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# Visualization and Interaction Model of Outdoor Landscape Design Based on Virtual Reality Technology using Optimized Sparse Spectra Graph Convolutional Neural Network



**Abstract:** - The artistic thought of traditional garden landscape design has significant effect on garden art, architectural theory, gardening theory are also inextricably linked. In modern gardens, traditional architecture lacks applicability to construction of garden painting environment. In this Manuscript, Visualization and Interaction Model of Outdoor Landscape Design Based on Virtual Reality Technology using Optimized Sparse Spectra is Graph Convolutional Neural Network is proposed (VIM-OLD-VRT-SSGCNN). Initially the data is collected from Arcbazer.com data. Afterwards sparse spectra graph convolutional neural network (SSGCNN) is used to design the Outdoor Landscape. In Generally, SSGCNN doesn't expose some adoption of optimization systems for calculating optimal parameters for exactly design the Outdoor Landscape. Hence, Piranha Foraging optimization Algorithm (PFOA) is proposed to optimize SSGCNN which precisely design Outdoor Landscape. Finally Visualization and Interaction Model of Outdoor Landscape Designed. The proposed VIM-OLD-VRT-SSGCNN method is implemented python and performance metrics likes accuracy, precision, F1-score, sensitivity, specificity, computational time, RoC are evaluated. The performance of VIM-OLD-VRT-SSGCNN method provides 18.31%, 20.72%, 21.67% greater accuracy, 17.83%, 18.42%, 20.38% greater precision and 21.75%, 22.36%, 23.59% greater computational time while compared with existing techniques like Utilizing Deep Learning to Generate Font with Backyards in Landscape Architecture (UDL-GFB-LA), Urban Landscape Design Depend on Data Fusion with Computer Virtual Reality Technology (ULD-DF-CVRT), perception of urban sounds cape and landscape utilizing different visual environment reproduction techniques in virtual reality (PUSL-DVER-VR) respectively.

**Keywords:** Computer Vision Technology, Database Management System, Generative Adversarial Networks, Piranha Foraging Optimization Algorithm, SSGCNN.

## I. INTRODUCTION

The AI has drawn the attention of many design disciplines in recent years. Research on DL systems to produce innovative floor plans or provide answers to other design problems are just a few examples of how AI is being used in design discussions. Our study investigates the potential of artificial neural networks (ANN) to generate small-scale residential front and backyard landscaping designs [1-3]. Using a big dataset of design photos, they readable by machines them and developed a workflow that uses simple sketches to predict multiple landscape layouts. Landscape architecture handles complex environmental challenges and works at many sizes. Smaller home landscape projects may teach us about fundamental and essential aspects of design, even when there are differences at different scales [4-6]. The actual situations supplied by the school-business joint venture act as foundation for production of virtual scenes for VR training instruction, with a focus on the fusion of virtual and real situations. It takes interaction and good experience to create virtual scenes. In order to address the issues in landscape design today, Wu tackles the challenge of the smart landscape by fusing cutting-edge technology, landscape teaching construction education reform mode, and digital landscape design with science, technology [7-9]. In addition to serving as an analytical framework for flat architecture art, this representational classical painting theory also serves as a positive reference, guiding meaning for 3D garden art. Based on this, the system for virtual reality and its different functions chosen by the research team are looked at, VR that fulfils requirements for development of garden landscape project is examined [10-12]. The 3D garden landscape virtual setting is ultimately selected by work flow. The construction of garden landscape at rail transit exit is engineered to develop ecological value, promote the interactivity of garden landscape, in keeping with the beautiful effect of virtual reality technology. Scholars that study modern gardens usually bring up the connection between architecture and gardens [13-15]. Gardens are complex pieces of art made up of many different parts, with each scene being similar to a different picture scrolling. Suggested that in order to properly plan residents' activity space, rural landscape design, designers should adopt a people-oriented approach as their primary design idea, depend on partnership, sustainable development [16-18]. These existing studies, goals were best addressed by GANs, which turned out to be most effective, efficient ANN. While there are numerous projects addressing innovative AI applications in architecture, there is not enough of study in this area when it comes to landscape architecture [19].

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In order to address our primary research question in this study, "Can they improve design tool from AI-created mechanism for residential landscape design?" they employed open-source data and software solutions [20]. These disadvantages of the existing methods motivate as do this work.

Major contribution of this paper includes,

- Visualization and Interaction Model of Outdoor Landscape Design Depend on VRT using Optimized Sparse Spectra Graph Convolutional Neural Network is proposed.
- They analysed whether sparse spectral graph convolutional neural network may improve the fields of landscape architecture, landscape planning, respective design processes in this work.
- Main focus of this method was to demonstrate an SSGCNN method for landscape architecture concept design development.
- They give an overview of our work, which involved building and evaluating garden layouts, and they make assumptions about how this method can assist landscape architects in creating their designs.

Remaining paper is arranged as below: part 2 designates literature review, part 3 designates proposed method, part 4 demonstrates outcome with discussion, part 5 conclusion.

## II. LITERATURE REVIEW

Amongst the several investigation works is design the Outdoor Landscape using deep learning most current research works were reviewed here.

SENEM et al. [21] have presented Utilizing DL to Generate Front and Backyards in LA. In this work discuss work on front- and backyard layout optimization with GANs in this publication. They are looking into several GAN engines that have been effectively applied in other design fields, such as DCGAN. They offer the finding works that is the development and evaluation of garden plans and make theories about how this methodology might assist landscape architects in creating their ideas. It provides higher accuracy but it provides lower precision.

Zhang et al. [22] have presented ULD depend on DF and CVRT. In this work, DF-CVRT were used to urban landscape design. Goal was to show that designing a more planned urban landscape can be achieved by utilizing the related guidance of virtual reality and data fusion technologies. This article makes use of a digital device for continuous digital photography and modelling with Sketch Up software. This method provides higher precision but it provides lower F1-score.

Jo and Jeon et al. [23] have presented perception of urban soundscape with landscape utilizing DVER techniques in VR. Here, order to compare the quality of the assessment methods, it also subjectively evaluated urban settings. As a means of visual reproduction, particular monitor, head-mounted display environments were used. This method provides higher recall but it provides lower specificity.

Zhang et al. [24] have presented VR design with realization of interactive garden landscape. They create virtual environment depend on historic city of Yangcheng and examine virtual landscape gardening system's implementation technique in this research. The experimental findings show the considerable improvement in drawing frame rate of 3D garden landscape vegetation scenes by little scene data, the viability of GPU-accelerated drawing technique depend on GLSL. It provides lower computational time but it provides lower accuracy.

Zhan et al. [25] have presented interactive application of VR with intellectual big data in landscape design. Here, landscape simulation design performance evaluation index data is analysed using the Clara algorithm. The data collected was used to create landscape simulation system's performance evaluation index system. A thorough evaluation model is constructed using the BP network. This method provides higher recall but it provides lower precision.

Wang et al. [26] have presented Design of Commercial Building Complex Depend on 3D Landscape Interaction. In this work examines, assesses the state of 3D landscape intersection in landscape design, looks into the possibility of 3D commercial building performance system used as template for large-scale urban commercial building landscape modelling in future, and makes some recommendations. This method provides lower recall but it provides lower specificity.

Yuan et al. [27] have presented Multimodal Interaction of MU Plant Landscape Design in Marine Urban Depend on CVT. Here, better meet people's necessities for leisure, viewing, entertaining, will examine design of marine urban botanical landscapes using CVT, multimodal interaction design theory. This method provides high Roc but it provides lower accuracy.

### III. PROPOSED METHODOLOGY

In this section, Visualization and Interaction Model of Outdoor Landscape Design Depend on VRT using Optimized Sparse Spectra Graph Convolutional Neural Network is discussed. Block diagram of VIM-OLD-VRT-SSGCNN approach is shown in Figure 1. Data acquisition, outdoor landscape Design and optimization of the three processes that make up this method. Consequently, a full explanation of each step is provided below.

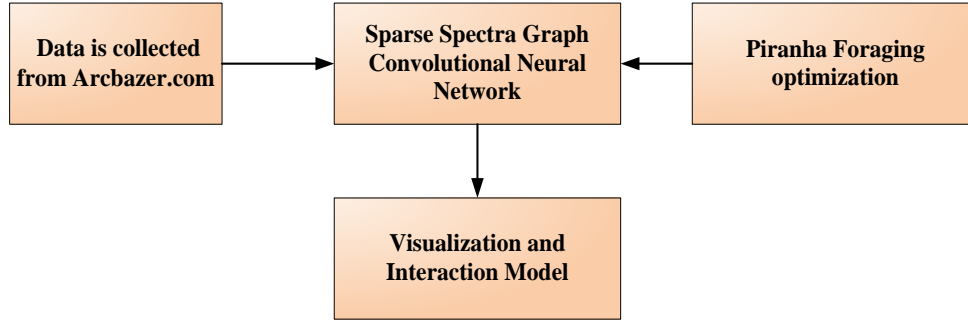


Figure 1: Block diagram of VIM-OLD-VRT-SSGCNN approach

#### A. Data Acquisition

The input images are gathered from extensive online repository, i.e., from Arcbazar.com, [28] online crowd sourcing platform for design projects. They selected data is completely completed garden plans from the DBMS. Users of the platform rated all projects according to functional and visual standards, with 1 being the worst and 10 being the greatest. They then chose the projects with scores of 5 and higher.

#### B. Outdoor Landscape Design using Sparse Spectra Graph Convolutional Neural Network

The SSGCNN [29] is used to Design Outdoor Landscape. A particular kind of discriminator known as SSGCNN penalizes structure at level of individual image patches in a SSGCNN. The discriminator, particularly for conditional images, is a using SSGCNN performs image categorization. Depend on the input of source, target image, it predicts likelihood that target image is correct translation of source image or misleading one. Input data image with data points is equal to the graph  $G$  with  $n$  nodes. Initially, they get the principal aggregate vector for every node along with its adjacent nodes via the vector's product it is given in equation (1)

$$h_{ui}^l = h_{ui}^{l-1} + \sum_{\{vi\}} h_{vi}^{l-1} \quad (1)$$

where,  $vi$  signifies  $i$  node of graph  $G$ ,  $ui$  signifies set of each neighbourhood nodes of  $vi$ ,  $k$  denotes the neighbour field coefficient,  $h$  denotes the duration and  $l-1$  denotes value of edge among data points. The vector  $h$  and adjacency matrix  $B$  are multiplied by  $k$  times in order to gather the node information is given in equation (2)

$$h^k = h^{k-1} \cdot B \quad (2)$$

where, value of  $h$  at  $k^{th}$  iteration is indicated by symbol  $h^k$ . Every node in the vector has the same relative location at the  $k^{th}$  time and  $A$  aggregation vector. After the convolution is finished, size of output vector matches the size of input vector. Afterward attaining node aggregation vector multiplied by all element of learnable parameter given in equation (3)

$$x^i = \sigma \left( \sum_{i=1}^n \omega_l^u \cdot o^{i+u+1} + a_l \right) \quad (3)$$

Where,  $\omega_l^u$  denotes convolution kernel parameter in  $l^{th}$  layer,  $a_l$  denotes bias in  $l^{th}$  layer,  $u$  denotes kernel size,  $x^i$  signifies auxiliary variable,  $i$  is indicator function,  $o$  is node range and  $\sigma(\cdot)$  denotes ReLU activation function is given in equation (4)

$$x^i = \max(x^{2i-1}, x^{2i}) \quad (4)$$

where,  $x^i$  is the auxiliary variable,  $x^{2i-1}$  is projection operator and  $x^{2i}$  is the optimal parameter. Here,  $x_i^j$  represents the output. Take in consideration that the model is optimized using the Adam optimizer, and the function. Then design the Outdoor Landscape images is given in equation (5)

$$f(z_{1:M}, y) = -\log \left( \frac{\exp^{xi^{fc}}}{\sum_{j=1}^d \exp^{xi^{fc}}} \right) \tag{5}$$

where,  $z_{1:M}$ , is projection operator,  $y$  is loss function,  $d$  is the positive parameter,  $j$  is diagonal sequence and  $xi^{fc}$  represents the output. Finally SSGCNN designed the outdoor landscape. Utilizing Piranha Foraging Optimization Algorithm (PFOA)for enhance SSGCNN weight parameter  $z_{1:M}$ , and  $y$ . Here, PFOA is used to turning the weight and SSGCNN bias parameters.

**C. Optimization of SSGCNN using Piranha Foraging Optimization Algorithm**

In this section, optimization of SSGCNN using PFOA [30] is discussed. The suggested steps for optimization are established, and Piranha Foraging optimization is offered. To ensure that all of the components, local specifics of design plan reached a commonality of perform, layout, complex real-time visual environment presentation technology can make it easier and more convenient to optimize the design structure, analyse the architectural landscape, and display the virtual architectural landscape.

**Step 1: Initialization phase**

The PFOA algorithm mainly consists of population initialization and evaluation, parameter and operator location updating. It proposes three patterns of limited group attack, furious cluster attack, scavenging foraging. Set of population candidate solutions in the PFOA algorithm can be written as follows

$$Y = \begin{bmatrix} y_{11} & y_{12} & y_{13} & \dots & y_{1D} \\ y_{21} & y_{22} & y_{23} & \dots & y_{2D} \\ & \dots & \dots & \dots & \\ y_{(n-1)1} & y_{(n-1)2} & y_{(n-1)3} & \dots & y_{(n-1)D} \\ y_{n1} & y_{n2} & y_{n3} & \dots & y_{nD} \end{bmatrix} \tag{6}$$

where,  $y$  are the Position vector representing piranhas,  $n$  denotes random number,  $D$  signifies local search capabilities.

**Step2: Random Generation**

Input parameters are made randomly. The best fitness value are selected depend on obvious hyper parameter condition.

**Step 3: Fitness function**

Initialized assessment's, random solution is produced. It is evaluated by values of parameter optimization for enhancing weight parameter of generator, thus given equation (7)

$$Fitness\ Function = optimizing [z_{1:M}, and y] \tag{7}$$

**Step 4: Localized Group Attack Pattern**

When hungry, this group-foraging monster assault prey that is several times larger than it. A splash of water images to the extremely perceptive piranha that prey has crossed into its domain. They rapidly gather around, bite the prey in succession, with agent closest to victim going first. Mathematical representation of the pattern of localized group attacks given in equation (8)

$$y_i(t+1) = \gamma_1 \sum_{k=1}^{pc} \frac{L_k(t) - y_i(t)}{pc} - y_{prey}(t) \tag{8}$$

where,  $y_i(t+1)$  ) denotes search agents' new location, a randomly generated integer is indicated by  $pc$ , the percentage of attacks on the local population is  $L_k(t)$ , the current agent's position is indicated by  $y_i(t)$ , position of best agent discovered in preceding iteration is indicated by  $y_{prey}(t)$  and the random integer  $\gamma_1$ .

**Step 5: Exploration Phase**

Due to their unique taste and strong sense of smell, piranhas are drawn to areas with large concentrations of blood when prey is injured or bleeding, which causes them to attack more forcefully. The greater the blood concentration, quicker it swims. Blood concentration  $F_i$ , distance  $d_i$  among piranhas, their prey, non-linear

cosine component  $S$  is regulated by  $E$  are all very important in this stage. Piranhas effectively avoid local optima, locate better prey by changing the direction of their movement is given in equation (9)

$$y_i(t+1) = \gamma_1 * d^{\gamma_2} * y_{prey}(t) + G * y_{prey}(t) * E * F_i + E * \beta_4 * S * F_i \tag{9}$$

where,  $y_i(t+1)$  signifies search agents' novel location,  $y_{prey}(t)$  and the random integer  $\gamma_1$ , and is  $d^{\gamma_2}$  uniformly distributed random number at  $[-1/2, 1/2]$  and random integer between 0 and 1 is shown by  $\beta_4$ .  $G$  is the piranha foraging ability coefficient, expressed as an integer such that  $G > 5$ .

**Step 6:** Exploitation phase

Due to their poor vision, piranhas separate from group when foraging in unclear basins, at night, swim irregularly as individuals throughout their habitat, eating on seeds and carrion is given in equation (10)

$$y_{i(t+1)} = \frac{1}{2} [e^{\gamma_2} * y_{c_1}(t) - E * y_i(t)] \tag{10}$$

where,  $E$  denotes parameter that modifies direction of movement,  $e^{\gamma_2}$  signifies random number uniformly distributed at  $[-1, 1]$ ,  $y_i(t)$  signifies  $i^{th}$  agent location randomly selected from agents,  $y_{c_1}(t)$  indicates  $c_1$  agent location randomly selected from Piranhas,  $C_1 \neq i$ ,  $y_{i(t+1)}$  signifies novel position of search agent and Figure 2 shows flowchart of PFOA for optimizing SSGCNN.

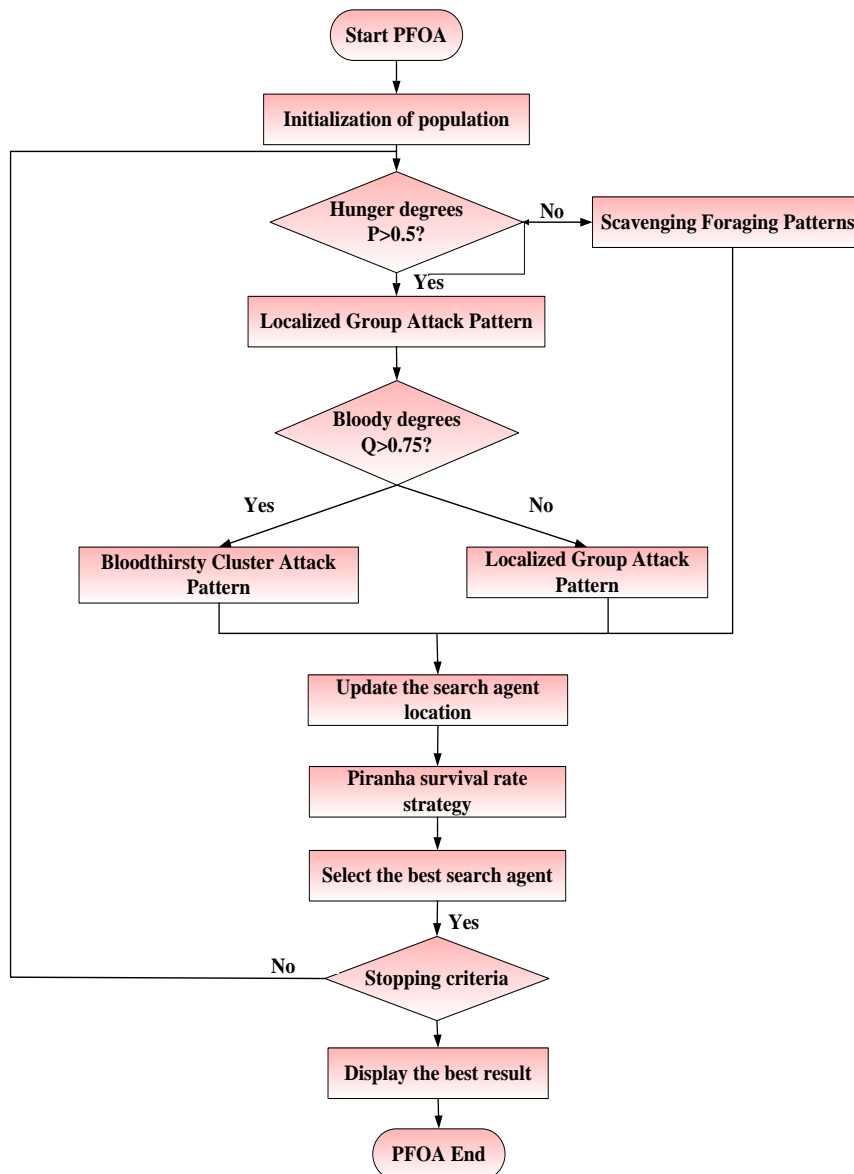


Figure 2: Flow chart for PFOA for optimizing SSGCNN

**Step 7: Termination**

Finally, the weight parameter values are optimized ( $z_{1:M}$ , and  $y$ ) from SSGCNN is enhanced by utilizing PFOA; it repeat step 3 until it attains halting conditions  $Y = Y + 1$  is satisfied. The SSGCNN Visualization and Interaction Model of Outdoor Landscape Design effectively.

**IV. RESULT WITH DISCUSSION**

The result of VIM-OLD-VRT-SSGCNN method is discussed. The proposed VIM-OLD-VRT-SSGCNN method is simulated in python. The performance of the proposed VIM-OLD-VRT-SSGCNN method is evaluated under some metrics such as accuracy, precision, F1-score, sensitivity, specificity, computational time, RoC. Obtained outcomes of technique are analysed with existing techniques likes UDL-GFB-LA, ULD-DF-CVRT and PUSL-DVER-VR.

**A. Performance Measures**

A few parameters are utilized to run tests and assess system performance. Performance indicators such as accuracy, precision, F1-score, sensitivity, specificity, computational time, RoC are studied. Scale performance metrics, confusion matrix is deemed. Measure confusion matrix likes True Negative, True positive, False Negative, False positive values are needed.

**1) Accuracy**

It is a metric that measures overall correctness of forecasts made by classification method. It defines ratio of exact forecasts to total instances.

$$Accuracy = \frac{TP + TN}{FN + TP + FP + TN} \quad (11)$$

Here,  $TP$  denotes true positive,  $TN$  signifies true negative,  $FN$  signifies false negatives,  $FP$  denotes false positive.

**2) Precision**

It is a metric that quantifies accuracy of positive forecasts made by classification method. It defines ratio of true positives to sum of true and false positives.

$$Precision = \frac{TP}{FP + TP} \quad (12)$$

**3) F1- Score**

It is known as F1-score. It is metric combines precision, recall to single value. It is mainly valuable in situations where you want to balance both false positive and false negative.

$$F1 - Score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \quad (13)$$

**4) Sensitivity**

It is well-known as true positive rate. It is metric quantifies ability of classification method to capture and properly detect each relevant instances of positive class.

$$Recall = \frac{TP}{FN + TP} \quad (14)$$

**5) Specificity**

Specificity can be quit divers and can represent relationships in physics, chemistry, biology, economics, and many other disciplines. It is utilized to measure the ability of classification method to properly detect negative instances.

$$Specificity = \frac{TN}{TN + FP} \quad (15)$$

**6) Computational time**

The computation time is very depending on the specific context, type of computation and the algorithm or method involved.

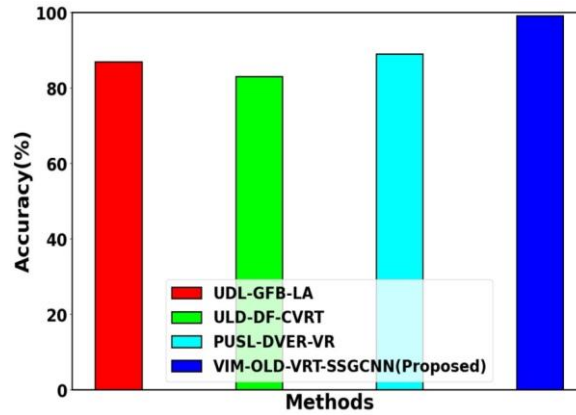
**7) RoC**

RoC is ratio of false negative to the true positive region, given in equation (16)

$$RoC = 0.5 \times \left( \frac{TP}{TP + FN} + \frac{TN}{TN + FP} \right) \tag{16}$$

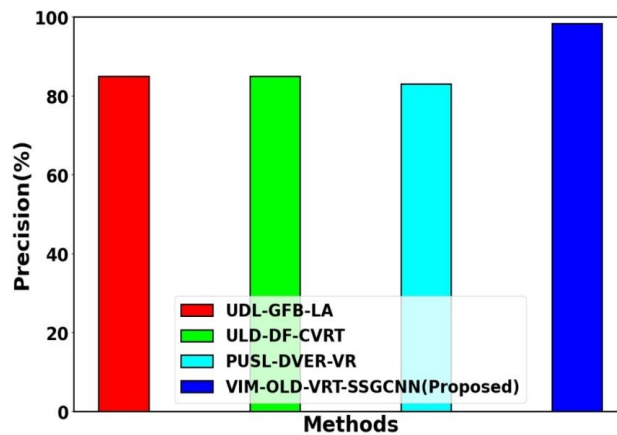
**B. Performance Analysis**

Figure 3 to 9 displays simulation results of VIM-OLD-VRT-SSGCNN technique. VIM-OLD-VRT-SSGCNN is analysed to the existing UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR respectively.



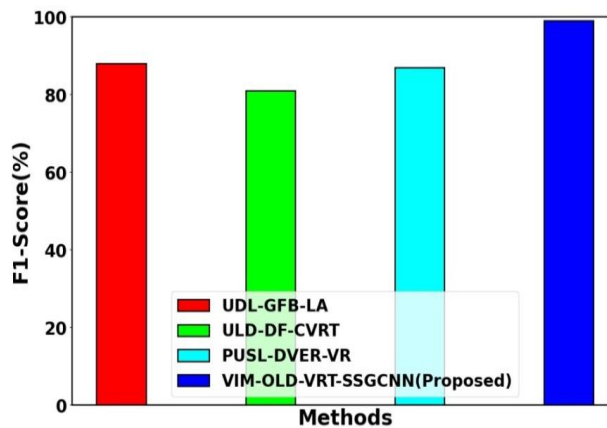
**Figure 3:** Accuracy analysis

Figure 3 shows accuracy analysis. The VIM-OLD-VRT-SSGCNN method attains 18.31%, 20.72%, 21.67% higher accuracy which analysed with existing UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR methods respectively.



**Figure 4:** Precision analysis

Figure 4 shows precision analysis. The VIM-OLD-VRT-SSGCNN method attains 17.83%, 18.42%, 20.38% higher precision which analysed with existing UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR methods respectively.



**Figure 5:** F1-Score analysis

Figure 5 shows F1-score analysis. The VIM-OLD-VRT-SSGCNN method attains 18.95%, 19.42%, 20.19% higher F1-score which analysed with existing GD-3DASDL-IST, GRADE-RR and POTS-LSD-LPT methods respectively.

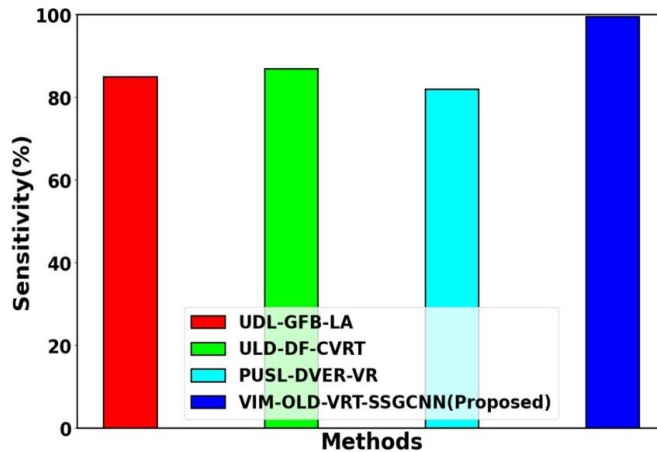


Figure 6: Sensitivity analysis

Figure 6 shows sensitivity analysis. The VIM-OLD-VRT-SSGCNN method attains 19.21%, 20.69%, 21.37% greater recall which analysed with existing UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR methods respectively.

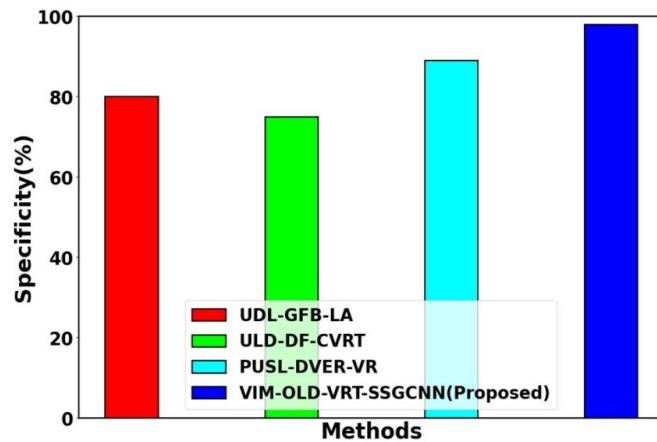


Figure 7: Specificity analysis

Figure 7 shows specificity analysis. The VIM-OLD-VRT-SSGCNN method attains 20.39%, 21.20%, 22.11% greater specificity which analysed with existing UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR methods.

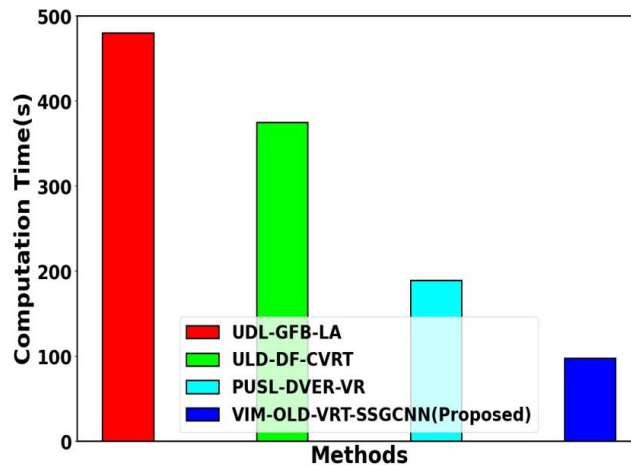


Figure 8: Computation time analysis



Figure 8 shows computation time analysis. The VIM-OLD-VRT-SSGCNN technique attains 21.75%, 22.36%, and 23.59% lesser computation time analysed with existing techniques likes UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR methods respectively.

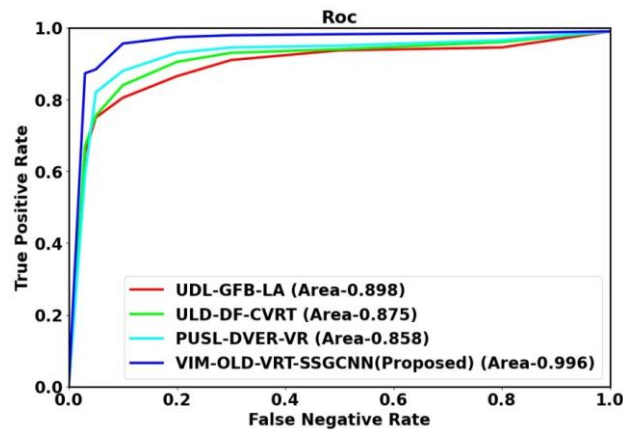


Figure 9: RoC analysis

Figure 9 displays RoC analysis. The VIM-OLD-VRT-SSGCNN method provides 23.34%, 24.67%, and 25.77% greater RoC analysed with existing techniques likes UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR methods respectively.

### C. Discussion

In this article, examined the use of VR to landscape architecture, with a focus on smaller-scale residential garden design. It looked at virtual reality potential and ability as a design tool. It is divided into two main sections. The first involves obtaining the dataset and preparing it so that the original information is readable by machines using DBMS of online design repository. This dataset is used in the second phase of the project to train Pix2Pix, which produces previously unheard-of residential garden designs. In fact, our model could produce backyard and front design ideas from a basic sketch. It also came across several restrictions. Developing all procedures and situations is the initial stage of the design process, and conceptual design is arguably the most crucial. In the future, we believe that this research can aid landscape architects in creating their conceptual design schemes and serve as a minor turning point in the application of the landscape architecture.

## V. CONCLUSION

In this section, Visualization and Interaction Model of Outdoor Landscape Design Based on Virtual Reality Technology using Optimized Sparse Spectra Graph Convolutional Neural Network (VIM-OLD-VRT-SSGCNN) is successfully implemented in python. Landscape architects are able to view the results of their designs and make continuous modifications and improvements by simply changing their points of observation inside the picture using the virtual reality system. Better design efficiency is possible with the use of the VR system in garden landscape design of rail transit exit. The VIM-OLD-VRT-SSGCNN method provides 18.95%, 19.42%, 20.19% greater F1-Score 19.21%, 20.69%, 21.37% greater sensitivity and 20.39%, 21.20%, 22.15% greater specificity when compared with existing methods such as UDL-GF-BLA, ULDB-DF-CVRT and PUSL-DVER-VR respectively.

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