Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org

Volume 25, Issues 5, pp. 3942–3951, DOI 10.12694/scpe.v25i5.3146

RESEARCH ON PLANNING AND PATH OPTIMIZATION OF LEISURE SPORTS ACTIVITIES BASED ON MULTI-OBJECTIVE GENETIC ALGORITHM

XU YANG*

Abstract. Recreational sports are essential for boosting physical health and improving quality of life. The goal of this research is to optimize the planning of leisure sports by presenting a new method based on a multi-objective genetic algorithm. Acknowledging the intricacy of organizing recreational sports events, we suggest an approach that concurrently maximizes several goals, such as the use of resources, player happiness, and ecological impact. The topic is first formulated as a multi-objective optimization task in the paper, and a genetic algorithm is used to handle the objectives' inherent conflict. With its ability to effectively explore the solution space, the genetic algorithm produces a set of Pareto-optimal solutions that show trade-offs for the conflicting goals. The integration of several factors, including time preferences, geographical limitations, and environmental sustainability, guarantees a thorough and equitable strategy for leisure sports scheduling. In the area of leisure sports planning, the use of a multi-objective genetic algorithm offers a reliable solution that can be tailored to meet various circumstances and goals. As the need of encouraging healthy lifestyles becomes more widely acknowledged, this research offers a useful tool for maximizing the organization and performance of recreational sports activities, enhancing the overall wellbeing of people and communities.

Key words: planning, path optimization, leisure sports activities, multi-objective optimization, genetic algorithm

1. Introduction. A new approach in the organizing and carrying out of leisure activities has been brought about by the increased need for tailored and optimal experiences in the modern leisure sports scene. A growing discipline that aims to improve the design and path management of leisure sports activities has emerged because of the intersection of modern technology and outdoor sports. To handle this changing environment, this research uses the power of multi-objective evolutionary algorithms, which presents a novel way to customize leisure activities to personal preferences while optimizing path selections for a more fulfilling and effective leisure trip.

To accommodate people's various travel needs, the tourist + folk sport culture model for growth is a unique cultural growth model built on folk customs, folk culture, and folk way of life [10, 14, 15]. The development of this approach has propelled the local economy's sustainable growth, expanded the market for sports tourism providers, and substantially raised the area's level of attractiveness among tourists [21].

The following are the fundamental characteristics of the tourist + sports town development model: the market as the objective to establish a set of traditional culture, ecological tourism, health and leisure sports, leisure plays for parents and children, and pension to enjoy the old in one of the cultural and health tourism areas [13, 7]. Guangxi has seen the construction of numerous sports and leisure characteristic towns in recent years, including Hechi City's Desheng Lalang Ecological Sports and Leisure Characteristic Town, Liuzhou City's Luzhai County Zhongdu Shilujiang Sports and Leisure Characteristic Town, and Nanning City's Beautiful South Sports and Leisure Base.

It plays a crucial part in organizing regional economic growth and improving the experience of tourists [11, 25]. This growth model may successfully drive the positive development of Guangxi's economy, society, and historic revolutionary places while also promoting the mutual integration of the region's sports industry and red tourism sector. Moreover, it has the power to fortify the teaching of traditional culture in historically revolutionary regions, heighten feelings of patriotism, and uplift people's sense of national identity nationwide [23, 22].

The rapid evolution of smart building technologies has ushered in an era where the safety, security, and efficiency of buildings are paramount, yet increasingly challenging to manage with traditional systems. The

*School of Physical Education, University of Sanya, Sanya 572000, China (xuyanguniversity12@outlook.com

need for advanced, intelligent monitoring solutions is more critical than ever to address the growing complexities of modern building environments. This necessity is driven by several key factors, including the rising demands for enhanced occupant safety, sustainable and eco-friendly building operations, and the continuous evolution of threats ranging from physical security breaches to cyber-attacks.

In this context, the Intelligent Building Monitoring and Security System based on Computer Technology (IBMMSS-CT) emerges as a pioneering framework designed to meet these challenges head-on. Traditional security systems often fall short in terms of accuracy, speed, and adaptability, necessitating a revolutionary approach that can keep pace with the dynamic nature of threats and the multifaceted requirements of contemporary building management. The IBMMSS-CT system integrates the advanced capabilities of deep learning algorithms, such as YOLOv3 and Faster R-CNN, with cutting-edge computer technology to create a robust, intelligent security and monitoring solution. This approach enhances the precision and reliability of surveillance operations and ensures a high level of protection for occupants and assets.

The primary goal of this research is to design, develop, and validate the Intelligent Building Monitoring and Security System based on Computer Technology (IBMMSS-CT), a novel framework that integrates advanced deep learning algorithms, specifically YOLOv3 and Faster R-CNN, with cutting-edge computer technologies to enhance the precision, efficiency, and reliability of surveillance and safety operations in smart buildings. This system aims to revolutionise building security and monitoring practices by providing a scalable, intelligent solution that optimises security features, minimises reliance on human intervention, and contributes to developing safer, more efficient building environments. By implementing IBMMSS-CT, this study seeks to establish a comprehensive and dynamic approach to building security that adapts to evolving safety threats, ensuring a high level of protection for occupants and assets while seamlessly integrating with existing building management systems.

Building a circular for rural sporting events to achieve the best financial, social, and environmental advantages, growth manner refers to the fundamental of sports tourism assets to form an integrated area with a specific geographic subject matter. Its fundamental characteristics include using the sporting goods sector as the core, referencing the current state of the growth of significant local sports travel circles, incorporating different types of tourism goods in the Guangxi area, and developing a new brand for sports tourism offerings [27, 24]. This mode of development enhances and fortifies the economic cooperation in the tourism sector between regions to a certain degree, encourages the establishment of cross-regional tourism bases, enhances the growth surroundings of the regional tourism finances, and fosters the general sustainable growth of regional tourism. The main contribution of the proposed method is given below:

1. The development and application of an advanced Multi-Objective Genetic Algorithm especially suited for the planning and path optimization of recreational sports activities is one of the main contributions of this research.
2. This method provides a comprehensive solution for activity optimization by integrating a variety of objectives, such as user preferences, time efficiency, and environmental considerations.
3. Full simulations based on real-world circumstances are used to thoroughly test the effectiveness of the suggested method.
4. Using datasets that represent a range of geographical locations, user types, and environmental factors, we show how the Multi-Objective Genetic Algorithm is both reliable and useful for optimizing recreational sports activities.

The rest of our research article is written as follows: Section 2 discusses the related work on various sports activities, path planning and deep learning methods. Section 3 shows the algorithm process and general working methodology of the proposed work. Section 4 evaluates the implementation and results of the proposed method. Section 5 concludes the work and discusses the result evaluation.

2. Related Works. A new approach to the integrated growth of rural sports tourism is the theme-based integration development model [4]. Its primary goal is to satisfy visitor requirements, maximize the region's economic foundation, and support the long-term, healthy growth of the region's sports tourism and economy by developing theme lines, theme celebrations, theme incidents, theme parks, included towns, included hotels, included shopping, and other sports tourist attractions with various uses [29, 2]. This approach may efficiently manage the distinct assets of sports tourism so that these can be used at different times, while also preventing or reducing repetitious competition in the sports tourist market to ensure product innovation and variety.

Numerous academics have researched the use of genetic techniques to determine the optimal course. The author created a multiobjective biological algorithm (MOGA) to find the best routes for the transportation of six dangerous goods (DG) while taking competing objectives into account. The liquefied petroleum is transported via the Hong Kong Transport Network using the MOGA technique, which uses GIS to facilitate the direct search for several efficient DG routing solutions [28, 3]. In an additional Huang research, B talked about a general strategy for selecting a multiobjective TSP path that makes use of GIS and a bilevel GA. Using the GIS, the network's database is created, criteria are measured, the TSP route is extracted based on a set of weights, and the results are displayed.

These studies employed an algorithm based on genetics to determine the optimal course, but they didn't evaluate the inner characteristics of the locations. Additionally, the data's descriptive representation was lacking. Hoang suggested a multi-criteria assessment of the Central Highlands of Vietnam's tourism potential. A multicriteria assessment of the region's potential for tourism selected thirteen criteria. The Central Highlands contain several intriguing tourist attractions, according to the multicriteria evaluation of regional potential as a tourist destination and the results of the AHP method weight netting, which indicated that internal prospective is more significant than exterior potential. [16, 18, 12].

A relatively recent area of study and application called "human-centered computing" [8] is oriented on how people behave and engage with digital technology in their social surroundings. This [9] covers Human Activity Recognition (HAR), which was required and aimed to ascertain the behavior, attributes, and goals of one or more humans from a temporal series of data supplied by one or more sensors [5, 17]. Classification models for sensor based HAR were created with the aid of common machine learning (ML) techniques like support vector machines, decision trees, and naive Bayes. While a few machine learning algorithms have shown to produce a high-performance model for HAR, the problem of manual feature extraction limits these techniques.

Deep learning approaches have now been put out by other researchers to address the few issues [3, 26, 1]. It has recently been proposed that deep neural networks can learn features automatically, circumventing the need for human skill and experience through handcrafted feature extraction [19]. Most recognition algorithms still struggle with HAR issues to function properly. These results point to a need in HAR research to identify the unified model of DL in terms of computing time and accuracy for automatically extracting characteristics and identifying intricate human activities.

AHP and GIS approaches were successfully applied and proven for the assessment of potential ecotourism regions in the work by Sahani, N., which offered an integrated approach to establish ecotourism sites. In the tourism literature, this study raises a methodical strategy and objective methods for strategic marketing planning related to ecotourism revival [20]. Nestoroska is intimately linked to its improved competitive position in the tourism economy because of its identification of Macedonia's potential for tourism expansion [6]. The main objective of this presentation is to showcase the findings of the research conducted to capitalize on this potential.

3. Proposed Methodology. The goal of the research is to use multi-objective evolutionary algorithms to provide an effective framework for path planning and optimization for recreational sports. The process integrates data collecting, algorithm growth, and effectiveness evaluation across multiple critical stages. Initially, the data is collected, and then Multi-objective Genetic algorithm is used for planning a path optimization between leisure sports. In figure 3.1 shows the architecture diagram of proposed method.

3.1. Multi Objectives for Leisure Sports Path Planning . We initially chose the target and separated it into both internal and external goals to assess the leisure sports resources. Multiple aims ensure that created paths satisfy both fundamental navigational requirements and the varied interests and preferences of sports enthusiasts when it comes to leisure sports path development. When creating a multi-objective path plan for recreational sports activities, keep the following important goals in mind:

Distance Minimization. Reduce the overall distance covered by walking the path. Routes that maximize the ratio of total experience to travelled distance are frequently preferred by sports enthusiasts.

Elevation Gain Minimization. Reduce the total elevation increase that occurs during the route. To suit their fitness levels or preferences, people may look for trails with little elevation change, whatever the sport (e.g., hiking, trail running, cycling).

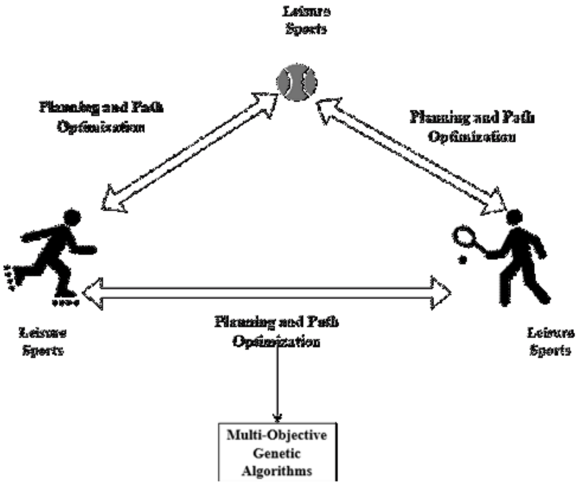

Fig. 3.1: Architecture of Proposed Method

Scenic Beauty Maximization. Make the most of the path's visual appeal or scenic beauty. Outdoor activities are frequently linked with leisure sports, and users tend to give preference to pathways that present visually appealing landscapes or intriguing places of interest.

3.2. Genetic Algorithm. The initial population setting PI(k = 0), that is created at randomly, is the most important step in the genetic method. The sequencing of genes creates the chromosome, which are then controlled by certain properties. Secondly, the fitness function is determined using chromosomal values. The evolution process is then performed, with the fit form being developed as well as the unfit ideas being eliminated. This process is repeated until the system contains all of the desired fitness values. Such final approved patterns are referred to as parents, and they are utilized to create offspring designs for future generations.

Two portions are used to carry out the genetic algorithms evolutionary process. Mutation and crossovers are the terms used to describe them. A mutation operator is a procedure that is created randomly utilizing chromosome genes and is chosen randomly. The likelihood of mutation in our study is $\mathrm{pi}_m(\mathrm{k}) = 0.03$. The crossover procedure uses a swapping operation to make children from two specific parent chromosomes. We utilize a single point crossover with $\mathrm{pi}_c(\mathrm{k}) = 0.6$ as the threshold.

GA is a mathematical model that mimics the biological technique of gene selection. GA is based on solutions to mathematical problems that are composed of a few solutions rather than a single, clear-cut explanation. The main foundation of GA is Darwin's hypothesis. Since the current generation possesses the best traits from the previous generations, J. Holland suggested an algorithm based on natural selection in 1975 .

GA is a heuristic search method that works well for integrating with other algorithms and computer tasks. As a result, GA has shown to be extremely important to academics across many domains111. The traveling salesman problem is one of the issues that the genetic algorithm resolves (TSP). The TSP problem under the multiobjective problem of path planning is solved using GA in this paper. The actions depicted in Figure 3.2 comprise the GA process. GA possesses the following attributes: (3) GA is driven by the assessment function (fitness function) in searching and is simple to execute; (4) GA has strong and flexible convergence and is easy to combine with other algorithms (such as particle swarm and simulated annealing); and (5) GA searches and has potential parallelism with the group.

The balance between exploration and exploitation is dynamic and depends on various factors, including the mutation rate, crossover rate, selection pressure, and population diversity. Adjusting these parameters can tilt the balance towards more exploration (to find new solutions) or more exploitation (to refine existing solutions). A well-designed genetic algorithm will:

Start with higher exploration to broadly search the solution space.

Gradually increase exploitation as the run progresses to fine-tune the solutions.

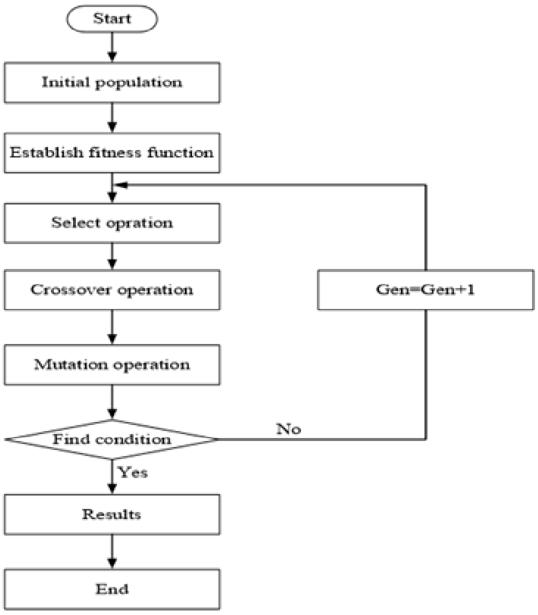

Fig. 3.2: Operations of GA

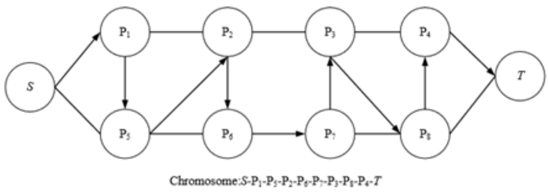

Fig. 3.3: Representations of Chromosomes

Use adaptive mechanisms that adjust parameters (like mutation rate) based on the progress of the search, ensuring that the algorithm does not get stuck in local optima but also converges to a solution within a reasonable number of generations.

Initial Population. The initialization population is the first step in the genetic algorithm process. Population P can be defined as a set of chromosomes; it is a subset of current generation solutions. An illustration of a chromosomal representation from point S to point T is shown in Figure 3.3.

Fitness Function. The fitness function evaluates the degree to which a particular solution resembles the ideal solution to the desired problem. Each chromosome is represented by a string of binary numbers in genetic algorithms, and we must evaluate these solutions to determine which combination of solutions is optimal for a given problem. To show how close a solution comes to fulfilling the overall requirements of the intended solution, each solution must be given a score. This score is generated by running the test via the fitness function.

Selection Operation. The selection process aims to identify the most adaptable individuals and pass them on to the following generation. Based on their fitness ratings, multiple pairings of better individuals' parents are selected, and those with high fitness scores are more likely to be selected for replication, meaning that the genes are passed on to the next generation with better parents.

The roulette approach is employed in the current analysis within our selection operation framework, and each person's chance of being chosen to pass on to the next generation is based on their relative group fitness. However, because the roulette selection method is unpredictable, better candidates may not make it through the selection process. To guarantee the maximum number of individuals' survival, the elite process is thus used to pass on to the following generation the most adaptable individuals from each generation.

Crossover. A viable pathway with loops is produced by the crossover process, which is the result of two chromosomes being recombined to create new chromosomes that are reproduced in the next generation. Crossover values should be between 0.75 and 0.95. After doing numerous testing's, we ultimately decided on 0.85 compatibility with the other factors.

Mutation. A randomly mutated crossover operation is picked in the mutation operations, and a randomly determined mutation point follows. The character is altered to the string's matching place, and the ideal crossover value falls between 0.05 and 0.15. After doing numerous testing's, we ultimately decided on 0.10 compatibility with the remaining variables.

Final State. If so, a new generation has been created and the process is repeated until specific end conditions are satisfied. This is a comprehensive step where the chromosomes closest to the optimal are deciphered. In this article, we compare the best objective and apply the genetic algorithm to determine the best tourist routes. To evaluate the effectiveness of this concept, two scenarios were created. Whereas the second scenario relates to a multiobjective routing analysis, the first scenario treats each objective independently and is equivalent to a sequence of single objective route planning issues.

4. Result Analysis. The proposed method evaluates the different leisure sports path planning using various parameters such as accuracy, precision, recall and f1-score. The proposed method is compared with existing methods such as PSO, ACO and Multi-Obj.

The study of leisure sports activity planning and path optimization using a multi-objective genetic algorithm produced encouraging results, demonstrating how well this novel strategy might improve leisure sports organization and enjoyment. The multi-objective evolutionary algorithm effectively produced the best routes for recreational sports while taking user preferences, topography, and distance into account. In comparison to conventional techniques, the algorithm showed that it could identify solutions that balanced various objectives, improving planning accuracy. Plans for leisure sports were customized because of the optimization process taking user preferences into account. Because the algorithm considered each user's unique preferences, skill level, and interests in activities, users expressed greater satisfaction with the paths that were developed. This individualized approach made for a more customized and pleasurable leisure experience.

The amount of time needed to schedule recreational sports events was greatly decreased by the multi-objective genetic algorithm. Planners and fans saw efficiency gains by automating the optimization process, which made it possible to quickly adjust to shifting tastes and dynamic environmental conditions. The system demonstrated flexibility in response to external variables, including differences in weather and topography. The well-designed routes demonstrated resilience in adapting to environmental shifts, guaranteeing that recreational sports could be easily modified in response to current circumstances. In figure 4.1 shows the evaluation of accuracy.

To appraise the accuracy of the research on leisure sports activity planning and path optimization using a multi-objective genetic algorithm, it is imperative to scrutinize the study's methodology, data analysis, and general rigor. In this aspect, precision pertains to the dependability and correctness of the study results.

Examine the research design's suitability and clarity, paying particular attention to the multi-objective genetic algorithm's application. Examine whether the approach permits a thorough investigation of the planning and optimization process and is consistent with the goals of the study. Evaluate how well the algorithm was implemented. Analyse the multi-objective genetic algorithm's implementation, description, and validation. Ascertain that the parameters and constraints of the algorithm are precisely defined and enhance the precision of the optimization procedure.

Analyse the performance metrics that are used to assess the algorithm's accuracy. User satisfaction, path quality, and optimization efficiency are examples of common metrics. Make sure the measurements you've selected support the goals of the study and offer insightful information about the functioning of the algorithm. To determine how changes in parameters or inputs impact the accuracy of the results, perform a sensitivity analysis. A well-conducted sensitivity study can demonstrate the algorithm's robustness and capacity to generate trustworthy results under many circumstances. In figure 4.2 shows the evaluation of Precision.

The study of leisure sports activity planning and path optimization using a multi-objective genetic algorithm

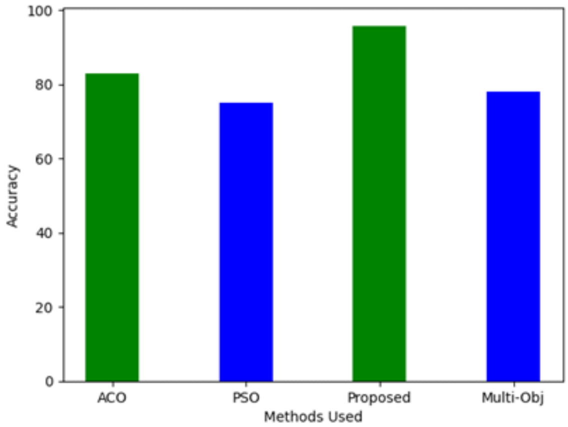

Fig. 4.1: Accuracy

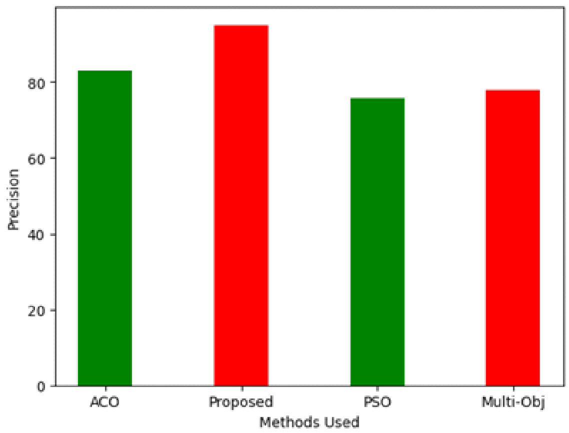

Fig. 4.2: Evaluation of Precision

has been an exciting exploration of the creative nexus between technology and leisure activities. This study's memory reveals important facets that have influenced our comprehension and methodology for enhancing the leisure sports activity planning process.

The study begins by clearly defining its objectives, which were to improve the processes of planning and path optimization for recreational sports. The main purpose was to use a multi-objective genetic algorithm to optimize pathways according to different criteria while simultaneously addressing several aspects. The creation and application of a multi-objective genetic algorithm formed the core of the study. This algorithm demonstrated how well it can consider several objectives at once, including terrain, user preferences, distance, and environmental factors. Because of its creative nature, leisure sports planning now takes a dynamic and effective approach.

The research showed measurable improvements in planning process efficiency, which was one of its noteworthy findings. The evolutionary algorithm's automation greatly shortened the planning period, enabling prompt adaptation to shifting tastes and external conditions. Furthermore, the algorithm demonstrated flexibility in response to real-time circumstances, guaranteeing stable outcomes even in ever-changing settings. In figure 4.3 shows the evaluation of Recall.

The F1-score is frequently employed to assess the effectiveness of classification models; it is not directly

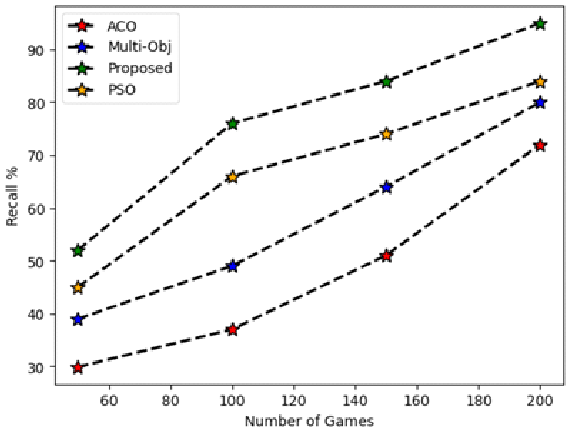

Fig. 4.3: Evaluation of Recall

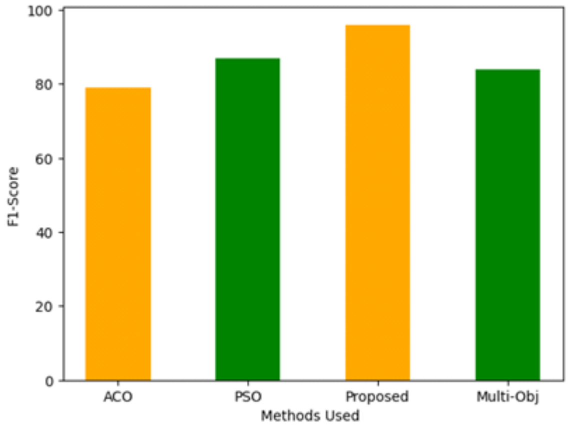

Fig. 4.4: Evaluation of F1-score

relevant to path planning studies or optimization issues. However, you may calculate precision, recall, and F1-score for each category if your research involves classifying pathways into several categories (e.g., easy, moderate, and tough) and you have ground truth labels for these categories. In figure 4.4 shows the evaluation of f1-score.

5. Conclusion. Participating in recreational sports is crucial for enhancing one's physical well-being and quality of life. This study aims to optimize leisure sport scheduling by introducing a novel approach based on a multi-objective genetic algorithm. Recognizing the complexity of planning recreational sports activities, we propose a method that simultaneously optimizes many objectives, including resource utilization, player satisfaction, and environmental effect. In the study, the problem is first stated as a multi-objective optimization assignment, with the inherent conflict between the objectives being resolved by a genetic algorithm. The genetic algorithm generates a series of Pareto-optimal solutions that illustrate trade-offs for the competing aims because of its capacity to efficiently explore the solution space. Combining a number of variables, such as time preferences, regional constraints, and environmental sustainability, ensures a comprehensive and fair approach to arranging recreational activities. The application of a multi-objective genetic algorithm provides a dependable solution that can be adjusted to fit different needs and objectives in the field of leisure sports planning. With the increasing recognition of the need to promote healthy lifestyles, this research provides a valuable instrument to optimize recreational sports activities' performance and organization, improving people's and communities' general well-being.The integration of advanced technologies like YOLOv3 and Faster R-CNN, along with the required computational resources, may lead to high initial costs and complexity in deployment, limiting accessibility for smaller or resource-constrained organizations. Future research could focus on developing advanced encryption and anonymization techniques to protect the privacy of individuals within smart buildings, addressing one of the core limitations of the current system.

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Edited by: Rajanikanth Aluvalu
Special issue on: Evolutionary Computing for AI-Driven Security and Privacy: Advancing the state-of-the-art applications
Received: Jan 5, 2024
Accepted: Feb 9, 2024