UTILIZE GAME THEORY TO PARTICIPATE IN ACADEMIC COURSES IN UNIVERSITY BY GD3 ALGORITHM

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Abstract

Nowadays, the competition between students when applying for credit on campus has become a rather persistent issue for both the student and universities. Network congestion, the lack of slots in a class, and the cancellation of a class after successful enrollment have led to the fact that students often graduate late or disrupt the registration plan of a semester. Considering that this dilemma requires a balance of benefits for thousands of people, in this case, all the students of a university, this paper aims to solve it using game theory, a branch of mathematics that deals with finding optimal strategies in competitive situations, which relies heavily on the concepts of strategy, opponent modeling, and equilibrium. To find a solution to this issue, we will apply the GDE3 Algorithm because, with our game theory-based registration system, credit registration becomes seamless and painless by incentivizing the students with rewards they will gain upon meeting some conditions. This research provides both students and universities with the optimal solution for successful credit registration in the future.

Key words: *GDE3 algorithm; course credit; Game theory; course registration*

1 Introduction

Academic courses, also known as college credits, measure a student's workload based on the necessary time to complete a teaching/learning unit in ECTS (The European Credit Transfer and Accumulation System) [3] . Participating in registering for academic courses on university websites is considered one of the most essential and challenging activities which students have to solve. This essential activity offers excellent benefits to students, such as flexibility in the course selection and the graduation time adjustment. To maximize those benefits, students must compete with tens of thousands of other students in a bruising credit registration battle. The most significant cause of this battle is the visitor overload to the course registration portal [11]. Too many students rushing in to log on to the website simultaneously causes lag, network congestion, and crashes for hours. Some students even utilize multiple devices to increase their chances of success, which makes congestion worse (see Figure 1). Even if students can access the website after a long time, it is possible that the class they want to take is already filled., forcing them to choose another class that may be canceled due to insufficient enrollment.

Time	8.26AM	9.17AM	10.13AM	10.25AM	11.28AM
No. of students accessing	28192	18114	19999	21125	21848
No. of students logged in successfully	1000/1000	897/888	888/888	889/888	891/888

Figure 1: ***The hits overload to the website during course registration (portal open time: 8AM)***

Another main reason for more intense credit registration is the inappropriate planning of the student's course choice. There are too many students enrolled in the same course, whereas other courses have few or no participants [11] . For instance, the number of students choosing CGR and PAP exceeded the available slots planned by the university. Conversely, the enrollment rates were much lower for FMO and FMT, so classes with insufficient students were canceled (see Figure 2). As a result, students who cannot register enough credits according to the university's regulations may be uneducated in that semester.

Realizing the importance and difficulties that students face in the race to register for credits, the article will initially build a consulting system for course registration in which students are encouraged to choose appropriate courses and timetables. This system can create fairness for all students to register and complete the course in the best way.

Of all the problem-solving techniques involved in achieving overall equilibrium between players - students in this problem, Game Theory arises as an up-and-coming technique. Many Game Theory applications have produced extraordinary scientific achievements, including the Nobel Prize. Therefore, the result will be determined by all players' decisions, with each player attempting to guess the remaining players' choices to reach their best decision [6] . GDE3 (the third evolution step of the Generalized Differential Evolution Algorithm) is the extension of differential evolution for multi-objective problems [4] . This third evolution enhances previous GDE versions by producing a more evenly distributed solution. The GDE3 can handle any number of M objectives and K constraints, including situations where M = 0 (constraint satisfaction problem) and K = 0 (unconstrained problem) [8].

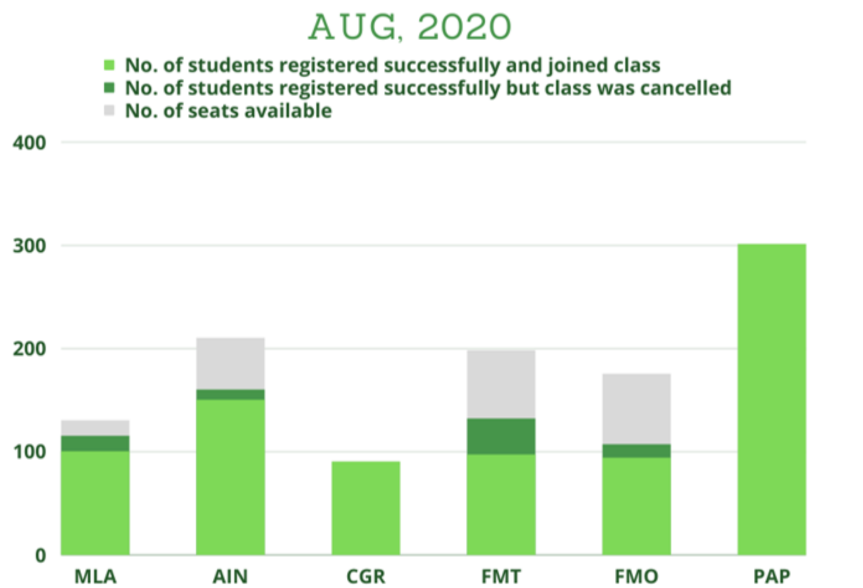

Figure 2: ***The percentage of student successfully participated in some courses***

The current study's findings on the conflicts in the academic course registration by the Game theory are not much. It contains the previous research of Michael A. Verlezza [16]on the competition of students in undergraduate course selection as a Nash n-person game. This problem was also raised at Cornell University by Mccabe J. [10] in which Nash equilibrium was applied to find the great benefit between two students with two distinct strategies. However, this approach based on the Nash model is insufficient for this issue because there are many students and different strategies.

Based on traditional game theory models, we can use the multi-objective optimization techniques and evolutionary algorithms, precisely the Unified Game-based model and Generalized Differential Evolution 3 (GDE3) algorithm, to find the Nash equilibrium. In this paper, we will explore and analyze this issue and provide possible solutions to assist students in getting the maximum benefit from credit registration. Students will be the main actors who construct their tactics and implement them to address the challenges of enrolling in the desired courses. The college's responsibility is limited to offering courses with a specified number of classes and confirming the enrolled students. Students' course registration concerns include: students cannot register for the classes they want; there is an unbalance in the number of enrolled students between courses; courses do not have enough slots for students to participate, and courses do not have the registered students. The rest of the study is organized as follows. In section

2, we discussed and analyzed the recent research on Game Theory. Section 3 described the conflict in course credits registration. We introduced the Unified Game-Based Model to the issue mentioned above in Section 4 and explained applied algorithms in Section 5. Finally, Section 6 ended with a conclusion and a preview of our upcoming projects.

2 Literature review

Course registration is one of the significant concerns of university students because it has an important influence on the graduation plan of every student. However, this problem only occurs in places where the credit system has just been developed because of the lack of human resources and limited infrastructure. There is still some evidence in the literature showcasing the credit registration problem in universities. In 2013, Verlezza stated that only 51.7 percent of students from Bridgewater State University graduate in time as a consequence of different kinds of dilemmas, one of them is the competition for course selection due to the finite number of seats and classes for a few preferred professors, a particular course or a specific time for an offering. In another article by Guoqing Sun in 2018, he mentioned the problem of course enrollment, precisely, PE course enrollment with the deviance between different classes. Another example of this problem can be seen in a paper by Ahrens and Zascerinska in 2012. They mentioned some external factors affecting student learning, including credit registration. Perhaps one of the most significant examples of this problem can be read from the "Registration Game" of Craig Haile(2003), when the author experienced the course registration problem with only three students registered for his regular course. In 2016, in Janice McCabe's paper "Friends with Academic Benefits," she categorized students' friendships into three types: tight-knitters, compartmentalizers, and samplers in common is to support each other for the difficult task, in this case, course enrollment. Some evidence can be found in a paper by William J. Stull (2004). It briefly discusses some factors that affect student choices in course registration, like the professor and the knowledge benefits the course can bring the student, which results in serious competition.

Each research paper analyzes particular and different problems, but in general, they all mention the course enrollment problem. The table below summarizes the elements of the above publication:

Author	Publication	Method
[16] Michael A.Verlezza	The Undergrad's Dilemma: n-Person Games and Information Asymmetry in Undergraduate Course Selection	Use Involuntary Equilibrium A Game-Theoretic Model of Curriculum Integration and School Leadership
[15] Guoqing Sun	Influence of Game Theory on Physical Education Teaching Mode	Apply game theory to PE teaching process to improve teaching quality
[1] A. Ahrens and J. Zascerinska	Perspective of Game Theory in Education for Sustainable Development	Modeling the process of teaching and learning in education for sustainable development
[5] Craig Hail	The Registration Game	Use Game theory and Nash equilibrium to model the registration problem
[10] Janice McCabe	Friends with Academic Benefits	Analyze friends' relationships based on mutual benefits using Game Theory
[14] William J. Stull	A Game-Theoretic Model of Curriculum Integration and School Leadership	Provide a formal model of Curriculum Integration implementation as it takes place in a school

In general, the above studies have pointed out the registration problem, but none has provided a solution to this dilemma. Most of the research papers focus on different aspects of education, but little mention the cause or the consequence that late credit registration can bring to the student.

In this study, we based the GDE3 Algorithm on conducting a new solution to help many students succeed in their course enrollment. Besides, applying game theory in this context helps visualize every student's obstacles when registering for a course. In the light of those mentioned above, it can be said that this paper's primary purpose is to discuss the solution to the credit registration problem by applying game theory combined with the GDE3 Algorithm.

3 Problem description

Course registration is a mandatory process for all students at the university before the start of each semester. Effectively completing the registration is a prerequisite for ensuring a student meets a university's graduation requirements in a comprehensive and organized way, with no unnecessary delays [2]. However, this is difficult because of the incomplete online credit registration system and the disproportionate course selection of students. Too many students rush the registration portal at the start of the process, causing network bottlenecks, high system demand, and database overload, which impacts the standard registration process as well as the usual operation of the information system. Besides, the selection of courses, including compulsory and elective courses, as well as the desired schedule among students, make this process more difficult. Students face common registration issues such as selecting courses with schedule conflicts, missing out on alternative semester courses, selecting free electives limited to specific departments, selecting too many or too few courses in a semester, and so on. As a result, students' graduation is delayed due to unneeded additional courses or dropping a semester because of a minimum required number of course credits [11]. Many universities worldwide spend significant money on individualized consulting and registration programs to assist students in this course registration activity. For instance, the College of Engineering, United Arab Emirates University, invested in building Student Advising Software (SAS) that supported and led students in picking suitable courses for online registration [9].

The course registration problem was mentioned at Assumption University in Bangkok, Thailand. This university usually faced course and section selection, which most students considered a difficult and time-consuming problem. To assists students in handling this problem, the university proposed a course and section recommender system based on the Constraint Satisfaction Problem, which combined three factors: individual constraints (preferred course selection), social constraints (the schedules and course selection of friends), and scheduling constraints (study time of section) [2].

In this problem, the university, as a particular player, the unit that designs the courses for students to register, do not compete or participate directly in the conflict. In specific, the university needs to use the following information:

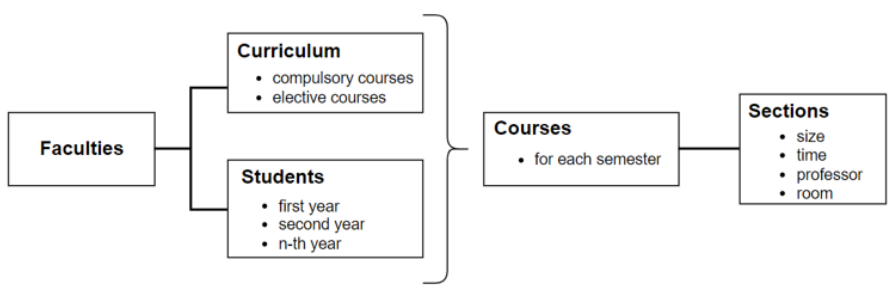

Figure 3: ***Course design activities of the university***

the total number of required courses in the curriculum, the number of opened courses in previous semesters and the number of remaining courses, the number of credits for each course, the tuition fee per credit, the numbers of students by each academic year, the total teacher numbers of the university. From the above information, the university designs courses with the elements: the number of open courses (both compulsory and elective courses) in this semester, the size of the course, the number of sections in each course, the minimum student rate of a section to not be canceled. Students are players that compete with each other and participate directly in the course registration process. Students will plan their choices based on three main factors: a targeted course, a preferred professor, and the desired time. Unfortunately, having a semester with an effective combination of courses, professors and times are rare. Typically, students list desired courses for the semester, including first-time and uncompleted courses in the previous semester. They tend to choose more accessible courses, courses that their preferred teachers teach, or the same courses as their friends. In addition, they often try to schedule their classes on a fixed or midweek day for personal reasons. Students' financial status also impacts how many courses they can take in a semester. Besides, the limited availability of slots and sections also affects the registration result of students [16]. These create an imbalance in the number of students enrolled in each course.

The characteristics of students include the number of new courses that a student needs to register, the number of owed courses that a student must register in the following semesters, the number of needly-register courses this semester, the minimum number of credits that a student must register in each semester, the student's financial status this semester, the numbers of friends in course.

Based on the analysis of players above, the player strategies can be formulated:

- Students can resolutely choose courses that satisfy their criteria: the targeted course, the preferred professor and the desired time. However, many students will face problems such as running out of registration slots or classes being canceled due to insufficient numbers.

- Students can flexibly choose the suitable courses. As a result, all students can register enough required courses with an appropriate timetable.

Player	**Characteristics**	**Strategy**
University	number of required courses	*creq*
	number of opened course	*copened*
	number of remaining courses	*cremain*
	number of credits per course	h
	tuition fee per credit	*fpc*
	numbers of students	*st*
	number of teachers	*tc*
	size of course	z
	number of sections	t
	minimum student rate of section	r
Student	number of new courses	*cnew*
	number of owed-courses	*cowned*
	number of needly-register courses	*creg*
	minimum number of credits	cre_{min}
	student's financial status	*fs*
	number of friends in course	*fic*

Consider the following example to clear this problem. Assume that a university will open three courses for 420 students this semester. Usually, the course selection of students is as below:

Course	Size of course	No. of section	Size of each section	Minimum size of section to not be canceled	Sections						Total
					1	2	3	4	5	6	
A	180	6	30	24	29	34	24	20	28	15	150
				Variance:	1	4	0	4	2	9	20
								X		X	Cancel
B	150	6	25	20	40	21	22	10	25	2	120
				Variance:	15	4	3	10	0	18	50
								X		X	Cancel
C	90	3	30	24	45	50	55				150
				Variance:	15	20	25				60
											Cancel

Table 4 : The course selection of students in the usual case

It can be seen from Table 4 that the number of students choosing to join course C is much more than the available slots, while there are two sections of the course, A and two sections of course B will be canceled due to insufficient enrollment. As a result, 126 students failed to register for the course.

A game theory should be applied to obtain a win-win situation, which means all students can successfully register for the course this semester.

Course	Size of course	No. of section	Size of each section	Minimum size of section to not be canceled	Sections						Total
					1	2	3	4	5	6	
A	180	6	30	24	30	30	30	30	30	30	180
				Variance:	0	0	0	0	0	0	0
											Cancel
B	150	6	25	20	25	25	25	25	25	25	150
				Variance:	0	0	0	0	0	0	0
											Cancel
C	90	3	30	24	30	30	30				90
				Variance:	0	0	0				0
											Cancel

Table 5: The course selection of student in case applied Game theory

4 Model

The Unified Game-based model is based on a general structure for incomplete-information, cooperative and non-zero-sum games. In the Unified Game-based model, a particular player with interests distinct from the other players is created. This player is considered a party that shows the benefit of all players or a referee in the game. Simultaneously, the tactics of each player will also be represented by a characteristic vector [6]. Therefore, by combining three factors: particular players, regular players, and a set of players' strategies, the formula of the Unified Game-based model is below:

$$G = (\{P_0, P\}, \{S_0, S_i\}, \{u_0, u_i\}, R^c) \tag{1}$$

where:

G represents the game;

P_0 is a special player who has distinct interest than the rest of the players, can be a party who shows the benefit ò all players or a referee in the game;

$S_0 = \{s_{01},...,s_{0j},....,s_{0M_0}\}$: a set of the special player's strategies; M_0 is the number of the special player's strategies;

u_0: $S_0 \to R$ is a payoff function of the special player;

$P = \{P_1,...,P_i,...,P_N\}$ is a set of normal players, N is the number of normal players;

$S_i = \{s_{i1},..., s_{ij},..., s_{2M_i}\}$: s set of strategies of normal player i ($1 \leq i \leq N$)

After all the above analysis, we propose to apply the Unified Game-based model to optimize conflict in course registration. From (1), our model with the practical information is determined as follows:

$$G = (\{P_0, P\}, \{S_0, S_i\}, \{u_0, u_i\}, R^c) \quad (2)$$

In which,

G: represents the game;

P_0 is the university, as a special player who does not compete or participate directly in the game;

$S_0 = \{s_{01},...,s_{0j},....,s_{0M_0}\}$: is a set of M0 courses which will be opened this semester;

u_0: $S_0 \to R$ is the payoff function of the university which shows whether the courses opened by the university are enough, and whether the courses proposed by the system are fully registered;

N is the number of students participating in registration;

$P = \{P_1,...,P_i,...,P_N\}$ is a set of N students who complete with each other and participate directly in the course registration process;

$S_i = \{s_{i1},..., s_{ij},..., s_{2M_i}\}$: is a set of courses student i ($1 \leq i \leq N$) decides to register for, including both the needed courses this semester and the owned-courses last semester; M_I is the number of course registration strategies of student i;

From the formula above, the parameters of the model are defined:

4.1 The strategies of university:

$S_0 = \{s_{01},...,s_{0j},....,s_{0M_0}\}$: is a set of courses that will be opened this semester, in which:

- M_0 is the number of courses that the university decide to open; - s_{0j} is an information structure about a course, including name, number of credits, tuition fee per credit, the estimated size, of course, and estimated number of sections for the course;

4.2 The payoff of university:

The university offers course i having the size of course z_i and the number of sections t_i. With $i(\%)$ is the (minimum student rate of the section to not be canceled, we have the size of each section is $\frac{z_i}{t_i}$ and the minimum students of each section is $\frac{z_i}{t_i} \times r$. Supposing that L is the size limit of each section to be opened successfully; A is the actual number of students who want to register for the section; then the payoff of the university:

$$u_0 = score_{tc} + \sum_{i=1}^{M_0} varc_i = \frac{\sum_{i=1}^{M_a}(cactual_i \times ta_i)}{tc} + \sum_{i=1}^{M_0}\sum_{j=1}^{t_i} vars_{ij}$$

$$= \frac{\sum_{i_1}^{M_a}(cactual_i \times ta_i)}{tc} + \sum_{i=1}^{M_0}\sum_{j=1}^{t_i}(L_i - A_{ij}) \qquad (3)$$

In which:

$varc_i$: is the variance between the limit it size for the course i to be opened and the actual number of students want to enroll in the course i;

$scre_{tc}$: is the variance between the teachers needed and the total teachers of the university;

M_0: the number of courses opened in the semester;

t_i: the section number of course j;

cactual: the number of course opened actually;

M_a: the number of actual courses opened in the semester;

ta_i: the number of teachers needed for course i;

$varc_{ij}$: is the variance between the limit size for the section j and the actual number of students want to enroll in the section j;

$L_i = \frac{z_i}{t_i}$ or $L_{ij} = \frac{z_i}{t_i} \times r$: is the size limit of section j in course i to be opened

A_{ij}: is the actual number of students who want to register for the section j in course i;

Calculating (L_j - A_{ij}) in (3):

$$L_i - A_{ij} = A_{ij} - \frac{z_i}{t_i} \qquad If \quad A_{ij} \geq \frac{z_i}{t_i}$$

or

$$L_i - A_{ij} = \frac{z_i}{t_i} \times r - A_{ij} \qquad If \quad A_{ij} \leq \frac{z_i}{t_i} \times r$$

From the university's interests, the difference between the planned courses to open and the actual courses opened successfully must be the smallest. The smaller u_0 is, the more beneficial the university gets.

4.3 The strategies of student:

$S_i = \{s_{i1},...,s_{ij},....,s_{iM_i}\}$: is a set of courses that student i ($1 \leq i \leq N$)

In which:

- M_i is the number of course that student i wants to register for, including a list of the owned courses last semester and the new courses, needed this semester

- s_{ij} is an information structure about a course including name, number of credits, tuition fee per credit, the estimated size, of course, estimated number of sections for the course, number of friends in the course;

4.4 The payoff of each student:

The student i has a list of courses they want to register for, based on the set of courses that the university has provided previously. The payoff of student i is the combination of these characteristics: credit, finance and friend.

$$u_i = score_{credit} \times (score_{finance} + score_{friend})$$

$$= [\sum_{j=1}^{M_c}(creg_j \times h_j) - cre_{min}] \times (\frac{fs}{\sum_{j=1}^{M_c}(h_j \times fpc_i)} + \frac{cwf}{creg}) \quad (4)$$

where:

M_c = *cowned* + *cnew*: the number of course that student need to register;

cwf: the number of courses consisting of friends;

The higher the ui function, the greater the benefit for the student.

The Nash equilibrium is the point at which no student can produce a larger profit than others by his strategies. When player **i** choose the strategy s_i, the strategy of the other players is s^*_{-i}. The payoff function of player i is represented as $u_i(s_i,\, s_{-i})$. The Nash equilibrium of the game is defined as follows:

$$u_i(s_i^*, s_{-i}^*) \geq u_i(s_i, s_{-i}^*) \quad (5)$$

In the five conflict-handling modes of Thomas-Kilman, which include competing, collaborating, compromising, avoiding, and accommodating, collaborating is proved as the best method of solving conflict [13].Moreover, Nash equilibrium in Game theory is fundamentally based on a solid collaboration/cooperation between numerous players [12]. Specifically, at the Nash equilibrium point, all players involved in the game must cooperate to determine a method that satisfies all parties. Thus, Nash equilibrium is considered an appropriate solution for the conflict. In addition, H. Nikaido and K. Isoda demonstrated that finding Nash equilibrium is a multi-objective optimization problem and can be solved by multi-objective evolutionary optimization algorithms [6]. The conflict in course registration is a multi-objective optimization problem that needs to satisfy the constraints of many students. At the same time, the multi-objective evolutionary optimization algorithm that converges after running through a certain finite number of iterations may become a candidate for Nash equilibrium. Consequently, the course registration problem has Nash equilibrium and can be found through multi-objective optimization algorithms.

5 Algorithm with NE

TThe first redundancy of a Generalized Differential Evolution (GDE) extended DE for restricted multi-objective growth by changing the original DE's collection rule. The fundamental belief behind the pick tests was that if the trial heading infirm constraint-ruled the traditional heading, it was preferred to follow it in the future generations. During the addition process, non-governed headings or means for upholding the allocation and considering the resolution were not sorted. There was also no supplementary warehouse for non-ruled headings.

Nonetheless, GDE was intelligent enough to produce an unusually appropriate answer but was overly delicate in conditions of control limit draft.

Later, GDE wasamended to form a fate based on mass when the trial and traditional heading were practicable and non-main in the objective function room. This increased the range and dispersion of the resolution but delayed overall populace union because it had chosen isolated headings aloof from the Pareto front before all headings converged towards the Pareto front. This rendition, GDE2, was still also impressionable when selecting control limits.

This work proposes a tertiary form of GDE that longers the DE/rand/1/container approach to questions accompanying M aims and K constraint functions.

$$
\left\{
\begin{array}{l}
\text{While } G < G_{max} \\
\quad \forall i \le NP \left\{
\begin{array}{l}
\text{Mutate and recombine:}\\
r_1, r_2, r_3 \in \{1,2,\ldots,NP\}, \text{randomly selected,}\\
\qquad \text{except mutually different and different from } i\\
j_{rand} \in \{1,2,\ldots,D\}, \text{randomly selected for each } i\\
\forall j \le D, u_{j,i,G} = \begin{cases} x_{j,r_3,G} + F\cdot(x_{j,r_1,G} - x_{j,r_2,G}) \\ \qquad \text{if} \quad rand_j[0,1) < CR \vee j = j_{rand} \\ x_{j,i,G} \quad \text{otherwise}\end{cases}\\
\text{Select :}\\
\vec{x}_{i,G+1} = \begin{cases} \vec{u}_{i,G} & \text{if} \quad \vec{u}_{i,G} \preceq_c \vec{x}_{i,G} \\ \vec{x}_{i,G} & \text{otherwise}\end{cases}\\
\boxed{\begin{array}{l}\text{Set :}\\ \begin{array}{ll} m = m+1 & \\ \vec{x}_{NP+m,G+1} = \vec{u}_{i,G} & \text{if} \begin{cases}\forall j: g_j(\vec{u}_{i,G}) \le 0\\ \wedge \\ \vec{x}_{i,G+1} == \vec{x}_{i,G} \\ \wedge \\ \vec{x}_{i,G} \not\prec \vec{u}_{i,G}\end{cases}\end{array}\end{array}}
\end{array}\right.\\
\boxed{\left\{\begin{array}{l}
\text{While } m > 0\\
\quad \text{Select } \vec{x} \in \{\vec{x}_{1,G+1}, \vec{x}_{2,G+1}, \ldots, \vec{x}_{NP+m,G+1}\}:\\
\qquad \begin{cases} \forall i \quad \vec{x} \not\prec_c \vec{x}_{i,G+1} \\ \wedge \\ \forall(\vec{x}_{i,G+1} : \vec{x}_{i,G+1} \not\prec_c \vec{x}) \quad CD(\vec{x}) \le CD(\vec{x}_{i,G+1})\end{cases}\\
\quad \text{Remove } \vec{x}\\
\quad m = m-1
\end{array}\right.}\\
G = G+1
\end{array}\right.
$$

Notation Crowding Distance (CD) measures by what method cramped a heading are in allure non-dominated set. Another distance measure for mass commits is still undertaken. Eq. 3 frames the new and distinguished parts from former GDE versions. The Algorithm is similar to the former GDE tale outside these elements. Later in this paper, the projected form in Eq. 3 is referred to as the Generalized Differential Evolution 3 form (GDE3). It can handle some M goals and some K restraints, containing M = 0 (restraint satisfaction question) and K = 0 (abandoned question), and the original DE is a subdivision of GDE3. GDE3 may be a mixture of previous GDE interpretations and PDEA [7]. Selection in GDE3 has established the following rules:

> - When handling impossible headings, the traditional heading is chosen as far as the trial heading infirm dominates it in the scope of restraint breaches.

- The appropriate heading is chosen between the doable and impossible headings.

- If two together headings are likely, the trial is chosen if it somewhat outperforms the original heading in the room of the objective function. When the traditional heading outperforms the trial heading, it is preferred. Both vectors are preferred for the following creation if neither heading entirely dominates the objective function scope.

The populace's ability has become more far-reaching later in an era. If so, it is before recoiling back to allure departed breadth using a pick plan complementary to the individual secondhand in NSGA-II. Based on non-supremacy and mass, vectors are ordered. The worst public appendages are removed and these calculations to fix the population to allure prior capacity. In order to produce a more constantly delivered set of headings, non-ruled sorting is upgraded over the original NSGA-II approach by communicable limits into the report and cramming distance.

The population might have become more extensive after a generation. If so, it is then shrunk back to its former size using a selection method similar to the one used in NSGA-II. Based on non-dominance and crowdedness, vectors are ranked. The worst population members are eliminated based on these measurements to restore the population to its previous size. In order to produce a more evenly distributed set of vectors, non-dominated sorting is improved over the original NSGA-II approach by taking restrictions into account and crowding distance.

6 Conclusion

Course registration is a necessary task for all students at the university because of its importance for helping to ensure a student fulfills a college's graduation requirements without unnecessary delays. Nevertheless, this is challenging due to the flawed online credit registration system and the unbalanced student course selection.

Therefore, introducing a specific solution method as presented in the thesis is necessary for solving an important problem of credit registration. Specifically, the above solution method has been applied in some typical conflict problems of schools and students in signing credits such as number of courses, number of students, number of teachers, and tuition to be paid. The application and testing show that the above problems have been solved, and a solution is found that all parties are satisfied.

This study has made some fundamental contributions to the research field: the model contains enough specific information, effectively conveying the optimal algorithms to solve the problem using the concept of equilibrium. Nash. With the balanced solution that Nash found, it will provide a valuable tool for school credit applications and students in decision-making regarding conflicts. The proposed solution can balance the parties' requirements to the conflict, and it can be said that the thesis has offered a win-win solution, which is one of the best wishes but also challenging to implement presently best for conflict resolution theory.

More specifically, the thesis has the following objectives:

- The overall analysis of conflicting credit registration issues and the modeling features required. In the first part of the study, it was shown that the current models have many problems in some of the following characteristics, especially for the problem of credit registration, which directly affects students' interests. and the organization of the school. In addition, in in-game models, where there needs to be a balance between the players' interests and where there will be conflicts of interest, these descriptions and constraints on the dispute (or conflict) are not described. Therefore, this is a mandatory condition of the conflict interpretation model;

- Build a general model of game theory-based modeling for all types of conflicts in credit registration while ensuring that the model is solvable using suitable multi-objective optimization algorithms, on the proof that the model can be solved, not only from the research, analysis, and articles published during the implementation of the thesis also show that the above conclusion is grounded. The data is described in the introduction to the problems: How many courses to open, number of students per class, number of credits students have to register in a semester, and number of tuition fees students have to pay to the school.

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