Enhancement of Online Education in Engineering College Based on Mobile Wireless Communication Networks and IOT

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Abstract—The field of Engineering is that which needs a high level of analytical thinking, intuitive knowledge, and technical know-how. The area of communication engineering deals with different components including, wireless mobile services, radio, broadband, web and satellites. There is a rapid decline in the quality of students produced by engineering faculties as a result of sufficient and quality methods and frameworks of student assessment. The production of high-potential engineers is limited by the utilization of old and traditional education methodology and frameworks. The student presentation estimation system in engineering institution is a motionless manual. Usually, the assessment of student's performance using the traditional system is limited to the use of students' performance scores, while failing to evaluate their performance based on activities or practical applications. In addition, such systems do not take cognizance of individual knowledge of students that connects to different activities within the learning environment. Recently, engineering institutions have started paying attention to evaluation solutions that are based on wireless networks and Internet of Things (IoT). Therefore, in this study, an automated system has been proposed for the assessment of engineering students. The proposed system is designed based on IoT and wireless communication networks with the aim of improving the process of virtual education. The data used in this study has been collected through the use of different IoT sensors within the premises of the college, and pre-processed using normalization. After the data was pre-processed, it was stored in cloud. In order to enable the classification of student's activity, an Adaptive Layered Bayesian Belief Network (AL-BBN) classifier is proposed in this work. The student's scores have been calculated using fuzzy logic, while Multi-Gradient Boosting Decision Tree (MGBDT) was proposed for decision making. The use of python simulation tool is employed in the implementation of the proposed system, and the evaluation of the performance benchmarks was done as well. Based on the findings of the study, the proposed conceptual model outperformed the existing ones in terms of improving the process of online learning.

Keywords—Internet of Things (IoT), Online education, Adaptive Layered Bayesian Belief Network (AL-BBN), fuzzy logic, Multi-Gradient Boosting Decision Tree (MGBDT)

1 Introduction

One of the key contributors to national development is the educational sector, which offers a wide range of learning locations and settings. The functionality and productivity of educational institutions have been significantly impacted on by the emergence of technology [1–3]. A key purpose of global computing technologies is to expand the engagement of students. It also aims at collecting data from a wide range of sources and incorporating them into different activity solutions, which is vital to the provision of ratings that are based on the daily activities of students based on an educational perspective. Regardless of the fact that there are huge technological advancements that have been made in the area of education, the assessment of students is still carried out manually. This is prone to human error as key features could be omitted when the performance of students is computed. The IoT is an internet of networked, distinct from others items that is gaining traction. It is basically aimed at developing intelligent spaces/environments as well as self-aware objects. The emergence of the IoT has resulted in the alteration of the global computing [4, 5] asides the numerous areas that surround different sensors. In more recent times, major new trends are emerging, particularly, in the area of combining sensors and device systems with technological systems. This is coupled with the interactions between device-to-device and technological systems, which helps in solving most problems associated with device and protocol. It is expected that the synergy between contextual data analytics and digital applications like machine-to-machine communications can promote the transformation of different industries. Also, it expected that the advancement of IoT innovation can be enhanced by the emergence of cloud computing as well as its use in the fog paradigm, considering the increased utilization of smart products. The interest in this study is motivated by these developments, stimulating the eagerness to examine extant work, develop novel models, and unearth novel IoT applications. The advancement in online education has been supported by the continuous technological advancement in the area of wireless communication networks, which have attracted the interest of professionals and academics, and they're already being used in nautical applications globally. Worthy of note is the fact that the current situation has resulted in the forced transition from face-to-face educational paradigm to online paradigm. Even though this paradigm is assumed to be simply embraced by learners, a closer examination shows that this paradigm births a significant variation. The productivity of learners can be greatly impacted on by changes made to mode of studying. Given that knowledge is owned by teachers, they are regarded as key players in the conventional learning system [6, 7]. Recently, there has been rapid advancement in the area of Mobile Wireless Communication Networks. The efficiency of wireless communication has been on the increase, which in turn allows for the deployment of several phases of cellular phone technology that is currently used by numerous people [8, 9]. This trend began with 5G network that was majorly employed in voice conversations, but served as the foundation of all mobile generations that emerged afterwards. In every phase, novel technologies are introduced, while new features and functions are supported. The basic overview of Internet of Things is graphically represented in Figure 1 below.

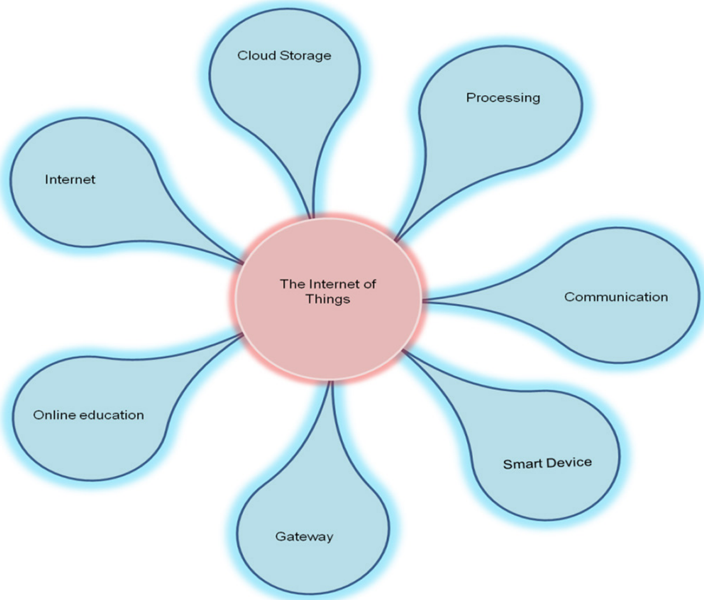

Fig. 1. General representation of Internet of Things

Investigations on IoT (Internet of Things) technology have focused on determining if it can be used in improving virtual teaching and learning. In the present study, an approach that supports decision-making among administrators of educational institutions is proposed. It is expected that with this approach, they will be able to use data obtained from the IoT to make well-informed decisions in the education sector. For educational institutions to be able to make decisions based on data, they can make use of real-time data stream which can be analysed and used to feed their learning analytic system. More so, the performances of the management of higher institutions are influenced by the ease with which academic platforms can be accessed through the internet. The key contribution of the proposed approach is that, it demonstrates to educational institutions that virtual teaching and learning can be supported and improved by using data obtained through the Internet of Things. The application of IoT in educational institutions is increasingly becoming popular, with institutions using the internet for the collection, storage, and transmission of information [10]. The critical role of technology has been experienced in the education sector, especially in terms of student connection and education. Virtual education has been significantly influenced by the Internet of Things, which has changed the conventional methods of teaching as well as the architectural setup of educational institutions. The concept of IoT is regarded in two-fold in terms of the roles it plays in virtual education, given that it can be used as a technology for the enhancement of educational infrastructure, and it can also be studied as a course [11–13]. The revolution of virtual education can be enabled at all levels of education through the use of IoT technology. This technology offers great benefits to different stakeholders at every level, including teachers and students. The use of Internet of Things has been employed in the areas of teaching and research. The incorporation of the Internet of Things into education allows the easy interaction between people and things in the academia. Figure 2 is a representation of an IoT enabled teaching model.

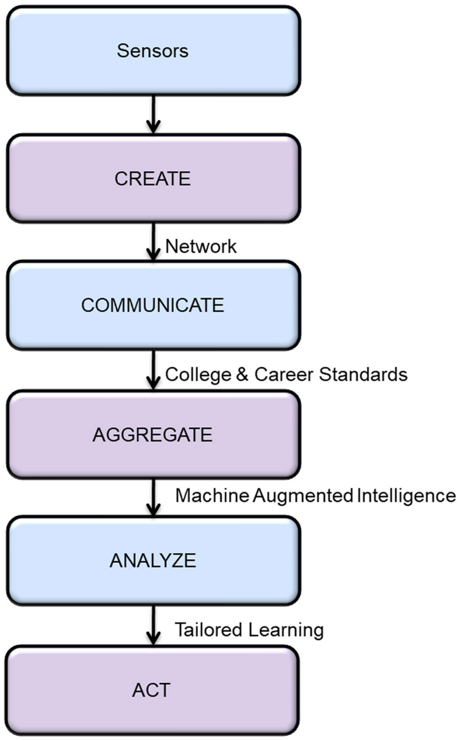

Fig. 2. Internet of Things enabled teaching

There is still need for the further improvement of the wireless communications, given the increasing need for connectivity between devices and the internet of things. In the nearest future, the paradigms of IoT wireless communications network will be needing approaches like dynamic spectrum access, spectrum sharing, optimal routing and extraction of signal intelligence. The recent upsurge in the demand for IoT wireless communications can be attributed to the unique nature of the Internet of Things wireless communication networks coupled with the latest ubiquity of machine learning. Given the high number of Internet of Things' devices, huge interactions, especially through wireless communication networks, it becomes important to have a networking architecture that is characterized by scalability. Particularly, the daily lives of humans are gradually being pinned around the IoT, giving room for unique access to information. In addition, the IoT enables the improvement of the virtual learning, enhancing more accessibility. At the moment, improved results in learning are being recorded due to the early efforts in IoT-based education. Learning and teaching resources have become increasingly accessible to people in different parts of the world through wireless or wired network, thereby increasing the potentials of education for everyone. Through IoT-based learning, students and teachers in different parts of the world can be able to obtain local and international information that can improve teaching and learning outcomes. Virtual education is regarded as a promising alternative for the application of IoT. Recently, the application of IoT technology has enabled the integration of instructional materials into the development of repositories that are scalable and rich in media content. The subject of Internet of Things in education has been extensively studied. The critical role of IoT in virtual education is illustrated in Figure 3 below.

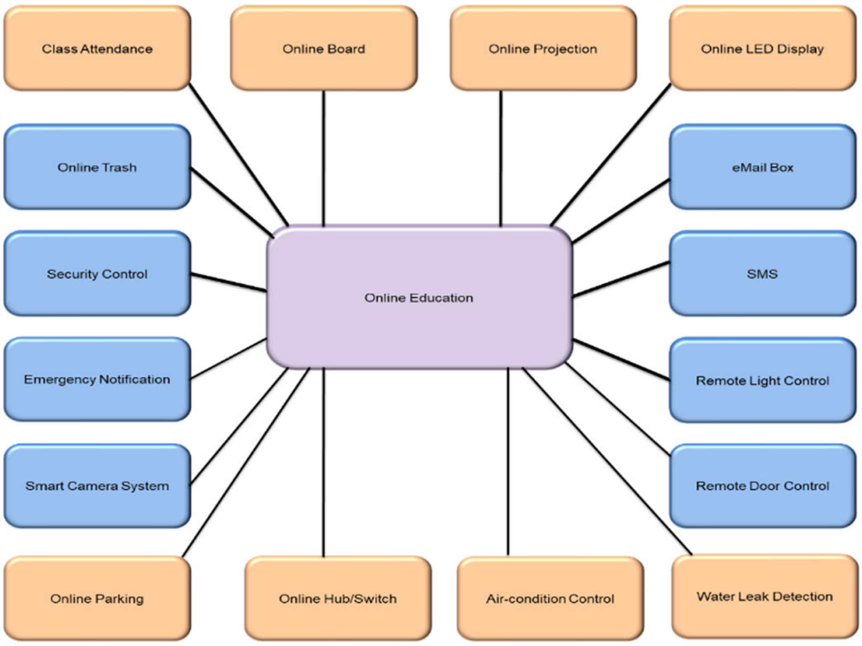

Fig. 3. IoT in online education

Huge advancements in telecommunications, cloud technology, detectors, nanotechnology, and big data will be recorded because of the impact of IoT. Communication between humans in different locations have been made possible and easy due to the presence of Internet of Things coupled with current trends in technological advancements. Also, a great number of intelligent systems have been created with the help of IoT. Quite a number of areas have been revolutionized because of the application of IoT in those areas. One of those areas is higher education, in which improved learning, experimentation, and management is being recorded due to the use of IoT [14, 15]. Thus in this work, a Multi-Gradient Boosting Decision Tree (MGBDT) algorithm and Adaptive Layered Bayesian Belief Network (AL-BBN) are presented as ideas for action development for optimal mobile wireless communication networks and IoT. The remaining parts of the paper are structured as follows: Part II. Review of Related Works and Problem Statement; (III) Proposed Work; (IV). Performance Analysis; (V) Conclusion

2 Related works

In the study carried out in [16], the challenges of educational system as well as the possible ways of addressing them through the use of IoT technology and were investigated the author examines educational system difficulties and how to fix them using Network infrastructure and IoT technology. In their work, they designed an algorithm that enables a modern approach to learning, and named it "IoT-based Centralized Double Stage Education". The algorithm allows for contemporary technologies and instructional strategies to be integrated. More so, the investigation of security challenges was done considering the physical layer due to the fact that core network safety systems are characterised by complete privacy, minor computer complexity, consumption of resources, and good adaption to change in channel. [17]. Their investigation focused on resource allocation, safety of intercept coding, processing of data, multi-node collaboration, alongside identification and extraction of application layer key. The aim of this investigation is to find ways through which the increasing security challenges can be tackled. The authors in [18, 19] beamed the flashlight on the present contributions of IoT to education, while highlighting a wide range of obstacles that can hinder or challenge experimental endeavours in the future. This study was a review study that focused on the use of IoT in education, vocational learning, clinical advancement, green IoT, and wearable technology. In [20, 21], the researchers proposed an online education system (OES), which checkmates abnormal behaviour of users. The system is able to flag consumers with unruly behaviour; the system exposes the private information of such consumers. This is the strategy used by the system to achieve system security. The aim of this is to make the user return to appropriate behaviour. The result of the system test based on reliability and safety parameters, the proposed system provides more security than existing ones. The security of the system enables stem education through the deployment of resource-constrained IoT devices. It was also reported that only little latency is required for communication and computation. In addition, efforts were made by [22, 23] to enhance the process of learning; the researchers integrated Learning management systems with AI "artificial intelligence" so that the process of learning can be improved. As part of the new normal, this is aimed at the creation of a standard educational shift that allows students to learn virtually and to be able to gain access to virtual assistants that can support their academic endeavours. The present level of research and practice in the area of engineering education was evaluated in study [24, 25]. Who also investigated the implication of industrial research. This was done considering the new trending services through wearable technologies, mobile computing, deep learning, and internet of things. A discussion on the ideas and history of internet of things was presented in [26, 27] alongside the idea of educational administration, education, and related issues. The application of such modern technologies can enable the identification of difficulties that exist within the education sector, and help decision makers in taking the right steps within a smart environment. To this end, FHM University of Applied Sciences, a well-recognized education in Germany, was investigated as a case study of an experimental implementation in the area of IoT. Another educational system was designed by the authors in [28–30], and the system was designed to imitate the intellectual intelligence of learning things. It is a learning system that is based on IoT, and designed to complement conventional methods of education alongside top-notch learning approaches. The use of this system can be employed on a wide range of applications and devices allowing interaction and opinion-sharing with consumers through the internet of things. The critical role of internet of things in enhancing the process of education, particularly learning was analysed by the authors in [31, 32]. In their study, they highlighted the application of IoT in different areas of education, including, distant learning, medicine, science, consumer green education amongst many others. The emergence of the internet, transformations in terms of human-to-machine, human-to-human interactions have occurred, and these have been transformed to worldwide communications network. In [33], the author proposes a strategy for developing a long-term educational environment that is financially, socially, and ecologically responsible. In addition to technology, a better IoT-supported educational environment necessitates increased collaboration among institutions, staff, and students. The vision of a completely reformed field of education, digitally assisted, enriched, and financially, economically, and socially economic health is only conceivable with the full commitment of every stakeholder and respective desire to help and team up. In [34], the use of blockchain technologies in education was systematically evaluated with the aim of providing in-depth insight on the critical application and role of blockchain in education. They also focused on highlighting its application in the future developments of the education sector. Blockchain technology has huge potentials in the area of education, and as such more efforts should be geared towards exploring such potentials. These authors, through their research have set the platform for decision makers and academics to further explore other areas in which this technology can be applied. The author in [35], proposed the use of a wide range of sensor devices in an educational system. The proposed system was found to be efficient in terms of its scalability in addressing the increasing sensor populations. They described the architecture and implementation of the IoT from a software perspective. They also provided a description of the proposed system's features, carried out an analysis of the lessons learned, while highlighting future trends of their work. The authors in [36] carried out an investigation of the basic principles, features, classifications, technologies, and challenges associated with the internet of things. In their work, the crucial role played by IoT in the development of a smart educational system was demonstrated. They also highlighted the contribution of IoT in decision-making by enabling sound judgement and capacity building which are critical to the daily activities of humans. Also, major utilities in different industries can be expanded and improved upon through the use of IoT. By improving those utilities, applications can be developed through a new ecosystem by means of a world-wide distributed local wireless system of intelligent items. In the work done by [37], a device referred to as wrist-based wearable for Education 4.0 (fitness tracker) was proposed, and the benefits that can be derived from the use of wearable device were highlighted. The authors also designed a questionnaire to evaluate the experiences of users in terms of their acceptance of modern electronic technology in higher education. Their experimental results showed the key procedures and sensors for education 4.0. They also demonstrated through their results that their proposed fitness trackers designed with a built-in sensor is capable of collecting a huge amount of real-time data while kids are studying. The researchers in [38] show the importance of the current education technology in enabling the productivity of students and teachers. They also demonstrated that it is time saving for teachers, and requires less efforts. In this study, it was revealed that the use of Learning Management systems helps students to acquire more knowledge within a shorter period of time. It was noted in the study that, interaction between teachers and students, teachers and teachers, and students and students is enabled through the proposed method. While showing the benefits that can be derived by integrating an LMS with higher education, the authors also urged other higher institutions to adopt this technology.

3 Problem statement

There is a wide range of devices that can be used by students to accomplish their academic goals and tasks, including computers, phones, and tablets. These devices offer them the benefit of participating in classroom activities virtually. In addition, IoT facilitates interaction and communication between instructors and students. Although IoT devices may have the simplest applications, such as registering entrance and exit at a security door, there more complex applications of such devices as they are designed with more sophisticated components. Additionally, the transmission of critical data to IoT systems can impact on all other things related to it in a negative way.

4 Proposed methodology

In the current work, a quality IoT strategy has been developed by using an Adaptive Layered Bayesian Belief Network (AL-BBN) alongside Multi-Gradient Boosting Decision Tree (MGBDT) algorithm within the internal environment. The purpose of this strategy is to increase data that can facilitate online learning. Figure 4 below shows the functional flow of this study.

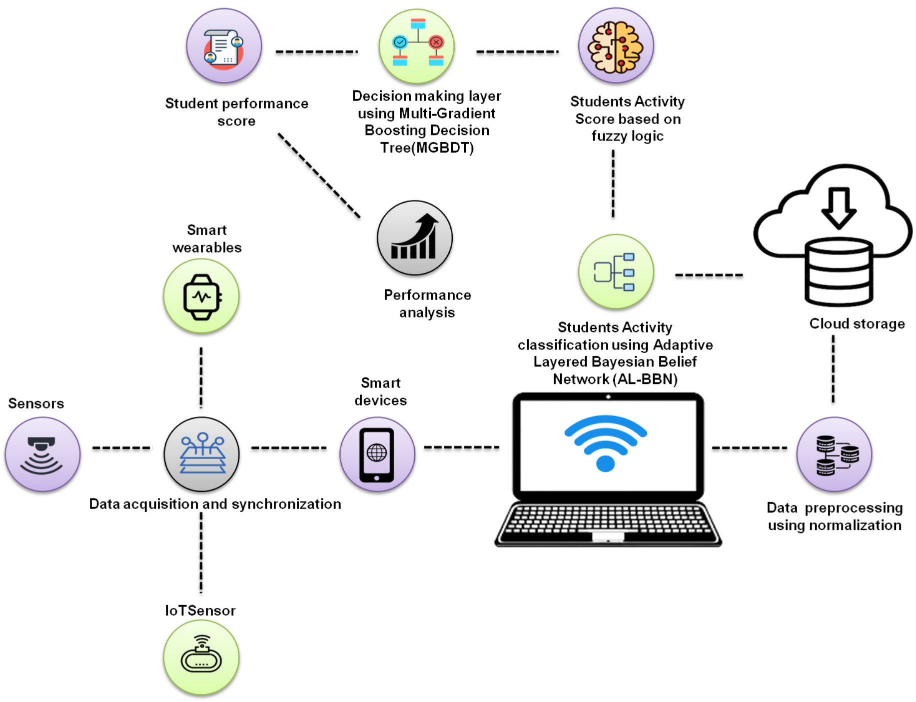

Fig. 4. Schematic representation of proposed work

4.1 Data acquisition and synchronization

Data such as students' geographical location and their daily interaction are collected through a data acquisition system. The data which is gathered enables the incorporation of energy-efficient sensors, intelligent systems, as well as other monitoring devices. A personal sensor network composes of GPS sensors, radio frequency identification (RFID), and other IoT devices. The purpose of designing this system is to enable the collection of students' information, daily engagements of both staff and students, and their locations. More so, both unstructured and structured data are collected from the personal sensor network by the gateway. After the data is collected, it is forwarded to a cloud storage database for further analysis. The features of the dataset are represented in Table 1 below.

Table 1. Personal attributes of student

S.no	Features	Explanation
1	SID	Student identification number
2	Name	Student name
3	Age	Age of the student
4	Sex	Male or Female
5	Address	Permanent address of the student
6	Family member name	Name of the family member
7	Family member mobile number	Family member mobile number
8	Student data	Student previous performance information

4.2 Data Pre-processing using normalization

The selection of the target data should be made from the unprocessed collection of financial data so that the performance can be boosted. It is important that this data be prepared to enable its usability. After the target data has been processed, it is analysed and then the results generated through the use of data mining methods. The purpose of transforming data is to alter the pattern and types of characteristics. The pre-processing of data is a step that is crucial to data processing and extraction. There are chances that data which is falsified will be found among the semi-structured, structured and unstructured datasets that are unprocessed. Thus, it is necessary for data to be processed so that it can be void of noises, and can be standardized. The elimination of noisy images from the dataset requires the use of image retrieval methods. The normalization of the dataset may be carried out at the stage of pre-processing. The arithmetical representation of D-count is given be Equation (1) as follows:

$$D = [(N - \beta) / \tau] \quad (1)$$

Where, β denotes the information's mean and τ represents the standard deviation, while D is represented as,

$$D = \frac{N - \bar{N}}{R} \quad (2)$$

Here $\bar{N}$ is the specimen's mean, and R denotes the standard deviation of the specimen.
Below is the representation of the random specimen:

$$D_s = \delta_0 + \delta_1 N_t + \rho_t \tag{3}$$

The defects that are depending on τ^2 are represented by *t*.
Ensuring that, as seen below, the defects should not depend on one another.

$$l_n \sim \sqrt{U}\,\frac{l}{\sqrt{l^2 + p - 1}} \tag{4}$$

Here, *l* represents the random parameter.
Then the movements of the variables are normalised using standard deviation. The momentary scale deviance is determined using the formula below (5).

$$\mathrm{NNR} = \frac{\mu^{\mathrm{nnr}}}{\theta^{\mathrm{nnr}}} \tag{5}$$

Here, momentary scale is denoted by mms. $\mu^{\mathrm{nnr}} = \mathrm{Va}\,(\mathrm{n} - \beta)\,\hat{}\;\mathrm{NNR}$ (6)
N represents random variable, while Va denotes predicted values.

$$\theta^{\mathrm{nnr}} = \left(\sqrt{\mathrm{Va}\left(\mathrm{n} - \beta\right)\hat{}\;\mathrm{NNR}}\right)\hat{}\;2 \tag{7}$$

$$l_p = \frac{nnr}{\bar{N}} \tag{8}$$

The coefficient of variance is denoted as l_p.
Each parameter should be fixed at zero so that characteristic scaling can be paused. This approach is referred to as "unison-based normalizing approach." After normalization, the formula will be as follows:

$$N' = \frac{(l - l_{min})}{(l_{max} - l_{min})} \tag{9}$$

Upon completion of the process of data normalization, the data may be saved and the dataset's anomalies and length can be maintained. This stage is aimed at minimizing or eliminating data delays. Afterwards, the dataset that has been subjected to the process of normalization can be used as input data in the subsequent stages of the process. The dataset for students' virtual education is saved in the cloud, which is referred to as an Infrastructure as a Service (IaaS) provider. Here, data is gathered from different sources and can be retrieved at any time. The use of cloud storage repository is employed in saving the time-stamped data, and this data is later on retrieved for analysis. The classification of students' activities is done appropriately based on the different hypotheses highlighted in the categorization section. In addition, students' personal information is saved in the cloud repository, where each student is assigned a unique number through which they can be identified. The unique number is connected to the daily IoT-based activities within the institution.

4.3 Students Activity Classification using Adaptive Layered Bayesian Belief Network (AL-BBN)

In the methodology that is proposed in this study, there are two main categories of activities including, rare and monotonous activities. The later refers to those activities that involve the daily monitoring of students' progress using data from IoT sensors and hardware devices. The use of activity models can be employed in defining a wide array of students' activities. In this work, the correlations between independent variables and student attrition (which is the dependent variable), are captured and described using AL-BBN. AL-BBNs are complex mathematical models that show explicitly and naturally show the link prediction structural correlation across different models in an array of variables and variable groups. The AL-BBN chain rule is an approach that can be used to conveniently represent complex probability distributions, whereby each i_x represents a variable and Tz_{i_x} indicates the parents of the same (i_x) variable.

$$T(i_1,\ldots,i_n) = \prod_{x=1}^{n} T(i_x|Tz_{i_x}) \tag{10}$$

Some of the important activities of students that can be captured include participation of students in different forums and discussions, participation of students in study cohorts, college involvement in interactions that are key to the theme, and terms of membership of physical activities. The Bayes rule is the conditioned stimulus, and this rule involves the computation of the possibility of each provided target number or class of value. After the computation, the structure possessing the best estimated prediction is selected for the next stage. Lastly, this replica is aimed at identifying provisional correlations between student attrition predictors. For a variable i_x, a suitable representation of the students is required:

$$Tz_{i_x} = \{B, i_{\delta(x)}\} \tag{11}$$

Due to the fact that exponential growth is exhibited by the amount of conditional estimations that must be created for each root, it becomes necessary for an intelligent and professional AL-BBN engineer to commit a good amount of time to one or more domain experts so as to be able to build a moderate-sized network manually. The example below shows that B serves as the base classifier in the second fall that has been recorded. These utilizing techniques how much material is supplied when the category variable is known.

$$X_T(i_x;i_y) = \sum_{i_x,i_y} T(i_x,i_y) log \frac{T(i_x,i_y)}{T(i_x)T(i_y)}, \text{x} \neq \text{y} \tag{12}$$

The ordering, which is determined by the relationship amongst each pair of variables, only includes edges amongst predictor variables. An edge's weight in a graph is determined by mutual information which denotes the relationship between two variables. The following formula defines mutual information between two random variables i_x = Fall student active and i_y = Spring student active:

$$X_T(i_x : i_y \mid B) = \sum_{i_x, i_{y,B}} T(i_x, i_y, B) log \frac{T(i_x, i_y \mid B)}{T(i_x \mid B) T(i_{y|B})} \text{ x} \neq \text{y} \tag{13}$$

Where the tree is a function over Tz_{i_x} is the set of parents for each i_y, and B is the class variable Tz_{i_x} that has no students.

4.4 Students activity score based on fuzzy logic

There is a relationship between each illustration and a period. The data which provides details about the activities of students is known as temporal data. Dissimilar activities-related sensory input is provided in the form of behavior metrics at different timestamps. Through the process of fuzzification, a collection of terms and fuzzy language concepts are created based on the exact set of inputs provided. Subsequently, the use of membership function is employed in creating a set of fuzzy logic, and followed by the establishment of the final inference. Intra-class deviation, Inter-class volatility, and feature-based time of each component for each sub-band are all fuzzy logic input elements provided to the student's activity. The sub-band specific feature subsets are selected by using fuzzy logic with the most suitable classifiers.

$$e : S^m \rightarrow [0, h]^n. \tag{14}$$

The following production rules guide the fuzzy logic:

$$S_i : IFr_1 \wedge y_1 = B_{1i} ANDr_2 \wedge y_2 = B_{2i} ANDr_n \wedge y_n = B_{ni} THENclass = d_i, i = 1, \ldots, S,$$

where I denotes the rule index, S represents the number of rules, B_{Ki} is a fuzzy term characterizing the *k*-th quality in the *i*-th rule (k = 1, … , m); d_i is the resultant class, R = (r_1, r_2, …, r_n) is the binary vector of features, and line $r_1 \wedge r_k$ shows if a feature is present ($r_k = 1$) or absent ($r_k = 0$) in the classifier.

There is no exact quantity at the timestamp axis, considering the fact that there is difference in timestamp according to student. A tensor which is referred to as the student-activity data tensor ($R_g P_s$) has been designed with the aim of achieving this purpose. The mathematical representation of the daily $R_g P_s$ of a student is given as follows:

$$R_g P_s = [R_1, R_2, R_3, \ldots, R_m] \tag{15}$$

In the observation table, the class label is defined $\{(y_p; d_p), \text{p} = 1, \text{z}\}$ as follows:

$$class = d_t, t = \underset{1 \le i \le n}{\text{argmax}}\{\beta_i\} \tag{16}$$

$$\mu_j(y_p) = \mu_{Bi1}(y_{p1}) \ldots \mu_{Bin}(y_{pn}) = \prod_{k=1}^{m} \mu_{Bik}(y_{pk}) \tag{17}$$

$$\beta_t(y_p) = S^{\Sigma}_{iD_j = classt}\mu_t(y_p) = S^{\Sigma}_{iD_j = classt}\prod_{k=1}^{m} \mu_{Bik}(y_{pk}) \tag{18}$$

Where $m_{Bik}(y_{pk})$ denotes the fuzzy term Bik's membership function value at point y_{pk}.

$$F(\theta, R) = \frac{\sum_{p=1}^{z} \begin{cases} 1, IFd_p = arg \max_{1 \le i \le n} e_i(y_p; \theta, R) \\ 0, OTHERWISE \end{cases}}{z} \tag{19}$$

Where e(y_p; θ, R) denotes the output of fuzzy logic with fuzzy terms θ parameters and R at point y_p. The key challenge of designing a fuzzy logic is to ascertain the maximum of the function in space R and $\theta = (\theta^1, \theta^2, \ldots, \theta^D)$:

$$\begin{cases} F(\theta, R) \to max \\ \theta^j_{min} \le \theta^j \le \theta^j_{max}, j = \overline{1, D} \\ R_i \in \{0,1\} i = \overline{1, n} \end{cases} \tag{20}$$

Where θ^j_{min}, θ^j_{max} denotes the upper and bottom bounds of each parameter's fuzzy logic, respectively. This is an NP-hard problem, and in this study a proposal is made to resolve the problem by dividing it into two tasks which are student activity and fuzzy term parameter. Each activity (Z_y), where y is the amount of actions from 1 to n, and the students must complete *t*. The probability assessment of actions Z_y at day f can be expressed as U^f_y, where $1 \le f \le t$ is the element of working days in a college term. Using the formula below, a student's score for each activity R (Z_y) can be calculated:

$$R(Z_y)\frac{\sum_{f=1}^{t} U^f_y}{t} \tag{21}$$

Activities that are of great significance are considered as monotonous activities and have a U^f_y score that is calculated on a regular basis. While on the other hand, the balance of the events set is made up of activities that occur occasionally.

The fuzzy logic algorithm is presented in Algorithm 1 below

Algorithm 1: fuzzy logic algorithm

```
Step 1 Initialization
Initialize (Pop)
Archive.add (Pop)
Set Operators Prob (1.0)
window = Stagnation = 0
Step 2 primary loop
if the stopping requirement is not met,
Step 2.1 Parents' choice
for x = 1 to |Parents| do
ifRandomDouble (0, 1) ≤ β then
    Parents[x] ← TournamentSSD (Archive)
else
Parents[x] ← TournamentSSD (Pop)
end if
end for
Step 2.Reprint
Operator ← Roulette (OpProb)
Of fspring ← Operator (Parents)
Consider your options (Offspring)
UpdateUse = OpUse (Operator)
window++
Step 2.3 Update on the Archive
if ! (Archive.add (Offspring)) then
    Stagnation = Update Stagnation ()
end if
Step 2.4 Invoke the Fuzzy Inference System (FIS)
if window == windowSize then
UpdateOpProb(OpUse, Stagnation)
    Stagnation = 0 window
end if
Step 2.5 Population Update
NewPop ← Pop.add (Offspring)
fast non dominated sortSSD (NewPop)
P op ← RemoveWorstSolution (NewPop)
end while
Step 3 Output
return Archive
```

4.5 Decision making layer using Multi-Gradient Boosting Decision Tree (MGBDT)

The results obtained from the previous classification of decision tree are used in training each decision tree. The linear nature of the Multi-Gradient Boosting Decision Tree, makes the parallel training of the decision tree challenging. The second S_2 tree training optimization target is the sum of the first S_1 decision tree's outcome and the remaining S-value, and the method's final outcomes are the sums of each decision tree's outcome. Equation (13), in other words:

$$\hat{S} = S_1 + S_2 + S_3 \tag{22}$$

There are two loss functions possessed by the MGBDT that are often utilized for iterative optimization as shown in Equation (13). Alternatively, the effect can be optimized instantly, whereas, the other alternative can be the optimization of the gradient's decent significance. There is a difference between MGBDT and classic boosting. If MGBDT is sub-optimized, the target is optimal. The booster is a resembling device.

The estimated value of the many samples i as a node average power, which may be represented as Equation, is the integral gain μ of a node split (14),

$$\mu = \left(\sum\nolimits_{y=1}^{e} i_y\right)/e \tag{23}$$

Consequently, the node's mistake can be written as Equation (15),

$$\text{Error} = \sum(i_x - v)^2 \tag{24}$$

In the process of node division, it is compulsory to select the feature which has the high tear gain for segment, and the tear winning L is determined using the following formula:

$$\text{L} = Q - Q_x \tag{25}$$

Based on Equation (17), the difference can be thought of as a less function, or Q_x:

$$Q_x = \sum\nolimits_{n\in f}(i_n - \mu_f)^2 \sum\nolimits_{e\in P}(i_e - \mu_P)^2 \tag{26}$$

Consequently, every splitting node problem will be focused on identifying a variable that is capable of increasing the split gain the most Q and Q_x are separated and expanded as in formula (18):

$$L = \left(sum_f^2 / \|F\| + sum_P^2 / \|P\|\right) - sum^2 / \left(\|total\|\right) \tag{27}$$

sum^2 represents the total of squares of all variations, as stated in Equation (18), where sum_f^2 and sum_p^2 are the total of the squares of all variants in the sub tree, respectively. Consequently, only L needs improvement. As mentioned earlier, the tree nodes in each tree node in the MGBDT are not together, rather, they are separated in isolation. Each trained forest is aimed at summing up the original trees and rate of presentation. The information entropy can be calculated using the training set. The n class y = 1, 2, … n is defined by Q, which holds the number of data samples. Q_y is the number of data samples.

$$\text{Y}(q_{1,}q_2,\ldots q_n) = -\sum\nolimits_{y=1}^{n} w_y log_i(w_y) \tag{28}$$

E is the tree's root, and E contains e values $\{e_1, e_2, \dots \dots e_e\}$ The training set S is divided into subsets $\{S_1, S_2, \dots \dots S_e\}$, with S_x denoting a specific subset and e_x denoting the value of e. S_{yx} represents the element of samples in S_x that belong to Q_y.

$$K(E) = \sum_{x=1}^{e} \frac{S_{1x} + S_{2x} + \dots S_{nx}}{S} Y(s_{1x}, s_{2x}, \dots s_{nx}) \tag{29}$$

$$Y(s_{1x} + s_{2x} + \dots s_{nx}) = -\sum_{y=1}^{n} w_{yx} \log_2(w_{yx}) \tag{30}$$

$$Gain(E) = Y(s_{1x} + s_{2x} + \dots s_{nx}) - K(E) \tag{31}$$

The purpose of using MGBDT algorithm in this research is to enable decision-making on the performance of college students' performance. Factors such as data extraction, data treatment, selection of feature, training model, and prediction of unknown data have been prioritized. The MGBDT algorithm is represented by Algorithm 2.

Algorithm 2: MGBDT algorithm

Input: The training data set $G \epsilon S^n$, size of training set $e=|G|$, sample data $i_x \epsilon G$, $x = 1, 2, \dots e$, number of regression trees N, the maximum depth of each tree F.

Output: Trained model $Q = \left\{ SP_p = q_{z(.)}^{(p)}, p = 1, 2, .., N \right\}$

Initialization: $Q = ø$, $p = 0$, p is the current number of regression trees

While $p<N$: For all $i_x \epsilon G$, calculate the corresponding d_x and l_x according to

$$d_p = \partial H / \partial \hat{j}_x^{p-1}(i_x) - \left[j_x - \hat{j}_p(i_x) \right] \text{ and } l_x = \partial^2 H / \partial^2 \hat{j}_x^{p-1}(i_x);$$

Initialize the p th regression tree $SP_p = ø$ and the current depth of regression tree $f = 0$;

While $f<F$:

Tranverse every leaf node N_y in SP_p, find the best split for each leaf node according to

$$split^* = \underset{split \in r}{\text{argmin}} \frac{D_H^2}{L_H} + \frac{D_S^2}{L_S} - \frac{(D_H + D_S)^2}{L_H + L_S}$$

where $DH = \sum_{i_x \in N_{y,h}} d_x$ and $LH = \sum_{i_x \in N_{y,h}} l_x$, and D_S, L_S are similar.

Split N_y into left child N_y^H and right child, N_y^S, then add them into SP_p;

Traverse all the leaf nodes of SP_p, calculate the predicted value of N_y;

Add SP_p, into set Q;

Return Q.

5 Performance analysis

The newly proposed IoT and Adaptive Layered Bayesian Belief Network (AL-BBN) models are functional to Selective Multi-Gradient Boosting Decision Tree (MGBDT) algorithm applications, according to this section. The performance of the proposed approaches was analysed using performance parameters like precision, recall, accuracy, and score. In analysing the performances of the models, they were compared with extant approaches like Naïve Bayes, Artificial Neural Network, Logistic Regression, and Decision Tree.

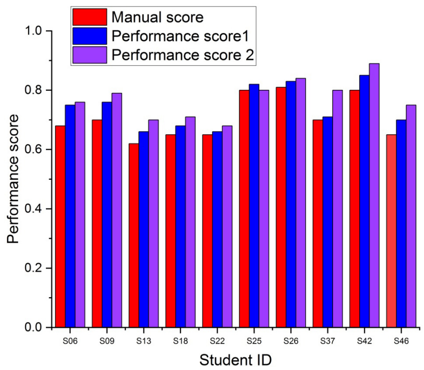

Fig. 5a. Performance score computation using proposed methodology

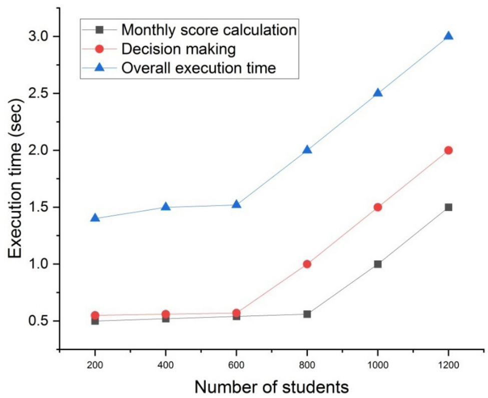

Fig. 5b. Proposed system component based execution time (in seconds) for each day

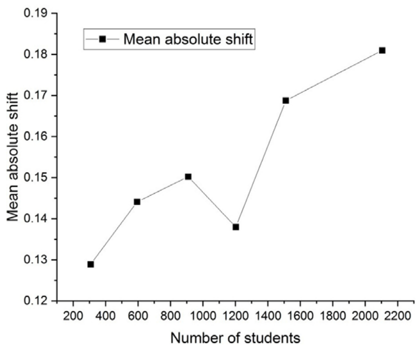

Fig. 5c. Proposed system stability

Figure 5. (a) The proposed mechanism for calculating performance scores, (b) proposed system component-based execution time (in seconds) for each day, (c) proposed system stability. Figure 5a Ten students from the same class were graded based on

their monthly performance over a period of three months. The performance of the first month was done using a manual system of grading, while that of the last two months was done using the approach proposed in this work. The effecting duration of numerous components required for the computation of the daily scores of students' performance is presented in Figure 5b. From Figure 5b, it can be clearly seen that the time required for the data mining stage is much longer than that of the recognition stage. Increase in the number of dataset based on the increase in the percentage of students' results in the relative shifting of the mean absolute value as shown in Figure 5c.

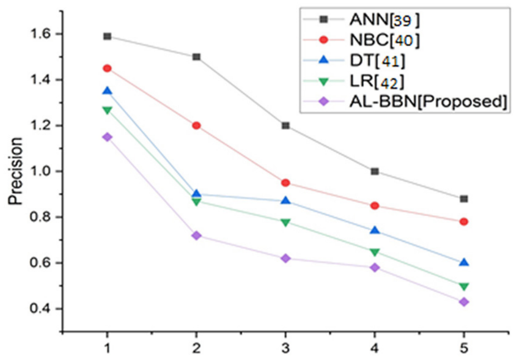

Fig. 6. Precision comparison

Precision refers to a quantity in decimal numbers that comes with the whole number and is unrelated to the accuracy. Practically, the concepts of accuracy and precision are synonymous, and as such, can be easily interchanged. The comparison of the proposed techniques with extant techniques based on precision is presented in Figure 6.

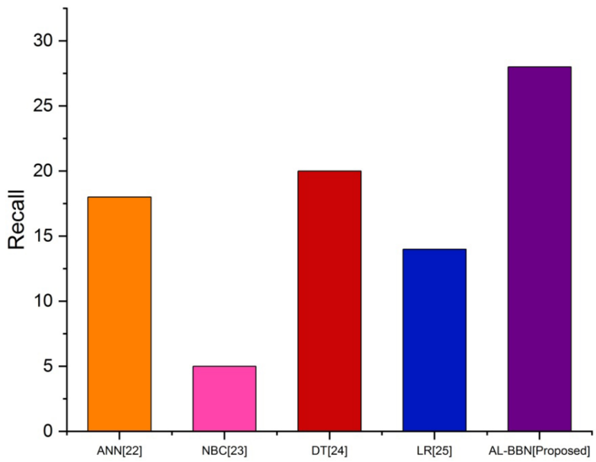

Fig. 7. Recall comparison

A user holds recall when recalling a visit or repeating a sonnet after reading its title. Here, a multiple-choice test was used given that is easier than an essay and more preferred by people. The administered test was based on recall remembrance. The result of the comparison between the extant approaches and proposed approach based on the recall parameter is shown in Figure 7:

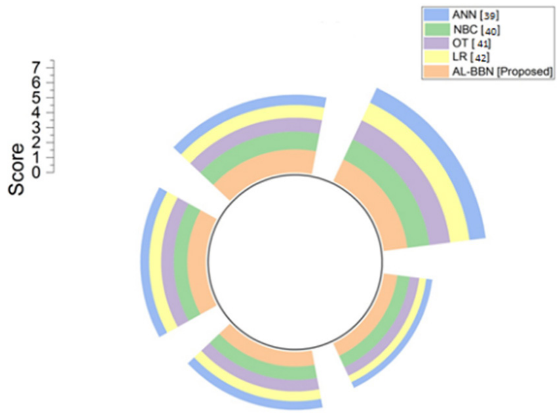

Fig. 8. Score comparison

Figure 8: Score of comparison between proposed approach and existing approaches.

$$score = \frac{tp}{tp + 0.5(fp + fn)} \tag{32}$$

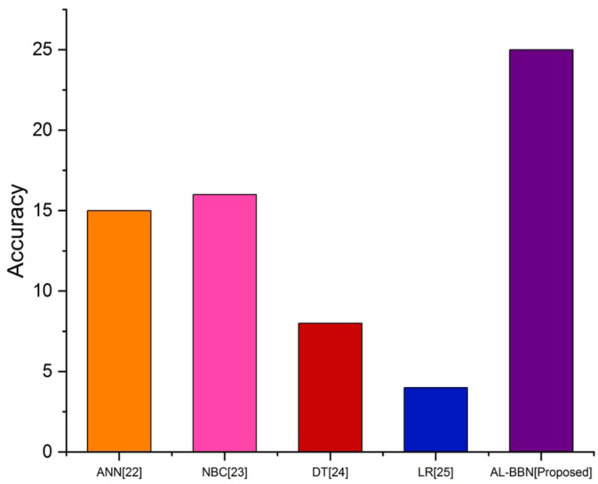

Fig. 9. Accuracy comparison

Accuracy provides the categorization with the required educational information. Figure 9: results of the comparison between the proposed approach and extant approach based on accuracy.

$$Ac = \frac{(tp + tn)}{(tp + tn + fp + fn)} \tag{33}$$

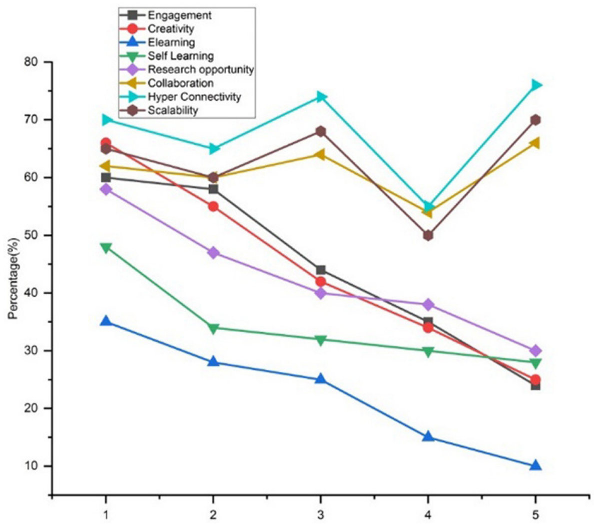

Fig. 10. Comparison between the predictions of teacher-based and student version

Figure 10 shows the results of the graphical comparison, with the two scenarios overlapping in three elements (research opportunity, e-learning, and hyper-connectivity). The organizations opine that the variables of virtual education IoT ecosystem are significantly influenced by the Internet of Things. Based on the student's view the most critical component in virtual learning is self-learning, however, it is not of much relevance in the eyes of the teacher. Also, the influence of IoT use in virtual education on the issue of cooperation is another difference between the two perspectives. It is believed by teachers that the IoT enables effectiveness in terms of teamwork, and cooperation, but students do not value the Internet of Things in that regards.

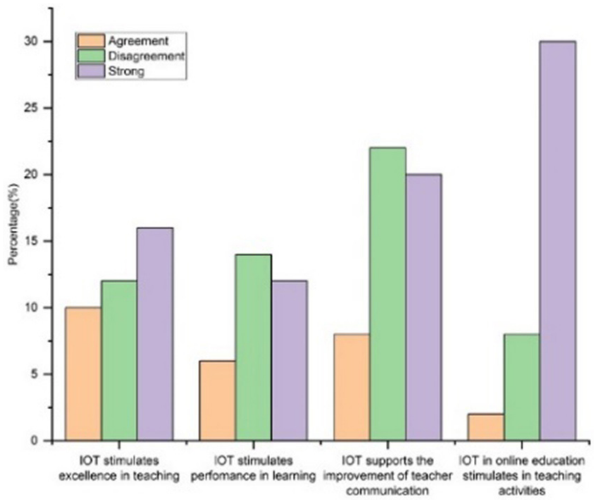

Fig. 11. Impact of the IoT in online education

Figure 11 presents the impact of IoT on virtual education. The findings revealed that IoT enables excellent performance in teaching, with high percentage in comparison to the disagreement and agreement. More so, the findings show that in terms of improvement in teacher communication, most respondents disagreed that the IoT enables improved communication. Meanwhile, a high percentage of the respondents agree that IoT enables teaching activities.

6 Discussion

Here, the usefulness of the approach proposed in this study is estimated in contrast to the IoT that was previously mentioned for the given data. It was also found that the method proposed in this study performs as good as that of global standard approaches like ANN [39], NBC [40], DT [41], and LR [42]. In ANN [39], the selected projection technique directly impacts on the connection's performance. The ANN should first be converted into numerical characters before it can be used to solve any problem. In the study of [40], the NBC 'zero-frequency problem,' occurs anytime the lowest error is assigned by the system to the predictor data whose category is not found in the dataset. Therefore, a mild strategy should be used in solving this problem. In the study of [41], it was demonstrated that the logistic regression may be significantly reshaped by a small piece of data, which can in turn increase insecurity for the system. In comparison with other approaches, the estimation of a decision tree can be extraordinarily complex durion. It takes a loger period of time to retrain a decision tree. The authors in [42] revealed that the key limitation of crucial limitation of logistic regression is the condition of proportionality between the logistic regression variables. Predictor accuracy (coefficient size) as well as connection direction are also revealed (positive or negative). However, the aforementioned limitations can be solved through the use of the proposed technique. In this part, the analyses of the experiments have been presented for MGBTDT algorithm and AL-BBN. Based on the evaluation, it can be concluded that the proposed approach demonstrated superior performance in terms of IoT as compared to ANN [22], NBC [40], DT [41], and LR [42].

7 Conclusion

The proposed system demonstrates an experimental configuration concentrating on the AL-BNN in a IoT virtualized environment. The MGBDT algorithm was presented to initiate, solve, and test the problem's intents. Consequently, the results revealed that improvements were achieved in the IoT method. The extant approaches include Naïve Bayes Classifier, Artificial neural network (ANN), Logistic Regression, and Decision tree (DT). Lastly, the performance parameters of the study are examined in comparison with those of other models with the aim of determining the most effective one. In addition, the procedures of data migration needed to meet the requirement of the future generations can be deployed.

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