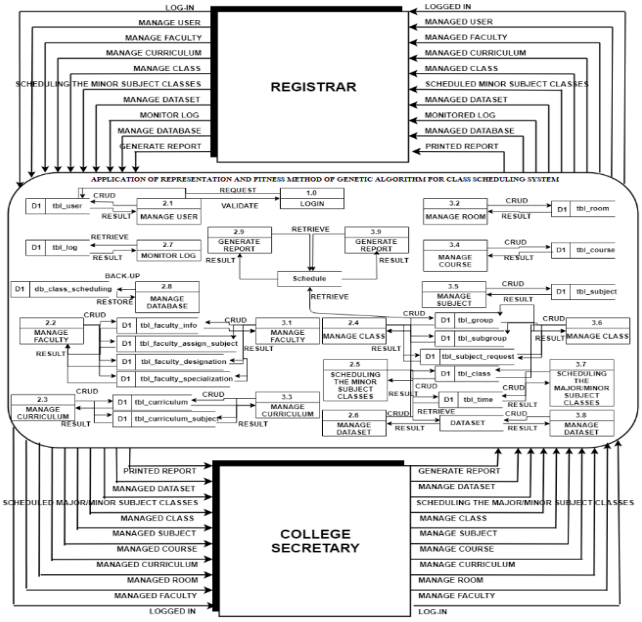

Fig. 3: Data Flow Diagram of the Class Scheduling System

B. System Evaluation

To have a thoughtful evaluation of the system's functionalities both the university registrar and college secretaries were mandated to evaluate the system. Also, for validation and enhancement as per the design and logical flow of the system, IT experts were also considered. The breakdown of the respondents to evaluate is presented in Table 1.

Table I: Number of Population

Respondent	Quantity
College Secretary	8
University Registrar	2
IT Professionals	5
TOTAL	**15**

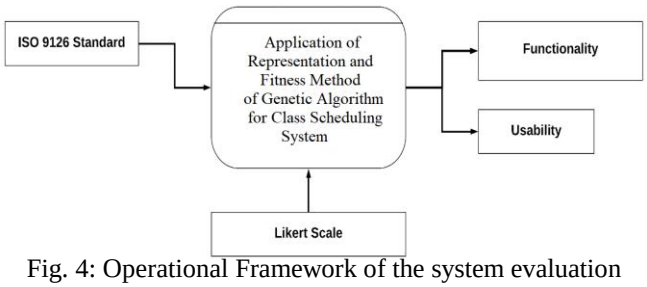

Fig. 4: Operational Framework of the system evaluation

Fig. 4 shows the diagram of the operational framework of objective 3 which the ISO 9126 Standard as an evaluation tool that was used and the Likert scale for the evaluation scale and score. The proponent used the ISO 9126 Standard to achieved the functionality and usability of the system (1) Usability - ability of the software to be easily operated by a given user in a given environment and learning effort for different users, i.e. novice, expert, casual etc. and (2) Functionality - a given software component or system does not typically function in isolation. This sub characteristic concerns the ability of a software component to interact with other components or system. To provide analysis of the evaluation the proponents used Likert scale to measure the degree of the user's perception on the functionalities of the system in terms of its functionality and usability. Table 2 present the grading scale point of Likert Scale used in evaluating the system.

Table II: The five-point Likert Scale

Scale	Range	Qualitative Rating
5	4.30 – 5.00	Strongly Agree
4	3.50 – 4.20	Agree
3	2.70 – 3.40	Undecided
2	1.90 – 2.60	Disagree
1	1.00 – 1.80	Strongly Disagree

IV. DISCUSSION OF RESULTS

A. The class scheduling system using the representation and fitness methods

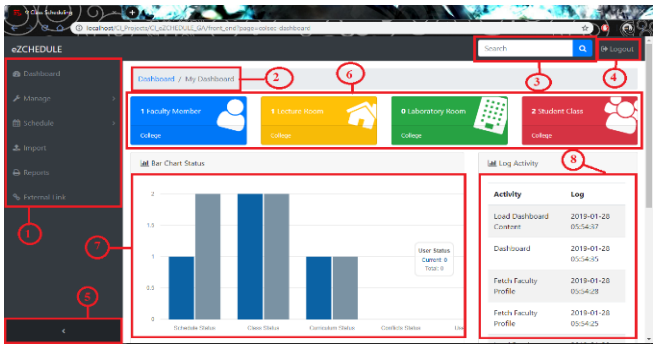

Fig. 5: Main Page of the Class Scheduling system

Fig. 5 shows the Application of Genetic Algorithm using Representation Method in Class Scheduling where the user can do the following: (1) Navigate and redirect each system functionality using the Navigation Drawer. In each item and sub-item of navigation drawer, the user can preview the dashboard status, manage or set-up where the user can do the 3 Phases Process of Class Scheduling, generate schedules and import dataset or modify the dataset, import faculty and subject using the system provided and generated Excel file template and generate reports. (2) Breadcrumbs where the user can easily navigate and redirect in each system function modules and sub-modules. (3) System Main Search Engine where the user can universally search for each system features. (4) Logout button where the user can end-session. (5) Navigation Drawer Trigger Button where the user can close or open the Navigation Drawer. (6) Status Panel where the user can see the number of each secondary data of the system. (7) Graphical Status where the user can see the number of each primary data of the system. (8) And User Log Activity Panel where the in-session user can see the log history of their transaction in the system.

B. Functionalities of the system applying the representation and fitness methods

Fig. 6 shows the scheduling form/template of the system as the output of using the representation and fitness methods. The process of generating the template was made possible through using the Equations (1), (2) and (3) of the representation and fitness methods that were presented in the previous section of this paper. The equations are responsible for computing the number of slots available in every template, identifying available time, rooms and faculty in plotting schedule of subjects and generating soft copy output of the generated class schedules.

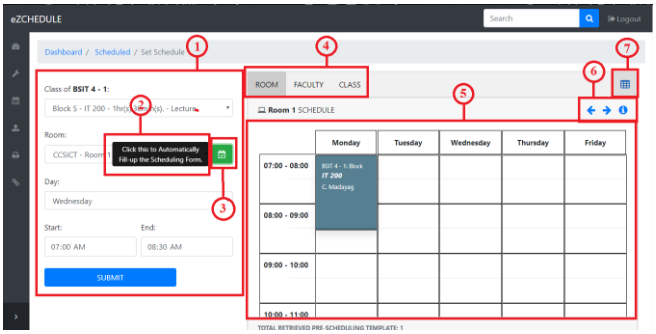

Fig. 6: Generation of Scheduling Template using Representation and Fitness Methods

Also, the fig. 6 describes the flow where the user can (1) set schedule of the selected course class, (2) tooltip showing instruction to help the user, (3) auto fill-up the scheduling form, (4) pre-scheduling template navigation, (5) pre-scheduling template previewing the actual schedule of the selected item in the pre-scheduling template navigation, (6) Pre-scheduling template action button with a different specific function and (7) time-table scheduling button to preview the faculty schedule of the selected course class assigned faculty and class preview of time-table schedule.

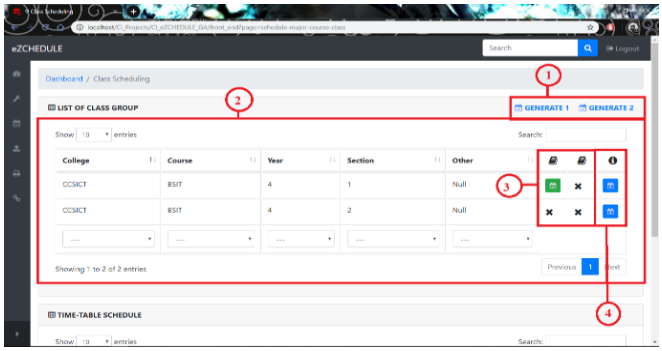

Fig. 7: Generation of Schedules

Fig. 7 shows the Scheduling Page of the system where the user can (1) one-click generate schedule of major/minor subjects, (2) search or filter all the list of class in data table, (3) shows the remark of the scheduling status of the class and clicking of green button to generate the major/minor course class of the selected class and (4) redirect to the manual scheduling form.

C. Evaluation Results

The researchers used the ISO 9126 Standard in evaluating the application using the criteria functionality and usability to measure if the system met all the requirements needed for each criterion. The system was evaluated by eight (8) college secretaries, five (5) IT experts, and two (2) staffs from the registrar's office. As presented in Table 3, the respondents rated 4.57 which has an equivalent qualitative rating of strongly agree under the functionality criterion which implies that The system can do the three phases/process of class scheduling, can generate schedules accurately in minimal or lessen conflicts of class, faculty and rooms schedules and has strong security that keeps the data safe from intruders/attackers and unauthorized user. For the usability criteria the respondents rated 4.73 which has an equivalent rating of strongly agree which means that the System design *(UI and UX)* suits its functionality, has a tooltip and instruction panel to guide the user on how the functional features work and can be used in any platform/ devices that have a browser supporting JavaScript.

Table III. Evaluation Summary

CRITERIA	MEAN VALUE	QUALITATIVE RATING
Functionality	4.57	Strongly Agree
Usability	4.73	Strongly Agree
Grand Mean	**4.65**	**Strongly Agree**

The evaluation summary obtained using the ISO 9126 standard of the system is Strongly Agree with the Grand Mean of 4.65. The result means that the system is effectively functional and usable for the user in charge of creating a schedule.

V. CONCLUSION AND FUTURE WORKS

Based on the methodologies used and results and discussions presented, it is further concluded that;

1. This paper presented the developed Application of Representation and Fitness Methods of Genetic Algorithm in Class Scheduling (ARFMGACS) of the college of CCSICT. Using the representation method makes the scheduling of classes more organize, it served as the container of generated schedules and through the help of fitness method is the formula used to plot the created course class into a schedule. The scheduling becomes easier. Therefore, the system is a great help to the college especially for the college secretary in managing class schedules.
2. The system provides the functionalities in generating the Pre-scheduling template using the representation method of Genetic Algorithm as shown in figure 5 and 6 and Generation of class, faculty, rooms and laboratory schedules, as shown in figure 7.
3. The evaluation summary in terms of Functionality and Usability is 4.71 and 4.75 respectively as shown in Table 3. This result means that the system is effectively Functional and Usable for the user who creates the schedule manually.

The conclusion confirms that the objectives were met. And for the following recommendation given for the future studies:

1. Include the Individual Student Schedules base on the course class enrolled.
2. Improve and reformulate the Fitness Function Method for the Generation of Irregular Student Schedules and Campus Extension Schedules.
3. Drag and Drop Scheduling for the Manual Scheduling features.
4. Include the other data components of the Generation of Faculty Workload.
5. Include the other indicators of the ISO 9126 Standard

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