Predicting University Student Retention using Artificial Intelligence

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***Abstract*—Based on the advancement in the field of Artificial Intelligence, there is still a room for enhancement of student university retention. The main objective of this study is to assess the probability of using Artificial Intelligence techniques such as deep and machine learning procedures to predict university student retention. In this study a variable assessment is carried out on the dataset which was collected from Kaggle repository. The performance of twenty supervised algorithms of machine learning and one algorithm of deep learning is assessed. All algorithms were trained using 10 variables from 1100 records of former university student registrations that have been registered in the University. The top performing algorithm after hyper-parameters tuning was NuSVC Classifier. Therefore, we were able to use the current dataset to create supervised Machine Learning (ML) and Deep Learning (DL) models for predicting student retention with F1-score (90.32 percent) for ML and the proposed DL algorithm with F1-score (93.05 percent).**

Keywords*—Artificial intelligence; machine learning; deep learning; retention; student; prediction

I. Introduction

To begin with, Neural Networks remained extensively recognized as Artificial Neural Networks. A construction similar to the biological neurons implementation, with a learning configuration grounded on probability that gets input data to make a decision on an output. Texts, images and audio files are examples of input data. Deep Learning (DL) employs artificial neurons to work on high dimensional data. DL can accomplish tasks including information processing and communication patterns [1, 2, 3].

Fig. 1 exemplifies the rudimentary structure of Neural Networks, beginning with the first layer called the input and the last one is the output with the middle layers as the hidden layers therefore the name “deep”. With additional research, and with the implementation of backpropagation, the structure was enhanced. The algorithm of backpropagation has two phases, the first one is for the input to forward the data in the direction of the output, the second one is to assess and approximate the error and back-propagating error values to the neural networks for correcting the error.

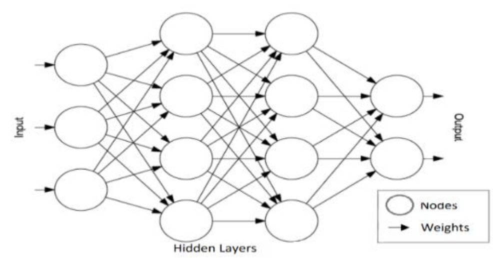


Fig. 1. Structure of Neural Networks

Every node in is an attribute pulled out from the portion beforehand. The count of neurons in a layer differs for every system, as c of the neuron in every layer should be capable of capturing the vital layer. The first layer of the model is usually high in terms of the count of neurons [4, 5].

DL defines an entirely new area of research with the architecture that has solved many of the problems that existed in the traditional systems in which the model was used for definite usage or exact commands [6].

DL was capable of a more unified model that could be useful on many applications in addition to diverse users. The structure of DL can be applied on numerous applications, like Google Assistant which can be implemented in mobile devices (Android), moreover can be implemented in search engines (Google) in addition to being applied on home devices (Google Home), and likewise employed in video captioning like video captioning on the YouTube [7, 8].

In this paper, some data classification techniques are applied to the evaluation of the dataset to predict whether students will continue to attend university or not by finding the best classification technique in accordance with these measures: F1-score, Accuracy, Precision, Recall, and time performance.

We used 20 machine learning algorithms to predict whether students will continue to attend university or not. Furthermore, a deep learning model was proposed for the same purpose.

The aim of this study is to answer the following questions:

- Can we use the dataset at hand to create a supervised machine learning classifier to predict reliably whether a student will go to university or not?
- Can we use the dataset at hand to create a supervised Deep learning classifier to predict reliably whether a student will go to university or not?
- Would the performance of Deep Learning techniques be better than the machine learning techniques in this case?

II. Machine Learning Algorithms

Machine learning algorithms can be applied to solve multiple problems. Classification can be used to assign a category to items or answer “yes” or “no” questions. An example of a classifier is a program that categorizes news articles or a spam filter that answers the question “spam” or “not spam”. Regression algorithms can be used to predict values for items such as housing prices. Ranking can be used to order items according to a criterion and clustering can be used to partition items into homogeneous regions [9, 10, 11, 12 , 13].

A decision tree is an example of a machine learning algorithm. Decision trees contain a root with a question. The root has branches to more nodes with questions and each path of nodes and branches ends with a leaf containing a label. The tree is traversed by taking decisions at each node based on the question until a leaf is found and the label for the leaf is returned as the answer to the root question [14, 15, 16].

Ensemble learning methods are boosting algorithms that combine several weak learners into a single strong learner. One example of a boosting algorithm, AdaBoost [17], builds this strong learner from several weak learners by making the next learner focus on improving the mistakes of the previous learner. The learners are assigned weights by the algorithm after each iteration and the weights are used to merge the weak learners into a strong learner [18, 19].

Linear models predict values by seeking a hypothesis of a hyperplane that has the smallest outcome of an error function. The linear model has to predict the value of y for the input value x. Using a set of known inputs x and labeled output values y a model is evaluated which has the smallest error, in this case distance of the line from the points in the graph. The model with the smallest error is represented as a line passing through the points. New input values x can then have their output values y predicted using the model by inspecting where the line meets the input value x on the y axis. Linear models such as Logistic Regression can also be used to solve classification problems [20, 21, 22, 23, 24].

Support Vector Machines (SVM) can be applied to both regression and classification problems. SVMs seek to find a hyperplane which has the maximum margin from all inputs in the training set. SVMs differentiate and improve upon Linear Models with a better error or loss function. SVMs can be even more improved upon with the use of kernels to define non-linear decision boundaries [25, 26, 27, 28].

In addition to the aforementioned algorithms, a great deal of other algorithms exist. K-Nearest-Neighbor considers neighboring objects in the dataset to train a better model [29]. Naive Bayes (NB) algorithms use Bayes’ theorem to compute conditional probabilities [30]. Discriminant Analysis classifies objects in a dataset by identifying the best feature to discriminate between classes [31, 32].

III. Methodology

In this section we will give details of the data collection, preparation, feature analysis, data splitting, modeling the proposed deep learning algorithm, training, validating and testing all the algorithms used in this study(as shown in Fig. 22).

A. Dataset

The dataset was collected from Kaggle depository. The dataset consists of 11 features and contains 1000 records. Table I lists all the features available from the dataset.

TABLE I. A List of Available Features

Feature	Type	Description
Type-school	object	Academic or Vocational
School-accreditation	object	A or B
Interest	object	Very Interested, Uncertain, Less Interested, Quiet Interested, Not Interested
Average-grades	numeric	75% to 98%
Gender	object	Male or Female
Residence	object	Urban, Rural
Parent-age	numeric	40 to 65 years
Parent-salary	numeric	1,000,000 to 10,000,000
House-area	numeric	20..120
Parent-was-in-university	Boolean	True or False
In-university	Boolean	True or False

B. Feature Analysis

1) Correlation matrix: The highest in negative correlation will be parents-was-in-university – parent-age, and with positive is parent-salary – in-university, house-area – in-university and average-grades – in-university as illustrated in Fig. 2.

2) Histogram for distribution: Fig. 3 shows the distribution of the features: parent-age, parent-salary, house-area, and average-grades.

3) Density plot for distribution: Fig. 4 illustrates the density plot distribution for parent-age, parent-salary, house-area, and average-grades. The overall distribution looks a little bit normal.

4) Outliers: Fig. 5 does not show so many outliers, so my decision is to keep it without further cleaning.

5) Residence count based on university status: Overall the Urban is more likely to go to university and the opposite happens in Rural as shown in Fig. 6.

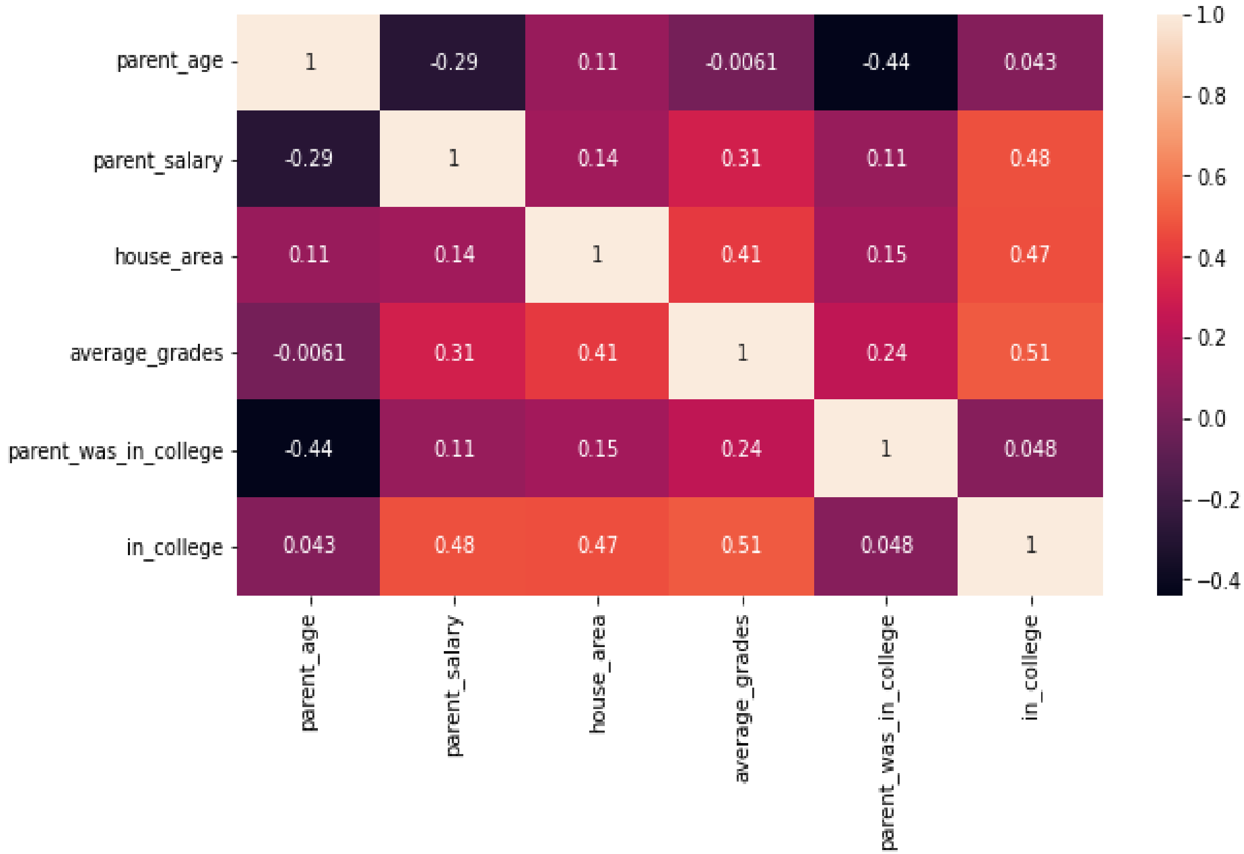


Fig. 2. Correlation Matrix.

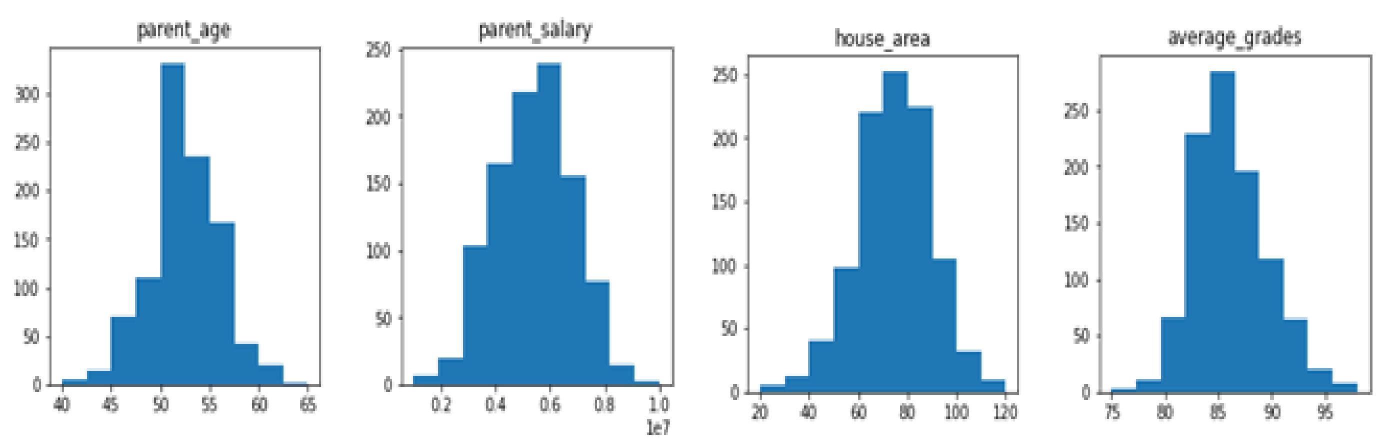


Fig. 3. Histogram for Distribution.

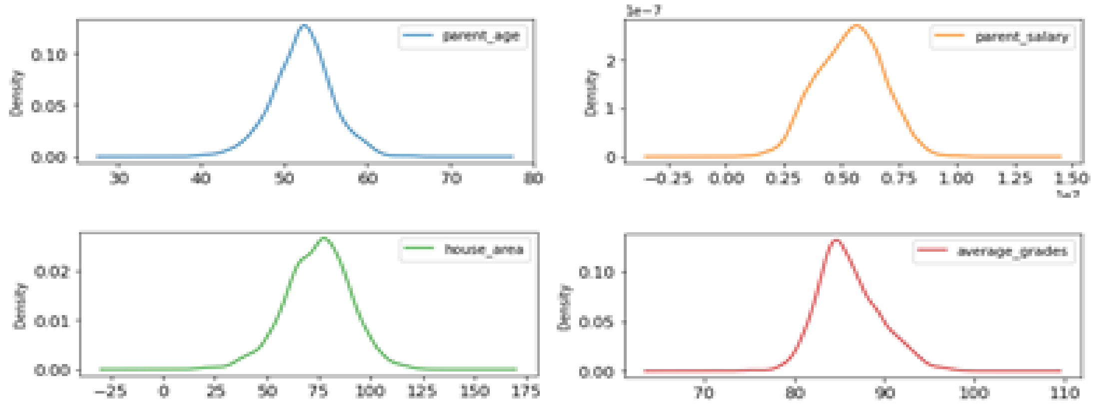


Fig. 4. Density Plot for Distribution.

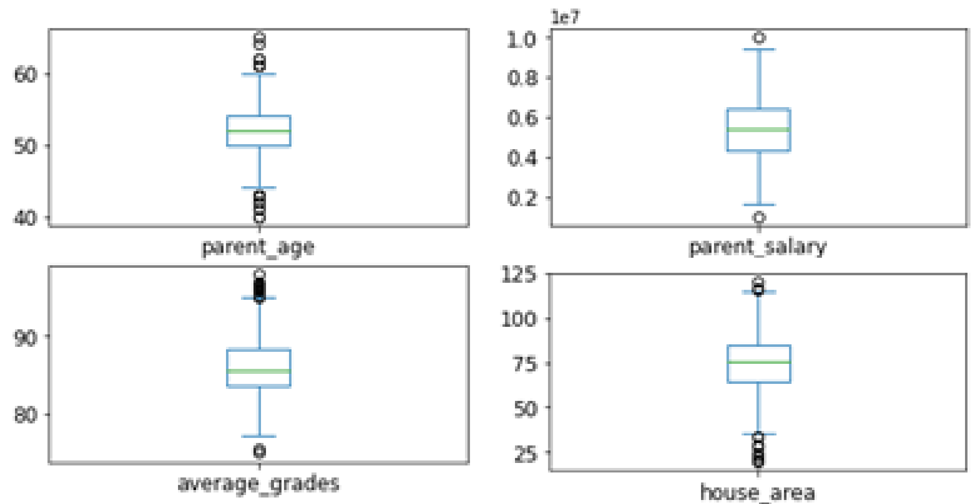


Fig. 5. Outliers of the Parent-Age, Parent-Salary, Average Grades, and House-Area.

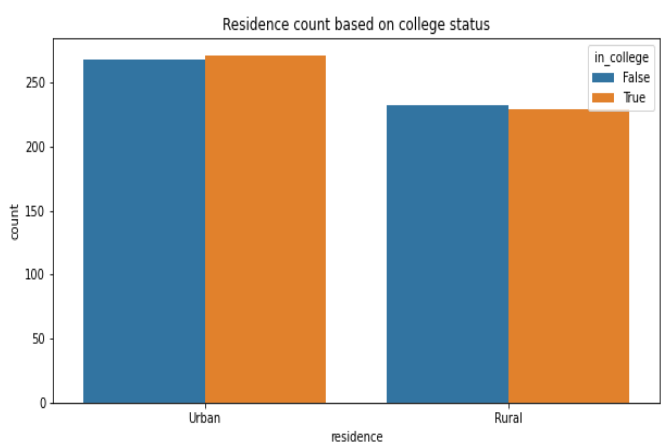


Fig. 6. Residence Count based on University Status.

6) Residence with parent salary based on university status: Fig. 7 illustrates that the higher the salary the more likely to go to university for both Urban and Rural.

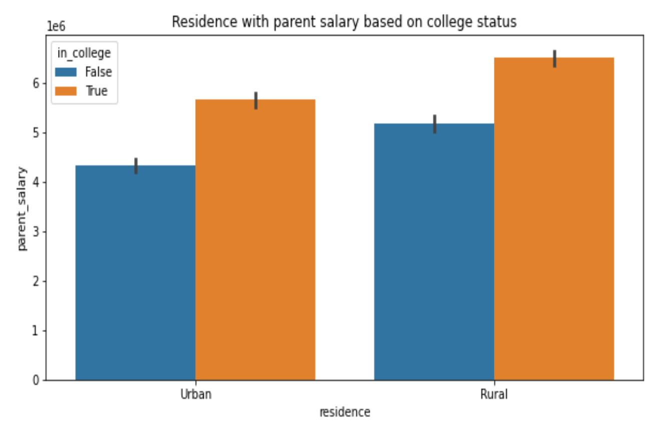


Fig. 7. Residence with Parent Salary based on University Status.

7) Interest count based on university status: From Fig. 8, Very Interested and Uncertain Interest are the two most categories attending the university, and Less Interested is the most in the category who does not attend the university.

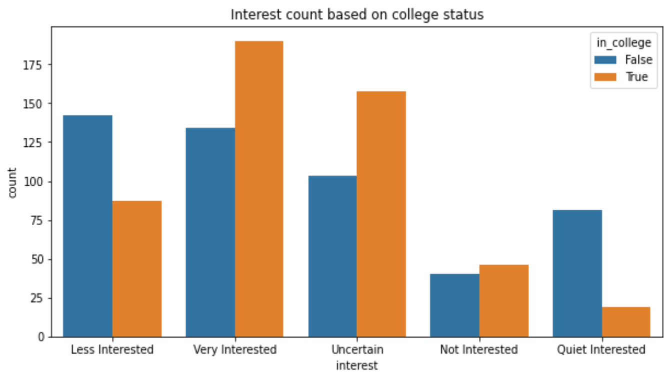


Fig. 8. Interest Count based on University Status.

8) School type count based on university status: Fig. 9 show that the Academic is the most in the category who attended the university.

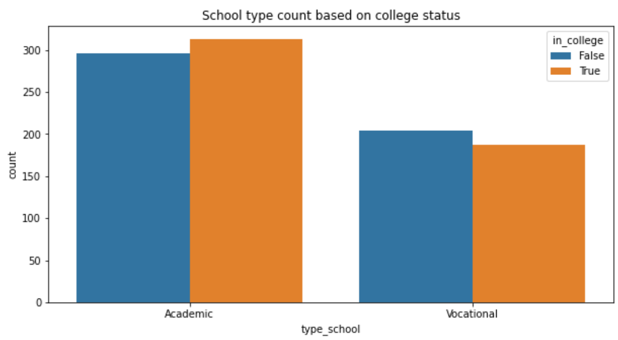


Fig. 9. School Type Count based on University Status.

9) Gender count based on university status: From Fig. 10, females are slightly higher to attend the university than Males.

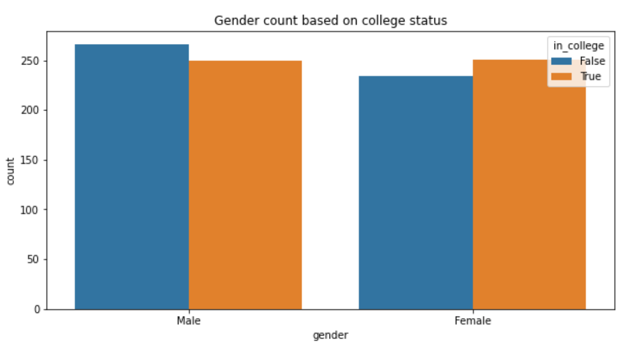


Fig. 10. Gender Count based on University Status.

10)Parent age, residence and parent–was-in-university: Fig. 11 illustrates that urban parents was slightly higher to attend the university than rural parents.

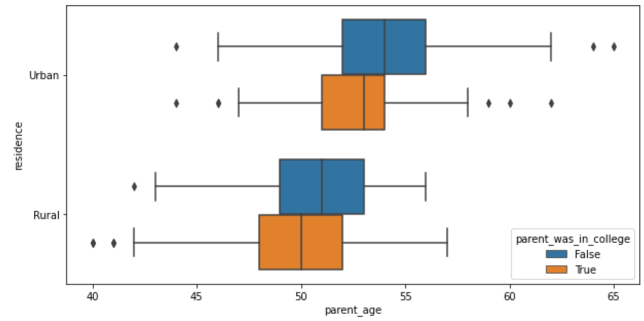


Fig. 11. Parent Age, Residence and Parent–was-in-University Relation.

11)Parent salary, residence and parent–was-in-university: Fig. 12 show that rural parents were higher salary and not attended to university and the opposite for urban parents.

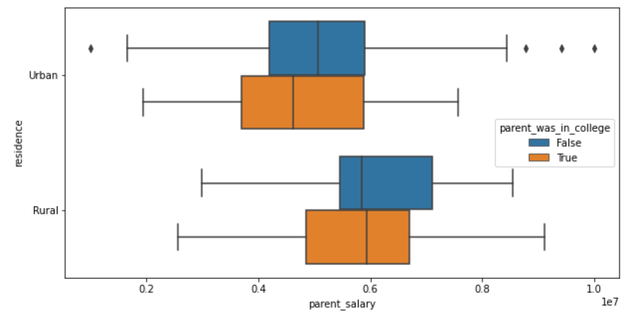


Fig. 12. Parent Salary, Residence and Parent–was-in-University.

12)Parent salary, residence and in-university: The more salary in both Rural and Urban parents the more likely for their child to attend the university as can be seen in Fig. 13.

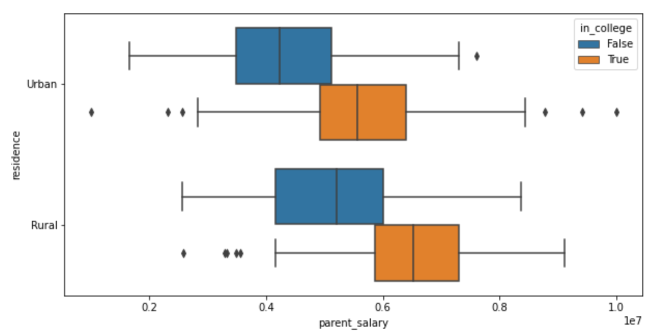


Fig. 13. Parent Salary, Residence and in-University.

13)House-area, residence and in-university: The more house area in both Rural and Urban the more likely for a child to attend the university, that's means by logic the family has more salary overall as can be seen in Fig. 14.

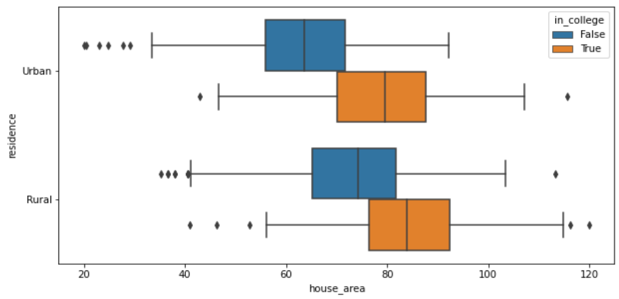


Fig. 14. House-Area, Residence and in-University.

14)Average-grades, gender and in-university: The more average grades in both males and females the more likely to attend university as shown in Fig. 15.

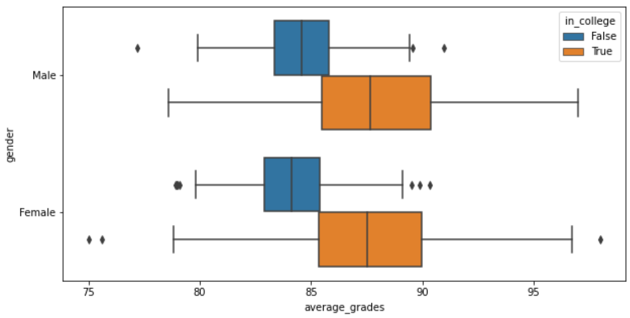


Fig. 15. Average-Grades, Gender and in-University.

15)Average-grades and in-university: The higher on average grades the more likely to attend the university as in Fig. 16.

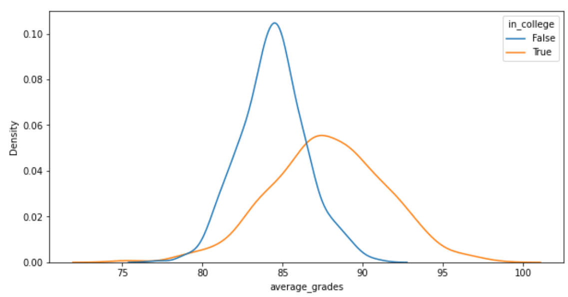


Fig. 16. Average-Grades and in-University.

16)Parent-age and in-university: Not so much effect by the age of parents for a child to attend the university as in Fig. 17.

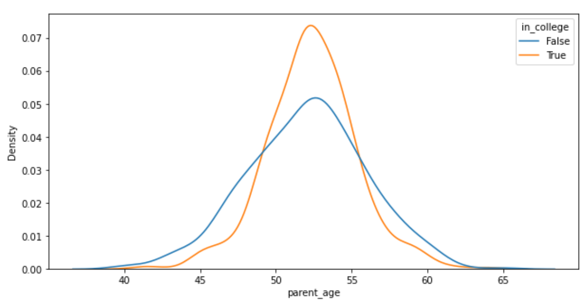


Fig. 17. Parent-Age and in-University.

17)Parent- salary and in-university: From Fig. 18, the higher on a parent's salary the more likely for the child to attend university.

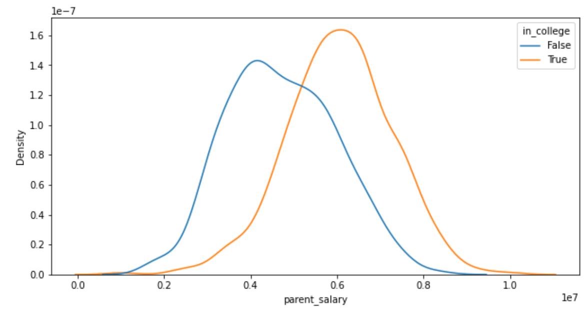


Fig. 18. Parent- Salary and in-University.

18)House-area and in-university: From Fig. 19, it can be seen that the higher the house area the more likely for the child to attend university.

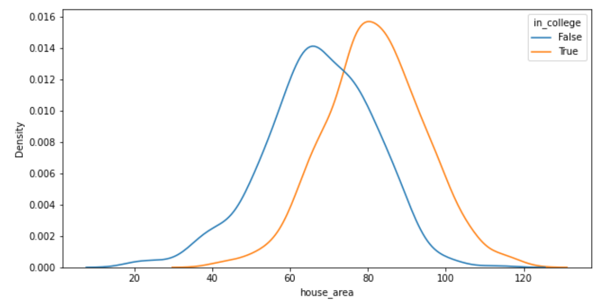


Fig. 19. House-Area and in-University.

19)Converting categorical column to numeric ones: We have converted the categorical type features (type-school, school-accreditation, gender, interest, residence, parent-was-in-university, and in-university) to numeric values.

20)Class (in-university) Distributions: We checked whether the class (in-university) is balanced or not. It turned out to be balanced as shown in Fig. 20.

C. Dataset Splitting

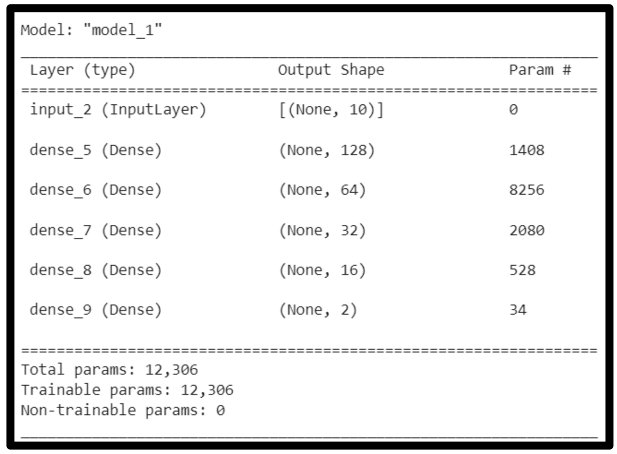
We have split the current dataset into three datasets: Training, validating, and testing datasets. The ratio of splitting was (80%, 10%, 10%).

Fig. 20. Class (in-University) Distribution.

D. Description of the Algorithms used in this Study

There are many algorithms of Machine Learning that can be applied for the prediction of whether the student continues to attend university or not. We have trained, validated and tested 20 various ML algorithms on our current dataset. The algorithms that were used for prediction and analysis are from different categories of machine learning algorithms to predict whether students will continue to attend university or not.

Furthermore, a deep learning model was proposed to predict whether students will continue to attend university or not. The proposed DL model consists of 6 Dense layers: one input layer (10 features), 4 hidden layers (128, 64, 32, and 16 neurons), and one output layer with 2 classes and softmax function as shown in Fig. 21.



```
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 10)]              0

 dense_5 (Dense)             (None, 128)               1408

 dense_6 (Dense)             (None, 64)                8256

 dense_7 (Dense)             (None, 32)                2080

 dense_8 (Dense)             (None, 16)                528

 dense_9 (Dense)             (None, 2)                 34

=================================================================
Total params: 12,306
Trainable params: 12,306
Non-trainable params: 0
_________________________________________________________________
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Fig. 21. Structure of the Proposed DL Model.

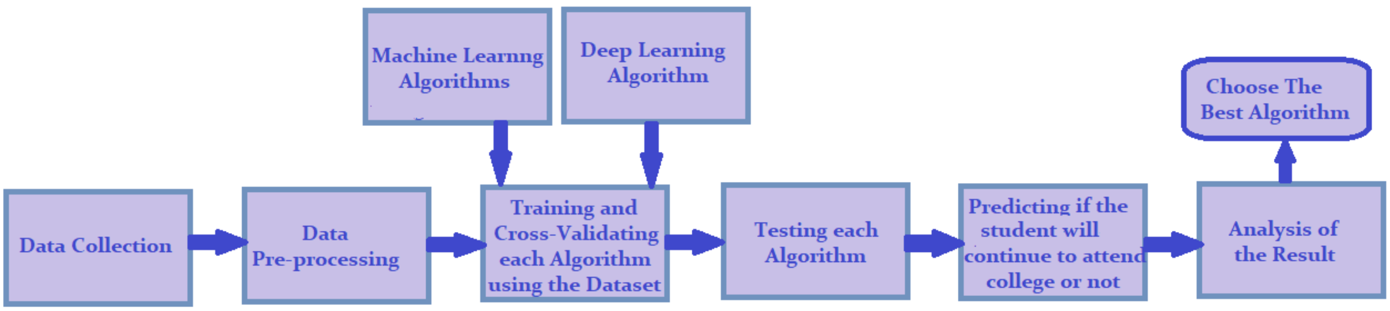

Fig. 22. Methodology for the Prediction if Student will Continue to Attend University or not.

IV. Results and Discussion

A. Performance Evaluation

We used the most popular performance measures for machine and deep learning algorithms such as: precision, recall, accuracy, and F1-score as outlined in eq. 1, 2, 3, and 4.

$$\text{Accuracy} = (TP+TN) / (TP + TN + FP + FN) \quad (1)$$

$$\text{Precision} = (TP / (TP+FP) \quad (2)$$

$$\text{Recall} = (TP / (TP+FN) \quad (3)$$

$$\text{F1-score} = 2 \times (\text{Precision} \times \text{Recall})/(\text{Precision}+\text{Recall}) \quad (4)$$

Where TP = True Positive, TN = True Negative

FP = False Positive, FN = False Negative

B. Performance of used Algorithms

We used a group of machine learning and one proposed deep learning algorithm for the prediction of whether a student will continue to attend university or not.

The machine learning algorithms belong to different categories of machine learning like Naïve based, SVM, KNN, trees, analysis, and others [28-30]. The proposed deep learning algorithm is custom made for the prediction if a student will continue to attend university or not.

We have split the dataset into Training, Validating, and Testing. We have trained every algorithm individually using our training dataset, tested it and we made a record of its accuracy, recall, F1-score, precision, and time needed for training and testing.

Furthermore, we have trained the proposed deep learning algorithm using the same training dataset and cross-validated it using the validating dataset. We kept training the proposed DL algorithm until there was no room for improvement. We made a record of the DL algorithm accuracy, recall, F1-score, precision, and time needed for training, validating and testing. Part of the DL algorithm training, validating accuracies and losses are shown in Fig. 23.

It turned out that the best Machine Learning algorithm was NuSVC for predicting whether students will continue to attend university or not.

NuSVC (Nu-Support Vector Classification) belongs to the family of Support vector machines (SVM). SVM can be used in classification problems as well as regression problems. SVC (C-Support Vector Classification): Support vector classification, based on libsvm, the time complexity of data fitting is the second power of the data sample, which makes it difficult to expand to 10,000 dataset, when the input is multi-category (SVM was originally to deal with two classification problems), through a one-to-one solution, of course there are other solutions.

NuSVC core support vector classification, similar to SVC, is also implemented based on libsvm, but the difference is the number of support vectors through a parameter null value.

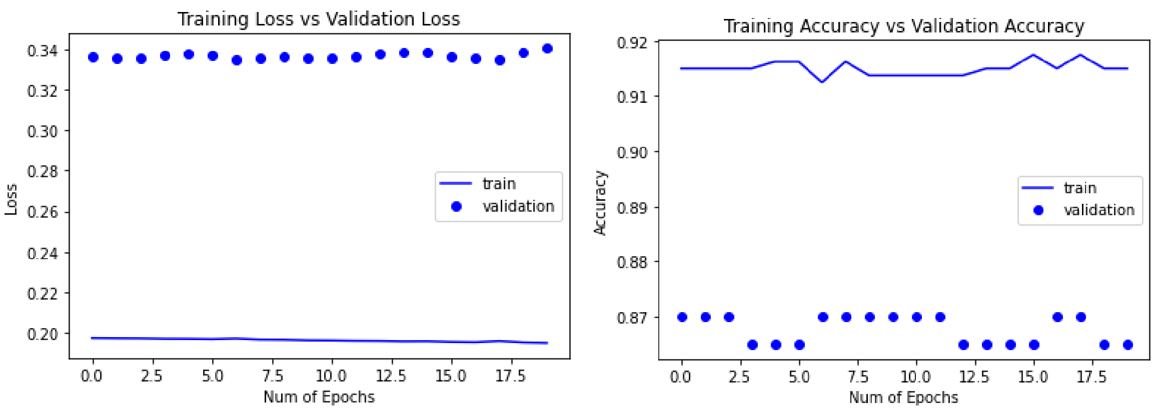

Fig. 23. Training vs Validation Losses and Accuracies.

NuSVC model achieved F1_score (90.32%), Accuracy (91.00%), Recall (92.31%), Precision (88.42%), time required for training and testing (0.05 second) as can be seen in Table II.

Additionally, the proposed DL algorithm scored: Accuracy (93.23 percent), F1-score (93.05 percent), Recall (93.22 percent), Precision (92.55 percent), and time necessary for testing (0.67 second) for predicting whether student will continue to attend university or not as can be seen in Table III.

The first aim of this study was to answer the following question: Can we use the dataset at hand to create a supervised machine learning classifier to predict reliably whether a student will go to university or not? The answer for this question is yes, we were able to create a supervised machine learning algorithm and F1-score accuracy was 90.32%.

The second aim of this study was: Can we use the dataset at hand to create a supervised Deep learning classifier to predict reliably whether a student will go to university or not?

The answer to this question was also yes and achieved an F1-score of 93.05%.

TABLE II. PERFORMANCE OF THE MACHINE LEARNING ALGORITHMS

Machine Learning Model-Name	**Accuracy**	**Precision**	**Recall**	**F1_score**	**Time-in-Sec**
NuSVC	91.00%	88.42%	92.31%	90.32%	0.05
RandomForestClassifier	90.00%	90.00%	90.00%	90.00%	0.19
GradientBoostingClassifier	89.50%	87.23%	90.11%	88.65%	0.14
LogisticRegressionCV	88.00%	83.84%	91.21%	87.37%	0.31
QuadraticDiscriminantAnalysis	87.50%	83.00%	91.21%	86.91%	0.01
MLPClassifier	87.50%	84.38%	89.01%	86.63%	0.68
LogisticRegression	87.00%	82.18%	91.21%	86.46%	0.01
LGBMClassifier	87.50%	85.87%	86.81%	86.34%	0.08
LinearSVC	86.50%	81.37%	91.21%	86.01%	0.01
CalibratedClassifierCV	86.50%	81.37%	91.21%	86.01%	0.06
LinearDiscriminantAnalysis	86.50%	82.65%	89.01%	85.71%	0.01
AdaBoostClassifier	86.00%	80.58%	91.21%	85.57%	0.10
GaussianNB	86.50%	84.04%	86.81%	85.41%	0.00
BaggingClassifier	86.50%	84.04%	86.81%	85.41%	0.05
Perceptron	85.00%	79.05%	91.21%	84.69%	0.01
SGDClassifier	84.50%	81.25%	85.71%	83.42%	0.01
KNeighborsClassifier	84.00%	84.71%	79.12%	81.82%	0.01
LabelPropagation	83.50%	82.22%	81.32%	81.77%	0.03
ExtraTreeClassifier	81.50%	78.12%	82.42%	80.21%	0.01
DecisionTreeClassifier	80.50%	74.53%	86.81%	80.20%	0.01

TABLE III. PERFORMANCE OF THE PROPOSED DEEP LEARNING ALGORITHM

Deep Learning Model-Name	**Accuracy**	**Precision**	**Recall**	**F1_score**	**Time-in-Sec**
Proposed DL Model	93.23%	92.55%	93.22%	93.05%	0.67

The last aim of the study was: Would the performance of Deep Learning techniques be better than the machine learning techniques in this case?

The answer is yes, because the deep learning algorithm scored 93.05% in F1-score while the machine learning algorithm achieved 90.32%.

V. Limitation of the Study

The current study is limited in terms of the dataset collected where it consists of 11 features (10 input features and one output feature) and 1100 records only. Furthermore, the current study is limited in terms of ML algorithms used, where we used only 20 ML algorithms among many as indicated in Table II.

VI. Conclusion and Future Works

In this study, we used twenty Machine Learning algorithms and a deep learning algorithm for predicting whether students will continue to attend university or not. The dataset was collected from Kaggle Repository. In order to predict whether students will continue to attend university or not, a group of 20 machine learning and one deep learning algorithm were used. Among the machine learning models used, the best machine-learning algorithm was NuSVC for predicting whether students will continue to attend university or not. NuSVC model achieved F1-score (90.32 percent), Accuracy (91.00 percent), Recall (92.31 percent), Precision (88.42 percent), time required for training and testing (0.05 second). Furthermore, the proposed DL algorithm attained: F1-score (93.05 percent), Accuracy (93.23 percent), Recall (93.22 percent), Precision (92.55 percent), time required for training and testing (0.67 seconds) for predicting whether student will continue to attend university or not.

In future work, other methods of ML algorithms may be utilized and the deep learning model should be tuned further to get better performance.

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