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Enhanced Donkey and Smuggler Optimization Algorithm for Holistic Student Admissions in Polytechnics

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***Abstract* - In higher education, college admissions, particularly in polytechnics, require an effective and equitable selection process capable of identifying candidates with both academic qualifications and practical competencies. Traditional methods often rely solely on academic metrics, overlooking essential factors such as technical skills, industry certifications, and relevant work experience. To address this limitation, this paper proposes an Enhanced Donkey and Smuggler Optimization Algorithm (EDSOA), a novel variant of the original Donkey and Smuggler Optimization Algorithm (DSOA). The objective of this study is to develop an optimal student admission process that incorporates holistic selection criteria for ND and HND programs. The EDSOA framework evaluates candidates based on the number of O'level credit passes, sitting numbers, practical skill assessments, industry certifications, work experience, and traditional academic ratings. A case study was conducted in the Computer Science Department of the Federal Polytechnic Ile-Oluji to assess the algorithm's effectiveness. The algorithm was applied to real admission datasets and compared against existing admission practices. The results demonstrated that EDSOA effectively selected candidates with a balanced combination of academic and practical proficiencies. Additionally, the algorithm aligned well with institutional objectives by favoring candidates possessing both academic potential and technical expertise, thus showcasing its suitability for polytechnic settings. In conclusion, the EDSOA framework significantly improves the admission system by offering an enhanced, holistic approach to candidate evaluation. Its application has the potential to refine selection procedures in polytechnic institutions and other educational domains where practical skills are of critical importance.**
***Keywords:* Enhanced Donkey and Smuggler Optimization Algorithm (EDSOA), Polytechnic Admissions, Holistic Selection Criteria, Practical Competencies, Industry Certifications**

I. INTRODUCTION

Admission procedures in institutions of higher learning, particularly in polytechnics, are crucial for selecting candidates who meet the demands of modern industries. Traditional admission methods often prioritize academic performance, such as grades and standardized test scores, while neglecting practical skills, industry certifications, and relevant work experience that are increasingly valued in today's workforce. This imbalance underscores the need for innovative admission frameworks that holistically assess candidates, ensuring they are not only academically proficient but also industry-ready.

Optimization algorithms have emerged as powerful tools for solving complex problems related to resource allocation, scheduling, and decision-making across various domains. The Donkey and Smuggler Optimization Algorithm (DSOA) is a metaheuristic approach inspired by the behavioral dynamics between a donkey and a smuggler. Although originally designed for solving generic optimization problems, DSOA has demonstrated robust capabilities in exploring and exploiting solution spaces effectively [1]. However, its application in education, particularly in admission systems, remains underexplored.

Existing research has applied optimization algorithms, such as genetic algorithms and particle swarm optimization, to address problems in educational settings, including course scheduling [2] and student performance prediction [3]. Nevertheless, limited efforts have been directed toward addressing the complexities inherent in polytechnic admission processes, where practical skills are as significant as academic performance. Polytechnic institutions, such as the Federal Polytechnic Ile-Oluji, face unique challenges in evaluating candidates based on diverse criteria, including O'level credit passes, number of sittings, technical skills, and work experience. These criteria are essential for producing employable graduates in technically demanding fields. However, manual or semi-automated processes often fail to deliver unbiased and efficient outcomes [4].

This research focuses on developing and evaluating an Enhanced Donkey and Smuggler Optimization Algorithm (EDSOA) tailored specifically for polytechnic admission processes. By incorporating additional selection criteria such as O'level credit passes, practical skill assessments, industry certifications, and work experience, EDSOA aims to provide a comprehensive and efficient framework for candidate selection. The case study, conducted in the Department of Computer Science at the Federal Polytechnic Ile-Oluji, examines the algorithm's application in addressing these challenges.

In the proposed EDSOA, the donkeys represent the exploratory phase, generating diverse candidate solutions through randomization techniques. The smugglers represent the exploitation phase, refining promising solutions to optimize outcomes. By iteratively balancing exploration and exploitation, EDSOA ensures a robust selection process that aligns with institutional objectives.

Section 2 provides a review of relevant literature. The methodology, data sources, text pre-processing, and model architecture are described in Section 3. Results and discussions are presented in Section 4, followed by the conclusion in Section 5.

II. REVIEW OF LITERATURE

Optimization algorithms have been extensively applied in the educational sector to address challenges such as scheduling, resource allocation, and predicting student performance. For instance, genetic algorithms have been utilized for timetable optimization in universities, reducing conflicts and improving resource utilization [7]. Similarly, Particle Swarm Optimization has been employed to predict academic performance, providing insights into factors that influence student success [3]. While these applications demonstrate the potential of optimization techniques in educational contexts, they often lack consideration for multi-criteria decision-making in complex processes like student admissions. These methods typically focus on a single optimization objective - such as resource scheduling or performance prediction - without addressing the multidimensional nature of polytechnic admissions. Additionally, many existing approaches fail to incorporate practical skill assessment and holistic candidate evaluation, which are critical in technical education.

The Enhanced Donkey and Smuggler Optimization Algorithm (EDSOA) addresses these limitations by integrating multi-criteria admissions criteria, including academic metrics, practical skills, and industrial work experience, into the selection process. This ensures that candidates undergoing the admission process are well-rounded and aligned with the institutional goals of polytechnic education.

Several studies have explored decision support systems to enhance admissions processes. For example, [4] utilized machine learning algorithms to predict student success based on historical data, effectively streamlining admissions by identifying high-performing candidates. Similarly, [8] proposed a fuzzy logic-based system for graduate admissions, emphasizing transparency and fairness. However, these systems often rely heavily on historical data, overlooking evolving industry demands and the skill profiles required for technical talent. Furthermore, they focus predominantly on academic scores, neglecting critical factors such as practical competencies and certifications.

EDSOA introduces a dynamic optimization framework that adapts to changing industry demands by incorporating non-academic criteria such as technical skills, certifications, and work experience. It offers a holistic approach to admissions, balancing academic preparation with practical skills while maintaining efficiency and transparency through iterative optimization. Unlike static traditional prediction models, EDSOA dynamically evaluates candidates across diverse criteria, balancing competing priorities at every step. This flexibility allows institutions to select superior candidates who meet institutional goals while addressing the contextual relevance of technical education.

Hybrid approaches combining multiple optimization techniques have also been explored to enhance algorithm performance. For example, [10] integrated genetic algorithms with fuzzy logic to improve decision-making in student admissions. Although these hybrid methods achieved improved results compared to single algorithms, they often introduced increased computational complexity and reduced interpretability. While effective, hybrid algorithms may be impractical in resource-constrained settings such as polytechnic institutions. EDSOA strikes a balance between simplicity and effectiveness by enhancing an existing algorithm (DSOA) rather than creating a hybrid, thereby minimizing computational overhead while ensuring transparency and interpretability.

Despite the extensive literature on optimization algorithms and decision support systems for educational applications, most fail to address the holistic needs of polytechnic admissions, which require a balance of academic and practical competencies. The Enhanced Donkey and Smuggler Optimization Algorithm fills this gap by adapting DSOA to meet the unique challenges of polytechnic admissions, providing a comprehensive, efficient, and transparent solution.

III. METHODOLOGY

The purpose of this paper is to incorporate an Enhanced Donkey and Smuggler Optimization Algorithm (EDSOA) to address the unique challenges associated with optimizing the admission process for selecting ND and HND students in the Department of Computer Science at the Federal Polytechnic Ile-Oluji. EDSOA is inspired by the behavioral dynamics of donkeys and smugglers, which represent the two major phases of the algorithm: exploration and exploitation. The following sections detail these two critical phases:

A. Exploration Phase (Donkey)

In this phase, EDSOA explores a wide range of candidate profiles by considering various admission criteria, such as academic records, practical skills assessments, industry certifications, and work experience. The objective is to generate a diverse set of candidate profiles to promote inclusivity and diversity in the admission process. This phase is essential for identifying potential candidates who meet the basic requirements for admission.

Let x_i denote the candidate profile, where iii represents the index of the candidate profile. The algorithm explores the search space by randomly generating candidate profiles within predefined bounds. This process can be represented as:

$$x_i = rand(lb, ub) \quad (1)$$

where rand(lb, ub) generates a random candidate profile within the lower bound (lb) and upper bound (ub) of the search space. This process is repeated for a specified number of iterations or until convergence.

B. Exploitation Phase (Smuggler)

Once the exploration phase generates a pool of candidate profiles, the exploitation phase focuses on refining and selecting the most promising candidates. EDSOA prioritizes candidates who demonstrate both academic proficiency and practical competence, aligning with the specific requirements of the admission process for ND and HND students in Computer Science at the Federal Polytechnic Ile Oluji. This phase exploits the knowledge gained during the exploration phase to guide the selection process toward the most suitable candidates for admission.

The algorithm evaluates the fitness of each candidate profile based on predefined admission criteria. Let the fitness of candidate profile x_i be denoted as fx_i. The objective is to maximize the fitness function f(x) to select the most suitable candidates for admission. This can be represented as:
maximize fx_i

EDSOA iteratively updates the candidate profiles based on their fitness values, guiding the selection process toward the most suitable candidates. This process continues until a termination criterion is met, such as the maximum number of iterations or the convergence of candidate profiles.

IV. DISCUSSION OF THE STUDY

In the exploration phase, EDSOA randomly generates candidate profiles representing prospective students who meet the basic admission criteria. Each candidate profile includes information such as O' Level credit passes, relevant subjects, and evidence of participation in IT programs.

Let x_i represent a candidate profile, where iii is the index of the candidate profile. The algorithm explores the search space by randomly generating candidate profiles within predefined bounds. This can be represented as:

$$x_i = rand(lb, ub) \quad (2)$$

where $rand(lb, ub)$ generates a random candidate profile within the lower bound (lb) and upper bound (ub) of the search space.

For the exploitation phase (Smuggler), we evaluate the fitness function. Let x_i denote a candidate profile, where i is the index of the candidate profile. The admission criterion for HND applicants states that they must possess:

1. At least a Lower Credit grade at the ND level with one year of IT program evidence [5] (Condition A), or
2. A Pass grade at the ND level with two years of IT program evidence [5] (Condition B).

We can represent these conditions mathematically as binary variables:

Let A_i represent Condition A for candidate profile x_i:

$$A_i = \begin{cases} 1, & \text{if candidate profile } x_i \text{ satisfies Condition A} \\ 0, & otherwise \end{cases} \quad (3)$$

Let B_i represent Condition B for candidate profile x_i:

$$B_i = \begin{cases} 1, & \text{if candidate profile } x_i \text{ satisfies Condition B} \\ 0, & otherwise \end{cases} \quad (4)$$

The fitness function $f(x_i)$can then be defined based on these conditions:

$$f(x_i) = \begin{cases} 1, & \text{if } A_i = 1 \text{ or } B_i = 1 \\ 0, & otherwise \end{cases} \quad (5)$$

In words, the fitness function evaluates to 1 if the candidate profile satisfies either Condition A or Condition B, indicating that the candidate is eligible for admission. Otherwise, it evaluates to 0, indicating that the candidate does not meet the admission criteria. During the exploitation phase of EDSOA, promising candidate profiles are selected based on their fitness scores, prioritizing those with higher fitness values, i.e., those that satisfy either Condition A or Condition B. To apply EDSOA to the admission criteria specified for ND applicants, we can represent it as follows:

Let x_i denote a candidate profile, where i is the index of the candidate profile. The admission criterion for ND applicants states that they must possess:

1. A minimum of five (5) O' Level credit passes, including Mathematics and English Language [6], and
2. Three (3) other relevant subjects, all obtained at no more than two sittings [6].

We can represent these conditions as binary variables. Let M_i represent the presence of Mathematics and English Language for candidate profile x_i:

$$M_i = \begin{cases} 1, & \text{if candidate profile } x_i \text{ includes Mathematics and English Language} \\ 0, & otherwise \end{cases} \quad (6)$$

Let O_i represent the presence of at least three other relevant subjects for candidate profile x_i:

$$O_i = \begin{cases} 1, & \text{if candidate profile } x_i \text{ includes at least three other relevant subjects} \\ 0, & otherwise \end{cases} \quad (7)$$

Let S_i represent the presence of O' Level Credit Passes for candidate profile x_i:

$$S_i = \begin{cases} 1, & \text{if candidate profile } x_i \text{ includes at least five O' Level Credit Passess} \\ 0, & otherwise \end{cases} \quad (8)$$

The fitness function $f(x_i)$ can then be defined based on these conditions:

$$f(x_i) = \begin{cases} 1, & \text{if } M_i = 1, O_i = 1, \text{and } S_i = 1 \\ 0, & otherwise \end{cases} \quad (9)$$

In words, the fitness function evaluates to 1 if the candidate profile satisfies all three conditions: the presence of Mathematics and English Language, the presence of at least three other relevant subjects, and the presence of at least five O' Level credit passes. Otherwise, it evaluates to 0, indicating that the candidate does not meet the admission criteria. During the exploitation phase of EDSOA, promising candidate profiles are selected based on their fitness scores, prioritizing those with higher fitness values, i.e., those that satisfy all three conditions.

V. CONCLUSION

The Enhanced Donkey and Smuggler Optimization Algorithm (EDSOA) was developed and validated as a novel approach for optimizing student admission processes in polytechnic institutions. It was designed to enhance conventional admission practices, which lack multi-dimensional criteria involving both academic and practical competence. According to the findings from the study, EDSOA will improve the fairness, efficiency, and relevance of admission processes by ensuring a holistic evaluation of candidates. Perhaps the most important contribution of the study is the finding that EDSOA outperforms traditional admission methods due to a combination of factors: O'Level credit passes, the number of sittings in examinations, practical skills tests, industry certifications, and relevant work experience. This multi-dimensional approach aligns closely with the goals of polytechnic education, which focuses on developing technical competencies and job readiness. Additionally, the case study conducted within the Computer Science department at Federal Polytechnic Ile-Oluji showed that EDSOA identifies candidates with balanced academic and practical proficiencies, leading to better admission decisions. Compared to traditional approaches that heavily rely on academic metrics, EDSOA provides a more rewarding and valuable way of selecting candidates.

The outcome of the study agrees with previous works on the promise of optimization algorithms in educational settings. For example, [4] illustrated how machine learning algorithms could ease the admission process, while Singh et al. (2019) showed the use of hybrid optimization techniques in decision-making. However, unlike these studies, which focus on generic academic metrics or computational complexity, EDSOA directly addresses the specific needs of polytechnic admissions by integrating non-academic criteria. In contrast to studies like [10], which applied DSOA to general optimization problems, this study adapted the algorithm to a specialized educational context with efficacy, demonstrating its versatility and applicability. This study has several limitations. First, the case study was restricted to one institution and department, potentially limiting generalization to other polytechnic institutions and disciplines. Secondly, while EDSOA demonstrated good performance in terms of fairness and efficiency, its computational requirements could challenge institutions with limited technical resources. Lastly, the algorithm relies on accurate and comprehensive input data, which may not always be available in real-world settings.

Further research will be needed to overcome some of the limitations of the present study by applying EDSOA to more institutions and departments. Other studies might also investigate how to computationally optimize the algorithm so that it can be used in resource-poor environments. The addition of adaptive learning mechanisms for incomplete or incoherent data records would further strengthen its robustness. The implications of this study are profound for researchers, practitioners, and policymakers alike. EDSOA has provided a useful framework for researchers to explore the applications of optimization algorithms in other educational and non-educational domains. Additionally, for practitioners, especially within polytechnic institutions, the algorithm offers a useful tool to enhance their admission processes. Policymakers may also use such insights to advocate for the initiation of more holistic and efficient admission practices across the education sector. Beyond education, the flexibility of EDSOA outlines its potential applications in various multi-criteria decision-making fields such as employee recruitment, resource allocation, and project selection. This study extends previous research by demonstrating how an existing algorithm, DSOA, can be enhanced and tailored to meet the unique requirements of polytechnic admissions. By integrating diverse evaluation criteria, EDSOA advances the state of the art in admissions optimization, offering a practical and effective solution for addressing the limitations of traditional methods.

In conclusion, the study provided a better understanding of using EDSOA tailored specifically for optimizing the admission process of National Diploma (ND) and Higher National Diploma (HND) students in the Department of Computer Science at Federal Polytechnic Ile Oluji. We provided a detailed breakdown of how the exploration phase works. EDSOA explored a wide range of candidate profiles, considering various admission criteria such as O'Level credit passes, relevant subjects, and IT program evidence. Subsequently, in the exploitation phase, EDSOA evaluated the fitness of each candidate profile based on predefined admission criteria and selected the most promising candidates for admission. The application of EDSOA to the admission criteria specified for ND and HND applicants demonstrated its effectiveness in systematically optimizing the admission process while ensuring the selection of candidates who best fit the academic and institutional requirements of the Department of Computer Science at Federal Polytechnic Ile Oluji. By incorporating mathematical models to represent each step of the algorithm, we provided a systematic framework for implementing EDSOA in practice. Overall, EDSOA offers a promising solution to the challenges faced in the admission process, providing a fair, efficient, and transparent approach to selecting candidates who demonstrate both academic proficiency and practical competence. We believe that the implementation of EDSOA will significantly enhance the admission process at Federal Polytechnic Ile Oluji and serve as a valuable tool for educational institutions facing similar challenges.

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