Construction of a Real-time Communication Platform for Regional Printmaking Using Virtual Reality and Big Data Analysis for Engineering Education

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Abstract. Modern training techniques and improved education practises are critical for maintaining the attention of the millennial population and equipping them with cutting-edge technologies. Innovative concepts and efficient approaches are needed to instil the required competencies and educate skills for learning industrial environments. Visualization techniques, particularly Virtual Reality (VR), have been stressed in the newest Industry 4.0 paradigm to teach and training young pupils sustainably. A networking community's online communications study on printmaking based on neural training and evolutionary method was suggested in this paper to examine the characteristic extraction technique of printmaking prototype, design depending on deep learning. A regional printmaking system with big data analytics using Virtual Reality (RPMS-BDAVR) is proposed in this article. The study's findings revealed that both characteristic extraction strategies were efficient and stable. The evolutionary matrix tool has been used to retrieve the features of consumer desires evolutionary processes approach. The procedure was found to be practically based on the results of the experiments. It can be deduced that the viability of online communication studies of printmaking conception systems based on deep neural networks and innovativeness tactic was verified by combining arts and sciences creation while willing to sacrifice time spent using the method image classification tasks and interactive transformation tactic.

Keywords: printmaking, big data analytics, communication, engineering education, virtual reality
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1 INTRODUCTION TO PRINTMAKING

Having a computer version and a machine learning that can produce it with great precision, with minimal human participation, and promptly is quite intriguing. That concept has been realized in the building projects thanks to the advancement of 3D printers and shape crafting, which involves placing consecutive layers of concrete mixture material to create building features [27]. But there are still numerous obstacles to solve (such as scalability, portability, and material). The 3D printer has already aided building projects.

In the last decade or two, modern industrial systems' design and operation complexity has grown [2]. This is due to innovative and customised goods, resulting in complicated processes and controls. Due to their complexity, these structures are challenging to create, implement, and theoretically materialise. In reality, the current Industry 4.0 paradigm's technical advancements have raised the levels of importance with design, creation, deployment, performance appraisal, and so on. As a result, experienced engineers and highly competent operators are required for the design, management, and long-term operation of these modern production systems. As a result, academic institutions must concentrate on the creation and implementation of educational programmes that use cutting-edge teaching methods. Unusual yet appropriate training approaches are needed to provide students and trainees with the necessary information and abilities.

The academic community has put much work into the technical elements of printing in the building industry, but the issue of cybercrime has been overlooked. The application of printing in buildings introduces new hazards and weaknesses [14]. Studies are starting to address the cybersecurity issues and risks posed by the building company's digital revolution and assess construction workers' cyber susceptibility [9]. It has previously been proven that it is possible to get unwanted access to external devices. The radio transmissions used by crane controls, for instance, are not secured and quickly received and faked with off-the-shelf gear and a rudimentary understanding of circuits and wireless engineering [18].

2D planes have managed to replicate the expanding expectations of people in various sectors, like scenarios in videogames or movies, as time has progressed; 3D stereoscopic visuals are frequently required to replicate reality and generate realistic effects [12]. Since its inception, 3D modelling software has been based on 3D modelling technologies and has been used in various industries and settings. However, as physical civilization progresses, so does the goal of mental civilization; as a result, creative works have become increasingly popular [26].

This article proposes a novel, innovative mode integrating technical invention and inspirational production, based on printmaking study ensemble learning and innovativeness [16]. That is also a new type of study that combines deep learning with simulated annealing. Two keypoint extraction techniques for 3D models were enhanced and suggested various feature harvesting of 3D models, merged with the actual incident of this research: one was focused on enhancing the preview separation technique of deep trust system, and another was centred on the keypoint recovery technique of permutation fully automated encoder [15].

3D model characteristics, interactive assessment, and training evolutionary function matrix were developed to approximate assessment methodology [6]. It was utilized to imitate artificial assessment and evolve into an acceptable final model. The evolutionary method was employed several times during the procedure, and the evolving matrix product was utilized to evaluate and compare differentiated development, Gaussian variation, and uniform variability. Trials have found that the suggested online communications study is possible based on thorough printmaking.

The primary contributions to this article are as follows:

- The system architecture is proposed to printmaking and communication model using VR for engineering education.

- The fuzzy-based classification and optimization techniques help to performance of the system.
- The big data analytics module helps to reduce the overall system error at the output.

The remainder of the paper is as follows: section 2 illustrates the background to the printmaking models. The suggested regional printmaking system with big data analytics (RPMS-BDAVR) is designed and analyzed in section 3. Section 4 discusses the software analysis and performance evaluation of the proposed system. The conclusion and limitation of the suggested model are shown in section 5.

2 BACKGROUND TO THE PRINTMAKING MODELS

Shankar et al. devised a Model based on the notion of lateral inhibition, which substituted the usual sigmoid function with the max-out value (maximum outcome from every node) [20]. However, the dropout strategy was used to solve the fitting difficulties; the author's study showed that the methodology improved training efficiency and maintained an excellent accuracy rate. The depth concept of networking in the network (NIN) was suggested in the literature to upgrade the classic convolutional neural network (CNN) [11].

The batch normalization (BN) procedure, comparable to the z-score standardization method, was also proposed by academics like Adnanet al. [1]. It estimated the group set's average and variance at every iteration, then normalized the whole learning algorithm using the computed average scores and variances to standardize the complete training set. The BN operation set the average value of every layer to 0 and the variation to 1, ensuring that the variance of levels was equal, reducing the susceptibility of the convolutional model to the original amount of the load and training the current price of the training data to the maximum. Avvenuti et al. presented a dropout strategy to overcome deep neural network (DNN) fitting difficulties by giving up specific neurons at random (during the learning phase and all of their links) [3].

The "relatively thin" neuronal system was created when giving up a set of troops. It was simple to reach the cognitive load, dramatically increasing the retraining speed and generalization network capacity [24]. Earlier, the dropouts approach was also a norm in the CNN program's whole connection layer. Xueruiet al. developed a novel use for deep learning's long short-term memory (LSTM) method for predicting time series models [25]. They presented a novel way to assist investors in making informed judgments depending on several indicators like the inflation figures, the price-earnings ratio, and news stories. The article vectors model was employed to translate newspaper stories into vector representations of dispersed interpretations. Afterwards, the LSTM network learns the impacts of many firms' starting prices on prior events [22].

Most scientists have overcome some flaws in the classic back-propagation steepest descent technique, such as sluggish convergence speed and regional extremum, by increasing the number of the link layer. Chen et al. suggested the delta-bar-delta (DBD) method for these troubles [8]. The training data was also altered by changing the movement component, which primarily fixed the buzzing sound and vorticity troubles at the early stage of the conventional gradient descent method and significantly improved neural network learning effectiveness. The AdaGrad approach was developed by Sabour et al. for moving objects to adjust to variables of various dimensions [19]. The methodology was also based on the idea of Level 2 regularisation, accruing all the steepest descent quadratic totals of the variables; the method would collide as the training error contacted zero [13].

Many scholars have used deep learning to address prediction issues in numerous disciplines, like stock price prediction, behaviour prediction, positioning forecasting, and traffic forecasting, since it can successfully handle complicated problems [4]. Deep learning methods were the starting point for machine learning (neural networks). Scholars proposed neural network models at the start of artificial intelligence (AI)Development. Deep learning methods were a parallel software algorithmic paradigm [21]. The necessary computational properties were retrieved and then conveyed by computing the units associated with the neurons.

Convolutional neural network study has been consistently worked out and improved in the latest days. It was a prominent topic in deep learning research and a fundamental model in AI algorithms. The notion of deep learning became popular around 2009. According to an in-depth examination of computer learning methodologies, transfer learning is the most prevalent AI-powered model [23]. The machine learning routing algorithm was a machine learning method that mimics the computational model of human brain cells. It primarily handles information in a human-like manner. It was now primarily focused on development and practice in speech, picture, and text. Chadwick et al. used the ImageNet image identification competition using a deep convolutional neural network, which was more accurate than the support vector machine (SVM) [7].

Microsoft used deep learning to improve voice recognition and achieved excellent results, lowering the voice recognition failure rate by even more than 20%. Everyone was familiar with Google's AlphaGo, and it used a Go game tactic proven by transfer learning training the world's number one player. The world had witnessed artificial intelligence's immense strength, propelling the concept of machine learning to the pinnacle of AI study.

Clustering was an experimental method, and the data it produced was typically label-free. People do not understand the qualities and inner workings of gathering and keeping original information in the world of big data, which was peculiar [10]. It was also hard to tell if the data source contains grouping patterns or what kinds of data features and regulations it reflects. Even though the scientists were aware that the training dataset included clustering patterns based on domain expertise, they navigated a vast pairing space when choosing a clustering technique and establishing hyperparameters.

Training factories (TF) have recently been presented as a way to update the learning process and make training procedures more realistic. Similarly, VR is an effective tool for teaching difficult concepts to trainers and learners [17]. VR may be characterised as a sophisticated visualisation approach that is successful and helpful since it can simulate a genuine environment and accurately materialise the result. With the online realm provided by VR, engineers and operators may interact with factory setups, practise on them, and assess their performance more intuitively and completely. VR may substantially contribute to manufacturing education under the Industry 4.0 concept, which is supported by innovative technologies such as the Internet of Things and big data technology [5]. As a result, new teaching methods like TF and VR and the integration of information from other modular courses are required to improve the capacities and talents of young engineers.

In conclusion, the diverse study findings supplied significant experience and suggestions for the printmaking study using VR for engineering education, particularly for the manufacturing industry. It was feasible to build a classifier that combined past network development information to specify the required structural properties and visualization features. It might also help academics conduct more in-depth network activities and give rational decision-making support for disseminating industrial information in printmaking.

3 PROPOSED REGIONAL PRINTMAKING SYSTEM WITH BIG DATA ANALYTICS USING VR

The proposed regional printmaking system has been studied where students completed a product design assignment to learn about the mechanics of design using virtual reality. The working area, also known as a TLF, concentrates on manufacturing principles teaching, development, and experimentation.

The exercises, as mentioned above, would expose pupils to the complexity of industrial systems, and students can focus on working both in groups and on their own. A technique was developed to meet the aims and analyse the TLF, and it examined the theoretical model.

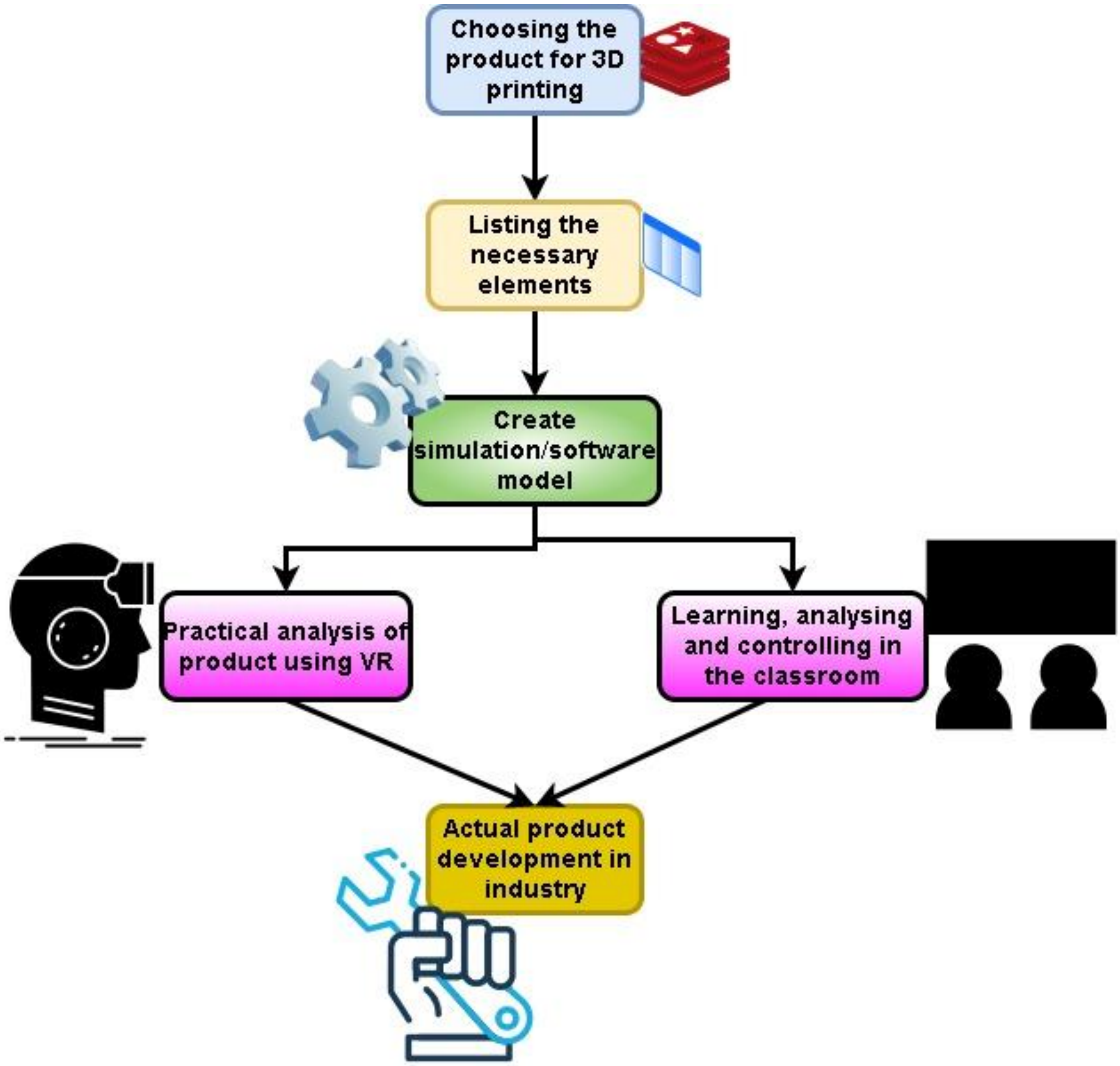

Figure 1: Illustration of the proposed RPMS-BDAVR model.

Figure 1 depicts a visual illustration of the proposed process. Two groups of 100 industrial engineering students participate in the 3D printing course in each academic session. The participants were divided into two groups for this project: practical (n = 50) and control/classroom (n = 50). The study participants were required to undergo six days of product engineering and construction training. The next week began with a lesson on design and production setup. The students had three weeks to complete the project, which required subjects in both groups to create a product using the skills and information they had learned throughout the previous weeks of training. The following tasks were part of the experimental group's final assignment:

• Choosing the product for 3D printmaking.

• Identify the requirements, elements and impending cost for the manufacturing process.

• Create the simulation tool or simulation Software along with the big data model required for the process of printmaking.

• Practical analysis of the process using VR and parallel analysis with controlling function from the classroom.

• Finally, actual product development in the industry.

The equipment and software design of an efficient platform are as follows, based on the given requirement specification:

3.1 Hardware Architecture

The physical design of the system is comprised of the following construction elements:

- **Sensors and actuators**

An incorporated relative humidity detector is connected to a microcontroller to quantify the environmental parameters, as the current proposal is to regulate and manage the AC units. The microcontroller turns the gadgets on and off as needed. A reference signal monitors the AC to determine the power usage in the printmaking process.

- **High-end microcontroller**

The element data capture component that controls the unit is a system on chip (SoC) high-end microcontroller. The SoC is appropriate for residential environments because of its small size, fast speed, and low weight.

- **Servers**

The workstations in the proposed framework are high-end personal computers that can also be put on the Internet for wide-scale connectivity. Broker, massively scalable Memory Server, Analytical Processor server, and Web host are among the servers deployed. In the system design section, the operation of every server is produced and used.

3.2 Software Architecture

The data collection component on the end devices, the middleware component, and the client computer module make up the software structure:

- **Data acquisition module**

The effective internal control operations of the data collecting module are the same. The control system continuously detects the temperature gradient, moisture, and AC power usage and sends the data to the middleware component. These variables are structured and provided to the middleware in conventional format regularly.

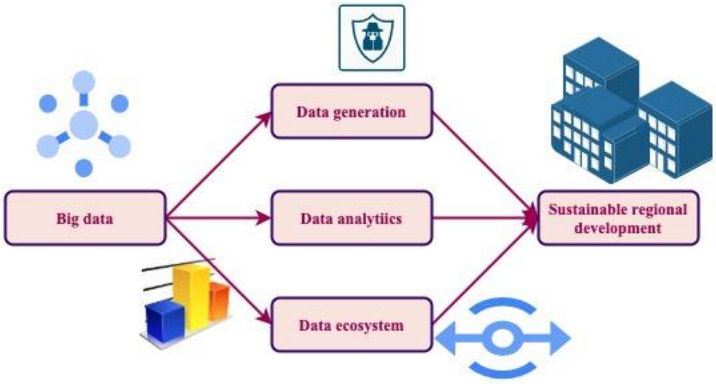

Figure 2: The big data analytics model of the suggested RPMS-BDAVR system.

The big data analytics model of the suggested RPMS-BDAVR system is shown in Figure 2. Big data is divided into data generation, analytics, and the data ecosystem, and all three models are combined to create a regional printmaking model. The data set, for instance, contains the user ID, home ID, device ID, and gauge values. The controller receives instructions from the middleware component and uses them for switching the AC-Units on and off as needed.

3.3 Middleware Module

As detailed below, the middleware component consists of multiple development tools and platforms that perform various services:

- **Server**

The server (Broker) is a communication channel between the network edge (including an AC-Unit) and the gateway. Password protection was implemented on the brokerage side to restrict illegal access to specific subjects. Some subjects, like intake monitoring and gadget state change monitoring, are set to be read-only, and those with the necessary permissions have access to what is being posted. Control commands are set to read-only to detect illegal control of the device.

- **Storage server**

The monitoring technologies and client information from the endpoints are stored on a scalability storage device that serves as a database system. It can manage the Big Data created by printmaking properties and ramp up to other residential regions later. A high-performance and flexible database are necessary to store user, user-house relationships, and house-device relationships. The practical system was chosen because it sits on top of the original robust file system.

- **Analytics engine server**

An off-the-shelf advanced analytics solution made wise judgments from the large incoming datasets. For instance, the observed information is organized and classed by heat, moisture, and electricity usage. This categorization is used to prepare reports, charts, and maps that show the printmaking process in a specific neighbourhood. That allows each user to examine their power use trend depending on the latest weather conditions. Furthermore, the benchmarking feature enables them to evaluate their usage data to others who have comparable settings.

As a result, if necessary, the user turns on/off the gadget based on that data. Furthermore, the program can enable municipal and regional utilities to see power use patterns based on their unique privileges. A local home utility centre sees the average use of every single dwelling within its geographic location. The aggregated usage of every residential region in the state is viewed at a state utility centre, and every state's usage trend is viewed at the centralized Utility centre. The web service provides these statistics and charts to the software application.

- **Webserver**

The client program uses JavaScript to access the nodes through several web services. These functions are being used to transfer files from and to the system and return it to the applicant. The user application uses web services to log in, monitor and manage devices, see registered assets, view listed devices, monitor and settle monthly bills and see graphs according to the customer's level. The hypertext transfer protocol (HTTP) standard is used to construct online services to secure traffic flow.

- **Client application module**

The front-end smartphone experience was created using a cross-platform. The use of this atmosphere has the advantage of allowing common web programming languages to be used. It also assures that applications are cross-platform, implying that only one program is produced for several cell phone systems, eliminating the need for recompilation. The program employs two authentication schemes: standard username-password verification and two-factor identity verification. Once a user has been authorized, actions are authenticated using an application programming interface (API) key, a completely random string.

This key could be updated, and the API key is unique to each session. The API key is updated after the client logs out. Furthermore, providing privileges such as designating a client, a state-owner needs a secret key as an extra option. This key is only recognized by top-level staff and constantly changes, biweekly or monthly. The entire flow chart in the two-way data transfer from printmaking to end-client applications; one route is for tracking device energy consumption information, another is for actual consumer remote management control.

3.4 Data Evaluation And Clustering

The fuzzy c-mean grouping shares the same essential qualities as the Kmean grouping algorithm in terms of simplicity and speed of cluster analysis. Still, the summary algorithm has flaws like responsiveness to the preliminary clustering centre, ease of falling into the locally optimal, and slow heuristic integration, as shown in Equation(1).

$$Z_s = \frac{\log_{10} q_x - \log_{10} \hat{q}_x}{\sqrt[2]{\propto^2 q_x + \hat{\propto}^2 \hat{q}_x}} \tag{1}$$

The outcome is denoted q_x, and the predicted outcome is denoted $\hat{q}_x$. The learning and predicted learning rates are denoted as $\propto$ and $\hat{\propto}$.

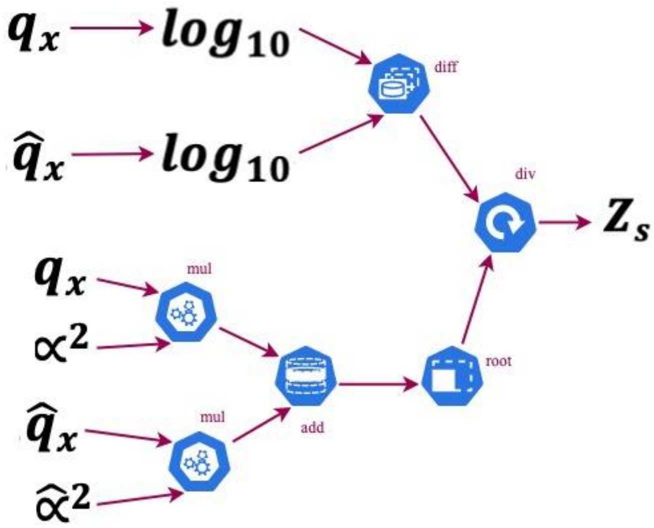

Figure 3: The graphical view of the function Z_s.

The graphical view of the function Z_s is denoted in Figure 3. It uses the output feature, the predicted feature, learning rate and the predicted learning rate to compute the result for Z_s. The approach splits grouping into stationary and non - stationary clustering then finds contenders for every cluster from the proposed routing centre to decrease computing complexity. However, a group relocation information approach is utilized to remove the problematic clustering centres of all vertices in the tree; this inclusion strategy impacts the overall clustering performance as the tree's network size grows. The matching functions are given by Equations(2) and (3).

$$S_x^+ = \sum_{y=0}^{n} S\left[\hat{V}_{xy}, \hat{V}_q^+\right] \tag{2}$$

$$S_x^- = \sum_{y=0}^{n} S\left[\hat{V}_{xy}, \hat{V}_q^-\right] \tag{3}$$

The expected network size and the positive performance are denoted $\hat{V}_{xy}$ and $\hat{V}_q^+$. The final negative performance is denoted $\hat{V}_q^-$. It devised a more efficient method for converting the graph division issue into a continual Laplacian matrix eigenvalues issue. The principal components belonging to the first core K lowest eigenvalues found using the Laplace matrix create a matching subspace. Various vector spaces lead to specific divisions, allowing graph divide to be achieved. The attraction and identification among incomplete information objects, incomplete information, and complete data artefacts in the two modules are zero when the vector is expanded to an imperfect data collection. Even though there is a group centre acceptable for the requirements in the partial data, it is impossible to locate it in the repetition if the signal is delivered straight. The mean squared error of the output is denoted in Equation (4)

$$\mathrm{MSE}(p) = \sqrt[2]{\frac{1}{M}\sum_{x=0}^{M} l^2(p_x, \beta)} \tag{4}$$

The total number of features are denoted M, the learning function is denoted l, and the deviation is denoted β. The input feature is denoted p_x.Furthermore, various sets of cluster analysis, test results, and qualities have a massive effect on the clustering techniques. Still, even when the methods, variables, and test results are constant, the cluster centres rapidly to the application's random selection of preliminary points.The original dataset's attractiveness matrix and attributing matrix are produced using the basic classical clustering algorithm. The attraction and credit matrices are expanded to the unfilled dataset using the K closest neighbour concept. Then the entire data collection is repeated many times until the grouping converges and the convergence length is denoted in Equation (5)

$$l = \min\left[\sum_{x=0}^{n}\left(p_{x,t} - \varphi_{xyt}\right)^2\right]^{1/2} \tag{5}$$

The input feature concerning time is denoted $p_{x,t}$, and the variance is denoted φ_{xyt}.

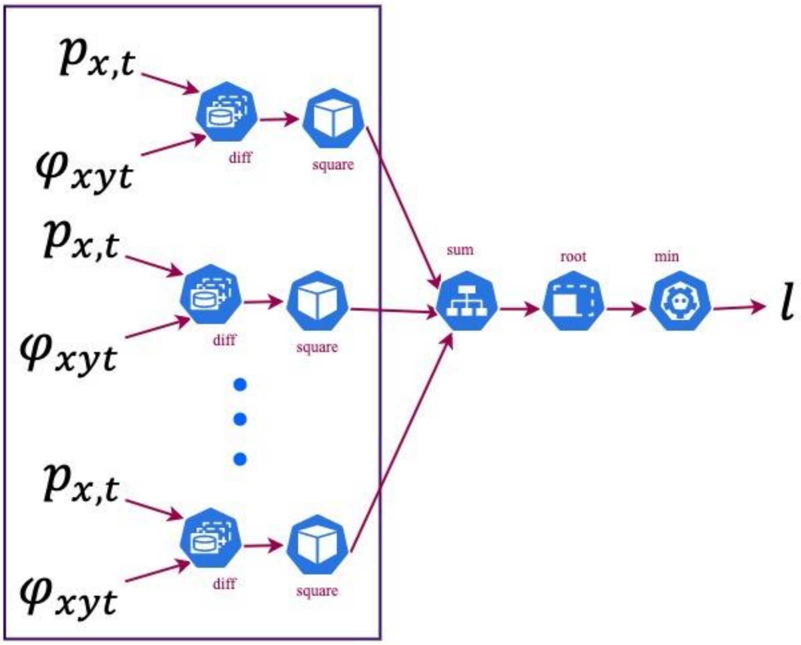

Figure 4: The graphical view of the function l.

The graphical view of the function l is denoted in Figure 4. It uses feature input and variance functions to compute the function l. Using the basic domain clustering approach, there is no need to map high-dimensional information to the low-dimensional area. The top-down or bottom-up continual evaluation, as previously explained, can be used to effectively mine clustering structures in high information, and consumers can also access the subspace of every cluster. Hyperspace grouping also aids high-dimensional information clustering in obtaining classification results, which differs from the matrix factorization method in that after the information is plotted from the absolute highest area to the low-dimensional room, the measurements implicated in the matching process used by the grouping method in the low-dimensional area have misplaced their initial meaning. The normalized output is denoted in Equation (6).

$$n(\theta) = \frac{\sum_{x=0}^{M} n_1(B_x) \times n_2(C_y)}{\sum_{y=0}^{M} n_1(B_x) \times n_2(C_y)} \tag{6}$$

The normalized feature 1 and 2 are denoted in $n_1(B_x)$ and $n_2(C_y)$. It compresses data using two-dimensional, three-dimensional, and scatter plot matrix visualization approaches and assesses the three methods' effectiveness for data distinction using a matrix interactive map.

3.5 Fuzzy Analytic Hierarchical Process

A collection of alternative $N_x, x = 1,2,\cdots K$ performance appraisal $C_x, x = 1,2,\cdots L$ linguistic judgment J expressing the relative value of every pair of assessing criteria, and a weighted vector $b = [b_1, b_2, \cdots, b_n]$. The suggested analytic hierarchical process (AHP) initial step is to create a structure of all the critical indicators and their relationships in the decision issue. Because the criteria chosen can impact the ultimate choice and assessment of both decision alternatives, this phase is critical. The hierarchy is usually organized from the highest level (i.e., the original problem's main aim), down to the varying levels (i.e., conditions and sub-criteria), and finally to the bottom floor (i.e., the list of options).

The AHP is used to analyze the criterion strength and alternative ranks in any case. The AHP hierarchy covers the full and ends mostly at varying levels. This study uses AHP to assess why deciding a 3D printer. The parameters on the top of the organization are matched to every one of the requirements on the previous (higher) layer using language phrases to assess fuzzy comparison analysis (very unimportant, less essential, equally significant, more essential, and very essential are examples of essential words.). These words create fuzzy comparability matrices represented by intuitionistic fuzzy or class labels.

The adverse judgment's component is considered the opposite and inverted order of the favourable impact judgment's fuzzy set. Accordingly, the triangle distributions express the decision-making state with gloomy, medium, and hopeful views in terms of linguistic judgment to represent the $\hat{J}$. A fuzzy triangle number reflects the most negligible value (L), most probable value (M), and max number (U).

Equation (7) depicts the fuzzy comparisons matrix $\hat{F}$ used to express the fuzzy relative merits of every pair of components.

$$\hat{J} = \begin{bmatrix} 1 & \hat{J}_{12} & \cdots & \hat{J}_{1m} \\ \hat{J}_{21} & 1 & \cdots & \hat{J}_{2m} \\ \vdots & \vdots & 1 & \vdots \\ \hat{J}_{m1} & \hat{J}_{m2} & \cdots & 1 \end{bmatrix} \tag{7}$$

The elements of the comparison matrix are denoted $\hat{j}_{xy}$. The average geometric technique is then normalized. Equation (8) is used to create a fuzzy pairwise comparison, wherein p_{xy} is a fuzzy triangular set.

$$\hat{F} = \begin{bmatrix} 1 & \hat{f}_{12} & \cdots & \hat{f}_{1m} \\ \hat{f}_{21} & 1 & \cdots & \hat{f}_{2m} \\ \vdots & \vdots & 1 & \vdots \\ \hat{f}_{m1} & \hat{f}_{m2} & \cdots & 1 \end{bmatrix} \tag{8}$$

The fuzzification feature and element is denoted $\hat{f}_{xy}$.Then, as demonstrated in Equations (9) and (10), the normalizing of the average geometric approach is used to obtain $\hat{j}_x$ and $\hat{b}_x$ as well as the local weight, where $\hat{j}_x$ is the fuzzy value.

$$\hat{j}_x = \langle (\sum_{y=0}^{N} p_{xy} \times i)^{\frac{1}{m}}, (\sum_{y=0}^{N} p_{xy} \times j)^{\frac{1}{m}}, (\sum_{y=0}^{N} p_{xy} \times k)^{\frac{1}{m}} \rangle \tag{9}$$

$$\hat{b}_x = \hat{j}_x \otimes (\hat{j}_1 \oplus \hat{j}_2 \oplus \cdots \oplus \hat{j}_m) \tag{10}$$

The feature input is denoted p_{xy}, and the three-dimensional data elements are denoted $i, j,$ and k. The biasing function is denoted $\hat{b}_x$, and the judgement matrix element is denoted $\hat{j}_k$.As illustrated in Equations (11) and (12), the $\otimes$ and $\oplus$ provide the fuzzy adding and fuzzy multiplying procedures for fuzzy integers, accordingly, to produce fuzzy weights.

$$\hat{j}_1 \oplus \hat{j}_2 = j_{1n} + j_{2n} j_{1m} + j_{2n} j_{1m} + j_{2V} \tag{11}$$

$$\hat{j}_1 \otimes \hat{j}_2 = j_{1n} * (j_{2n} + j_{1m}) * (j_{2n} + j_{1m}) * j_{2V} \tag{12}$$

The judgement matrix element is denoted as j_{xy}. Lastly, we may use the centre of area approach to the fuzzy value and produce a crisp quantitative score, as indicated in Equation (13).

$$b_x = \frac{b_{xi} + b_{xj} + b_{xk}}{3} \tag{13}$$

The three-dimensional biasing elements are denoted b_{xi}, b_{xj} and b_{xk}. The AHP approach analyses factors/criteria connected to the optimization procedure of three-dimensional devices or 3D printing during the development and manufacturing phase. To synthesize the weight information, it collected decision information from previous policymakers (three representations of 3Dprintmaking technical specialists and three clients of 3D printmaking consumers). Technical specialists are 3D printmaking company consultants, whereas consumers are 3D printmaking clients.

3.6 Communication Model

This architecture for the communication model (CM)combines the CM developed with components.

The workflow of the communication model is denoted in Figure 5. The process of the flowchart is explained below:

Step 1: Define problem statement

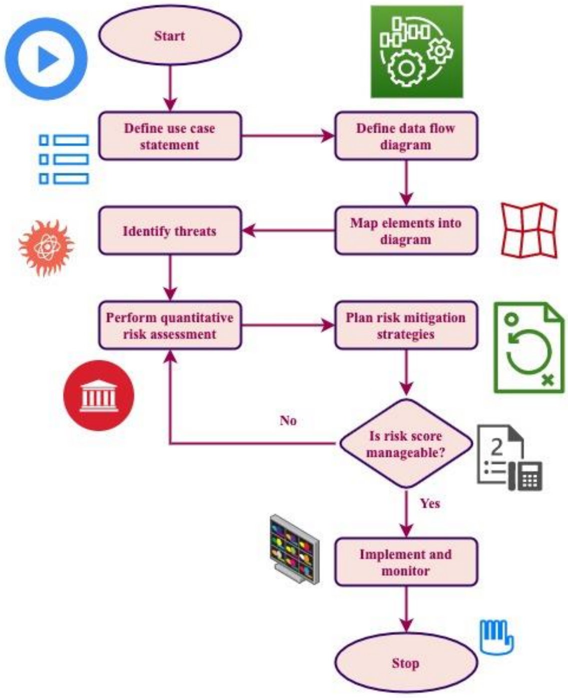

Figure 5: The workflow of the communication model.

It starts by defining the system, which comprises a description of the main goals, related equipment, data flow inside the system, and critical users.

Step 2: Define data flow diagram (DFD)

Organizations, Information Flow, Data Warehouses, and Operations are used in Data Pipeline Charts to split the computer into discrete components. Trust Boundary is another element used to define the boundary between trustworthy and untrustworthy elements in the DFD. The DFD serves as a graphical depiction of these elements, providing a high-level perspective of the relationships between the different members of the structure to the client. The user generates a DFD with the needed granularity for a specified use scenario or issue statement. A more acceptable resolution results in a more detailed picture, yielding more dangers connected to individual elements relationships later.

Step 3: Map elements into DFD

Following the creation of the DFD, it employs threat categorization to map specific elements of the DFD to the appropriate danger classes. The risk classifications linked with every component are listed and developed. After that, the user might absorb the danger forms that surface. This stage addresses common danger categories for every element and prioritizes the threat detection algorithm for those categories.

Step 4: Detect threats

Iterate through each element of the DFD, starting with generic assaults and working the way up to more process-specific assaults. If needed, create brief abuse possible conditions for each assault once risks have been identified and catalogued. Due to capacity constraints, this research did not provide abuse case situations.

Step 5: Perform risk assessment

Using the data collected in the initiation section creates assault trees for every element in the DFD and the corresponding threat categories. To determine the ultimate risk rating of the attacks, these component-based assault trees are assessed using a mix of the Common Vulnerability Scoring System and a hazard propagation approach.

Step 6: Plan risk mitigation model

The users consider various measures to minimize these dangers by examining the assault trees, their related ratings, and the previously produced misuse-case situations. After developing mitigation methods, a user can re-evaluate the clearly stated attack branches to modify the hazard class's vulnerability index. Steps 5 and 6 are performed until the degree of threat mitigation is satisfactory to the user. The mitigation strategies are introduced when a tolerable risk score is determined, and the technology is reviewed and revised as necessary.

The printmaking fabrication uses collaborative and pervasive additive manufacturing and networking model that depicts the functioning of the cooperative and omnipresent advanced manufacturing network for creating dental components, which consist of the following:

(1) A consumer orders 3D components through the Internet.

(2) The algorithm then looks for nearby 3D printmaking services that are accessible and free.

(3) The method allocates the required amount to the 3D-printing companies, allowing them to work together to complete the order.

(4) In each 3D printing facility, the method recognizes the laxity for immediate withdrawal and restarting.

(5) Each 3D printing equipment prints the items that have been given to them.

(6) The program advances to Step 8 if any 3D printing operation is halted early; else, it advances to Step 9.

(7) If the gap is reached, the program goes back to Step 4 to optimize; if not, it goes back to Step 6 to reproduce.

(8) To collect the 3D products, a transport system makes one-by-one trips to the 3D printing factories.

(9) The item is delivered to the consumer by the transport company.

For the applications, the study built a two-tier administration platform. The three-tier design of the cooperative and universal advanced complete manufacturing network is the connected device, the systems (i.e., internet company), and the 3D-printing capabilities.

The suggested RPMS-BDAVR system is designed with the big data analytics model and fuzzy AHP system, and the regional printmaking system is designed and constructed with a communication model. The software findings of the suggested RPMS-BDAVR system are analyzed in the next section.

4 PRACTICAL AND SOFTWARE OUTCOME EVALUATIONS

This section concentrates on the computer-aided design (CAD) and practical effectiveness of the experiment through VR. By researching the acceptability mentioned above-optimized layout model as a tool, an essential computer-aided,patience-optimised plug-in design program was installed on the automatic email acceptability designing phase. It then accomplished the original sensitivity allocation, acceptability analysis (check), and acceptability optimizing distribution functions in their entirety. It could not only receive and allocate the ring's diameter and standard data and automatically produce it in CAD style, but it could also accept the manual intervention of tolerances values for tolerance verification in the printmaking process.

Figure 6 depicts the finishing time of the project by the student groups in practical group and classroom group using the proposed RPMS-BDAVR scheme. Practical engineering education employing 3D printmaking, VR and big data analysis helped the practical group of students complete their projects in less time than the control/classroom group of students. This demonstrates the advantages of the VR-based education technique. One of the key benefits of adopting a VR system is that it allows the participant or user to interact with digital items in the same way they would in the real world. It gives a framework for studying through doing. The amount of mistakes made by the practical group participants is likewise lower than those of the classroom group of students.

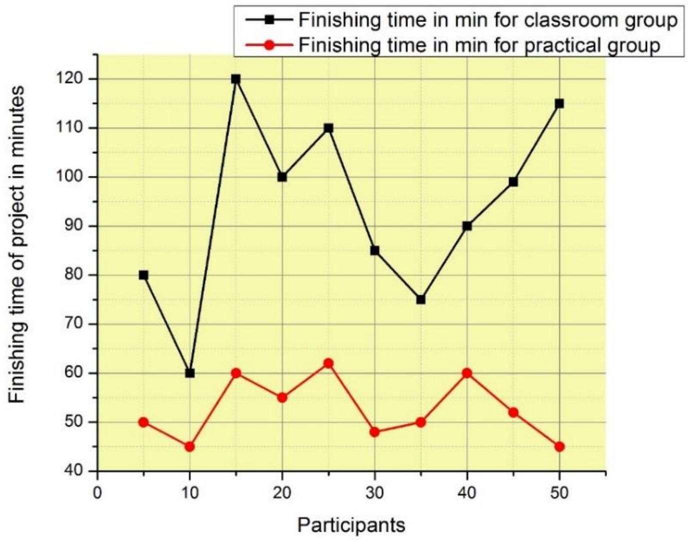

Figure 6: Finishing time of the project by the student groups in practical group and classroom group using the proposed RPMS-BDAVR scheme.

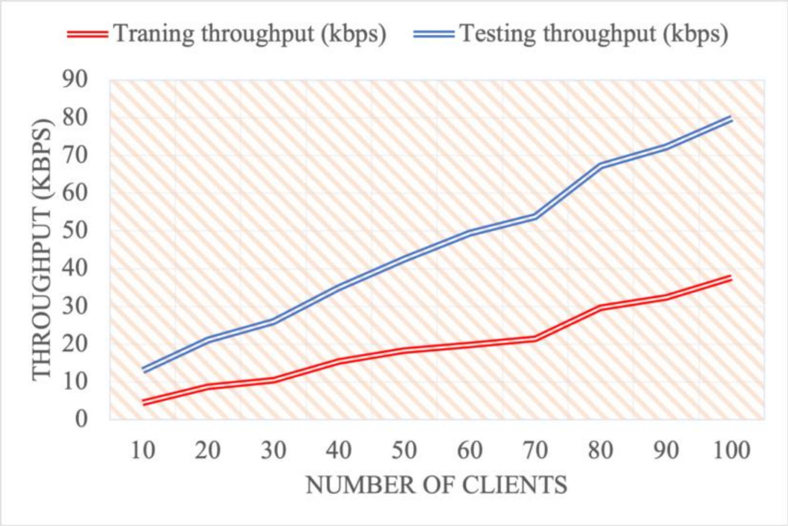

Figure 7: Throughput analysis of the suggested RPMS-BDAVR system.

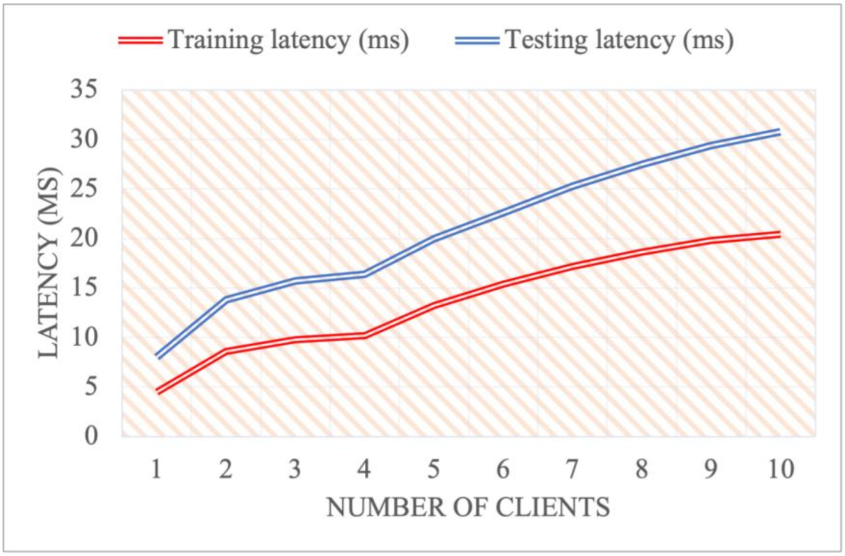

Figure 8: Latency analysis of the suggested RPMS-BDAVR system.

The throughput and latency analysis of the suggested RPMS-BDAVR system are depicted in Figures 7 and 8. the number of clients is varied from small to larger count for the simulation analysis. The respective simulation outcomes in terms of throughput and latency of the suggested RPMS-BDAVR system are evaluated and monitored. The training and testing outcomes are compared with each other. The suggested RPMS-BDAVR system requires more time to train the model and exhibits better and faster results at the testing conditions than the training conditions.

Number of clients	*Training throughput (kbps)*	*Testing throughput (kbps)*
10	4.5	8.5
20	8.7	12.4
30	10.4	15.6
40	15.4	19.5
50	18.3	24.3
60	19.8	29.6
70	21.4	32.4
80	29.6	37.6
90	32.4	39.8
100	37.6	42.3

Table 1: Throughput analysis of the suggested RPMS-BDAVR system.

Table 1 indicates the throughput analysis of the suggested RPMS-BDAVR system. The software outcomes of the suggested RPMS-BDAVR system is evaluated under two different simulation environment, namely the training and testing phase, with the help of a big data analytics module. The number of clients for the simulation analysis is varied from a minimum of 10 clients to a maximum of 100 clients with an increment level of 10. As the number of clients increases, the throughput of the suggested RPMS-BDAVR system decreases because of the overutilization of the given wireless channel. The testing performances are always higher with the fuzzy AHP system.

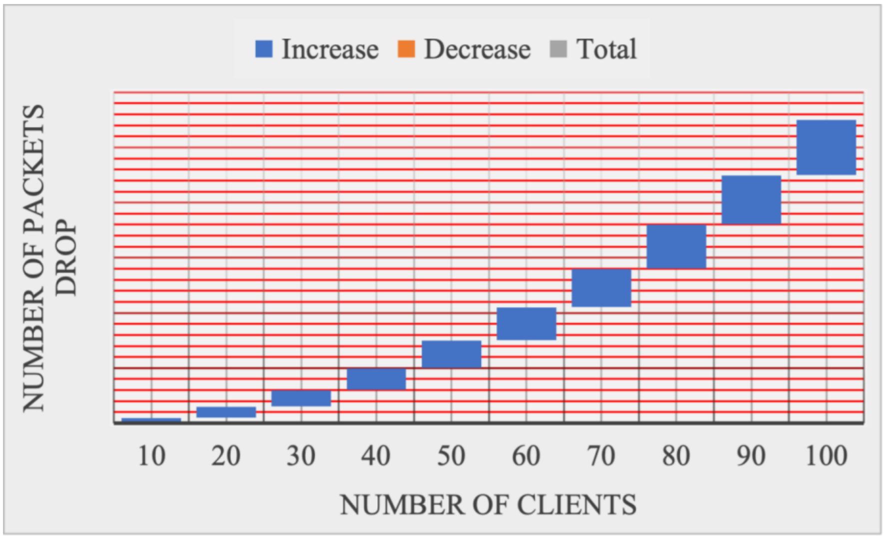

Figure 9: Packet drop analysis of the suggested RPMS-BDAVR system.

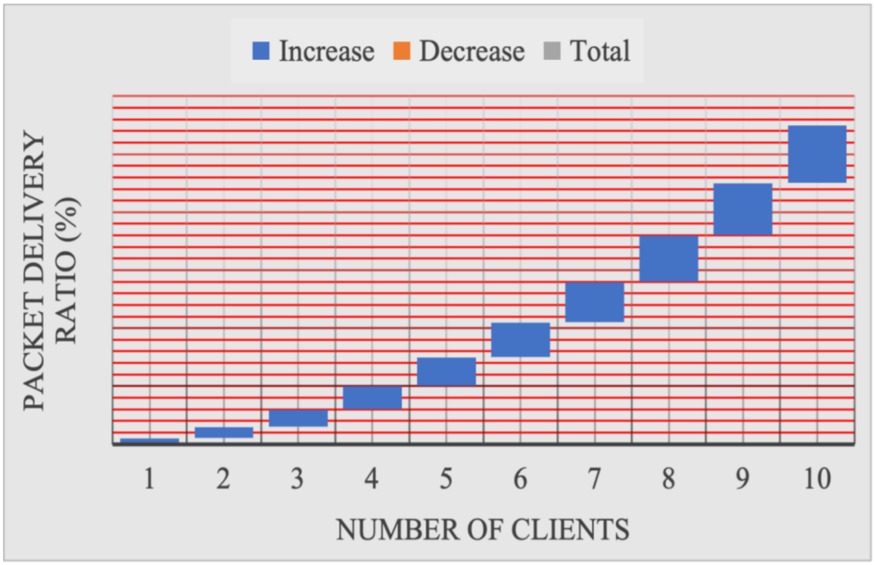

Figure 10: Packet delivery ratio analysis of the suggested RPMS-BDAVR system.

The packet drop ratio and packet delivery ratio of the suggested RPMS-BDAVR system are depicted in Figures 9 and 10. The simulation analysis of the suggested RPMS-BDAVR system is carried out by varying the number of clients, and their simulation outcomes are evaluated. The simulation results for the number of packet drops and the packet delivery ratio of the suggested RPMS-BDAVR system are computed. The packet delivery ratio and packet drops are inversely related to each other. The fuzzy logic helps to minimize the computation time and complexity, and thus, the number of packet drops in the network reduces.

Number of clients	*Training latency (ms)*	*Testing latency (ms)*
10	4.5	3.5
20	8.6	5.2
30	9.8	5.9
40	10.2	6.2
50	13.2	6.8
60	15.4	7.2
70	17.2	8.1
80	18.6	8.9
90	19.8	9.6
100	20.4	10.4

Table 2: Latency analysis of the suggested RPMS-BDAVR system.

Table 2 depicts the latency analysis of the suggested RPMS-BDAVR system. The suggested RPMS-BDAVR system is analyzed and evaluated under two conditions, namely training and testing conditions. The respective simulation outcomes in terms of latency are computed from the time to send the data from source to time to reach the receiver. Because of the big data analytics model, the suggested RPMS-BDAVR system exhibits lower latency in training and testing cases. The mathematical model helps to reduce the complexity and thus increase the overall system outcomes.

Figure 11: Mean absolute error analysis of the suggested RPMS-BDAVR system.

Figure 12: Mean squared error analysis of the suggested RPMS-BDAVR system.

Figures 11 and 12 indicate the mean absolute and squared error analysis of the suggested RPMS-BDAVR system, respectively. The number of clients for the simulation findings are varied from a minimum of 10 to a maximum of 100 with a step of 10 clients. As the number of clients in the networks increases, the system performance degrades. It happens because of the overutilization of the wireless links and buffering time at each client. The suggested RPMS-BDAVR system produces better results with the help of big data analytics modules and fuzzy AHP systems.

The suggested RPMS-BDAVR system is evaluated under different simulation conditions, and the outcomes are monitored under different clients. The simulation outcomes of the suggested RPMS-BDAVR system exhibits higher performance in both training and testing conditions with the help of fuzzy AHP systems and big data analytics modules.

5 CONCLUSION AND FUTURE SCOPE

A regional printmaking system with big data analytics (RPMS-BDAVR) is proposed in this article. The suggested deep learning-based printmaking feature extraction approach is a new creativity model that blends technical and inspirational production. It's also a novel approach of study that blends deep learning with simulated annealing. The first is built on the deeper trust network's enhanced value extraction approach, while the second is built on the convolutional automated encoder's characteristic extraction technique. After that, an approximate assessment model is generated using 3-dimensional features, interaction assessment, and the training evolutionary functional matrix. The synthetic assessment is modelled and developed to produce the final suitable model. Practical engineering education employing 3D printmaking, VR and big data analysis helped the practical group of students complete their projects in less time than the control/classroom group of students.

The paper's primary source is a basic model. Because the research is only an experiment on a new topic, the issue of inapplicability cannot be remedied in most cases. Only the designer's viability has been shown based on subjective limits; the viability of scientific development and creative inspiration production requires additional investigation. The artificial intelligence module can be inherited in the future to improve the efficiency of the printmaking process.

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