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Towards a digital enterprise: the impact of Artificial Intelligence on the hiring process

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ABSTRACT: In this paper, we proposed a decision support tool for recruiters to improve their hiring decisions of suitable candidates for such a vacancy post. For this purpose, we proposed the use of the Artificial Neural Network (ANN) method from Artificial Intelligence (AI), thus we used real data from a recruitment agency. However, for the adopted methodology, we used the process opted by the methods and techniques related to Data Mining.
As a result, after completing the modelling process, we were able to obtain a model capable of predicting the decision to accept or reject such a candidate for such a vacancy. However, we obtained a model with an accuracy of 99% as well as with a very low error rate.
However, our results show that Artificial Intelligence techniques can provide a better decision support tool for recruiters while minimising the cost and time of processing applications and maximising the accuracy of the decisions made.

KEYWORDS: Artificial Neural Network (ANN), Human Resources (HR), Artificial Intelligence (AI), Digital Enterprise, Recruitment

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INTRODUCTION

In the current era of globalisation and the emergence of new technologies, as well as the competition of the global business market, companies cannot afford to continue to adopt traditional methods in the various business processes. However, new methods emanating from Artificial Intelligence (AI) can improve the smooth running of the company, especially in managing the hiring process. However, the hiring process follows important steps such as the selection and appointment of suitable candidates for such a vacancy post.

Every enterprise invests a lot of money and time in recruiting persons for specific positions and wastes resources in searching for potential candidates. The total investment becomes a loss if the selected candidates do not meet the company's requirements after completing the whole hiring process. Therefore, the objective of this empirical study is to propose a decision support tool to improve the hiring process using a method from Artificial Intelligence.

In this paper, we have applied the Artificial Neural Network (ANN) method to build a predictive model of the decision in the hiring process. Our methodology consists of adopting the process applied by Data Mining techniques, starting with a pre-processing and exploratory analysis of the data, then building our model by the Artificial Neural Network method using the proportion of training data and finally evaluating the model using the proportion of test data, using the various validation metrics emanating from the confusion matrix.

1. LITERATURE REVIEW

A range of scientific papers have revealed the importance of exploiting new methods from Artificial Intelligence in several fields and disciplines.

For (S. Singh et al., 2013) compared several methods from Artificial Intelligence, in order to build a model capable of analysing the performance of students' academic records as well as to rank students according to their final grade in different classes (Excellent, Average, Poor), however the results obtained revealed the robustness of these methods.

In the employment market, and more specifically in the application of Artificial Intelligence techniques in the hiring process, several studies have been carried out in this sense in order to improve the said process.

Therefore, the study conducted by (D. Alao et Al., 2013), the authors constructed a set of rules using the decision tree method in order to build a model capable of predicting new employee attrition, however, the results obtained yielded a model with an accuracy of 74%.

For (C. E. A. Pah et al., 2020) proposed a decision support model for ranking candidates in the employee hiring process using a variety of methods from Artificial Intelligence, namely, C4.5 decision tree, Naïve Bayes, SVM and Random Forest. However, the authors achieved a maximum accuracy of 88.24% using the decision tree method.

2. HIRING PROCESS

If a company wants to select a specific employee profile and skills, it will need to introduce sound tactics into the hiring process.

Owever, the hiring process can be internal or external, therefore, it can take many forms that differ from one company to another, but remains faithful to the single purpose of choosing the best profile for such a job vacancy. However, the selection of candidates for an interview is a crucial step and represents more than 50% of the rating assigned to the pre-selected candidates.

3. ARTIFICIAL NEURAL NETWORK (ANN)

Artificial neural networks (ANNs), inspired by biological neural networks, represent a field of research that deals with learning and reasoning problems. As statistical classification techniques, unlike parametric techniques, ANNs are robust to misspecification (Cybenko, 1989; Funahashi, 1989; Barron, 1993).

Neural networks, as systems capable of learning, implement the principle of induction, i.e., learning from experience. By confrontation with specific situations, they infer an integrated decision system whose generic character depends on the number of learning cases encountered and their complexity in relation to the complexity of the problem to be solved.

An artificial neural network is generally composed of a succession of layers, each of which takes its inputs from the outputs of the previous layer. Each layer i is composed of N_i neurons, taking their inputs from the N_{i-1} neurons of the previous layer. The first layer is called the input layer and the last layer, composed of a single neuron, is called the output layer. The intermediate layers are called hidden layers.

3.1 Presentation of Artificial Neural Networks (ANN)

An artificial neural network is generally composed of a succession of layers, each of which takes its inputs from the outputs of the previous layer. Each layer i is composed of N_i Neurons (nr) taking their inputs from the neurons of the previous layer. The first layer is called the input layer and the last layer, consisting of a single neuron, is called the output layer. The intermediate layers are called hidden layers (Fig. 1).

3.2 Structure and operation of an artificial neural network

An artificial neuron is considered to be a device that receives input from other neurons and weights it with real values called synaptic coefficients or synaptic weights.

Consider the neuron j of a layer i. Let us note $x_1^i, x_2^i, \ldots, x_{N_{i-1}}^i$ the N_{i-1} inputs from the layer $i-1$ to the neuron j of the layer i. We also consider the N_{i-1} weights denoted $w_{1j}^i, w_{2j}^{i-1}, \ldots, w_{N_{i-1}j}^i$. The neuron j calculates the sum of its inputs weighted by the respective synaptic coefficients, to which it adds a constant term called the bias b_j^i. This gives the formula:

$$S_j^i = \sum_{k=1}^{N_{i-1}} w_{kj}^i x_{kj}^i + b_j^i$$

The bias is an external parameter of the neuron j. It can be integrated into the weighted sum, as the signal x_0^i which takes the value 1, weighted by the weight w_{0j}^i whose value is equal to the bias b_j^i:

$$\begin{cases} x_{0j}^i = 1 \\ b_j^i = w_{0j}^i \end{cases}$$

The sum S_j^i can thus be written as:

$$S_j^i = \sum_{k=1}^{N_{i-1}} w_{kj}^i x_{kj}^i + b_j^i$$

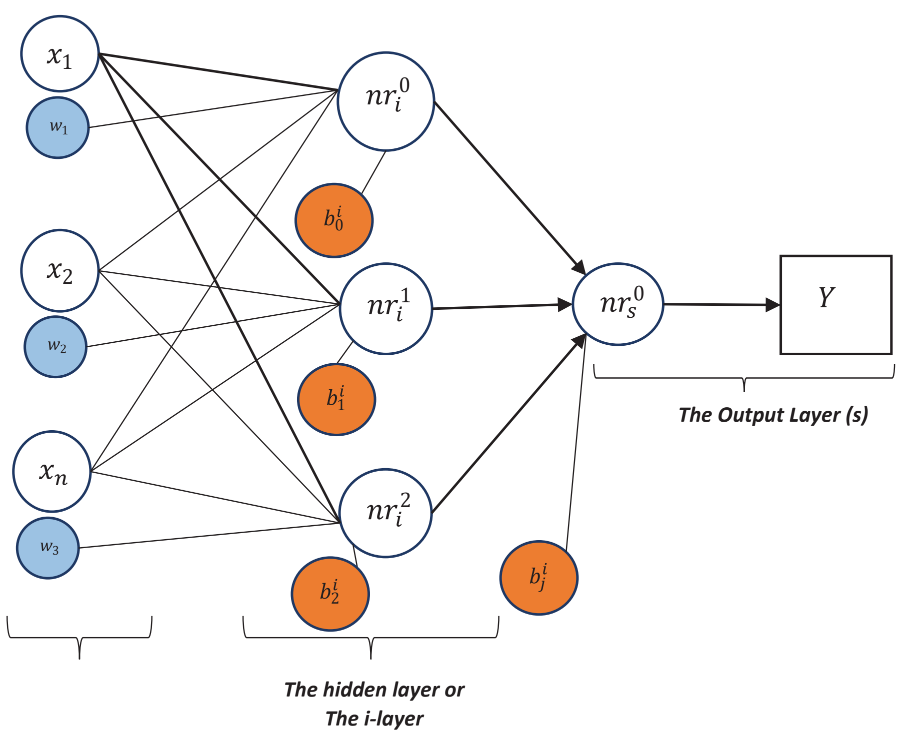


Figure 1. :Architecture of an artificial neural network (Source: Author).

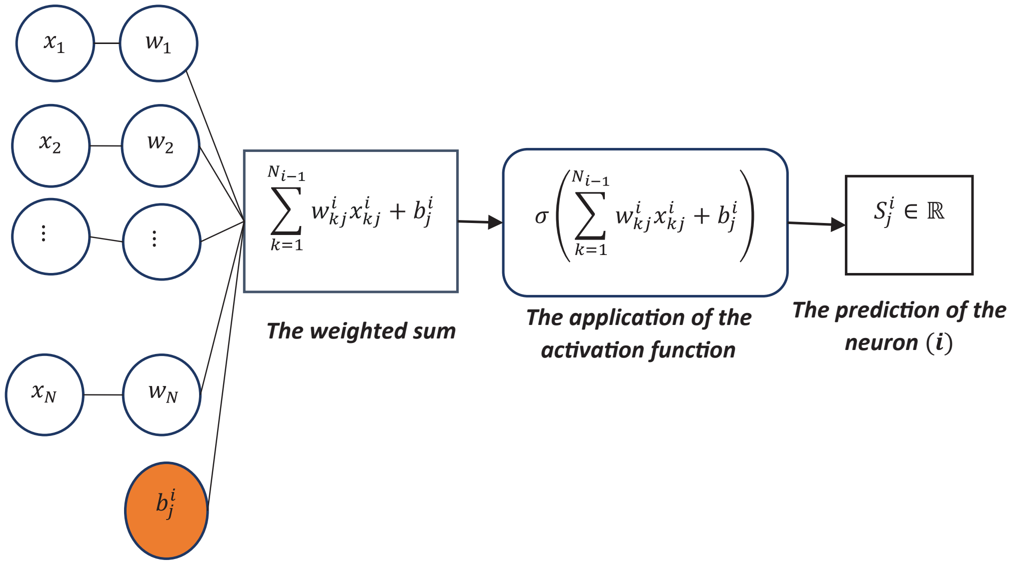


Figure 2. The mathematical formulation of an artificial neurons (Source: Author).

To this sum S_j^i the neuron applies an activation or transfer function φ to obtain an output y_j^i (Fig. 2)

$$y_j^i = \varphi(S_j^i) = \varphi\left(\sum_{k=0}^{N_{i-1}} w_{kj}^i x_k^i\right)$$

The output y_j^i (output) of the neuron j neuron in the i layer is sent to other neurons or to the outside.

3.3 Matrix writing

We consider the layer i layer composed of M_1 neurons.

For any neuron j with $1 < j < M_i$ we put:

$$X^i = \begin{pmatrix} x_0^i \\ x_1^i \\ \vdots \\ x_{N_{i-1}}^i \end{pmatrix} \quad W_j^i = \begin{pmatrix} w_{0j}^i \\ w_{1j}^i \\ \vdots \\ w_{N_{i-1}j}^i \end{pmatrix}$$

So:

$$S_j^i = \sum_{k=0}^{N_{i-1}} w_{kj}^i x_{kj}^i = \begin{pmatrix} w_{0j}^i & w_{1j}^i & \cdots & w_{N_{i-1}j}^i \end{pmatrix} \begin{pmatrix} x_0^i \\ x_1^i \\ \vdots \\ x_{N_{i-1}}^i \end{pmatrix} = {}^T W_j^i . X^i$$

We pose:

$$S^i = \begin{pmatrix} S_1^i \\ S_2^i \\ \vdots \\ S_{M_i}^i \end{pmatrix}$$

So:

$$S^i = \begin{pmatrix} S_1^i \\ S_2^i \\ \vdots \\ S_{M_i}^i \end{pmatrix} = \begin{pmatrix} w_{01}^i & w_{11}^i & \cdots & w_{N_{i-1}1}^i \\ w_{02}^i & w_{12}^i & \cdots & w_{N_{i-1}2}^i \\ & & \vdots & \\ w_{0M_i}^i & w_{1M_i}^i & \cdots & w_{N_{i-1}M_i}^i \end{pmatrix} . \begin{pmatrix} x_0^i \\ x_1^i \\ \vdots \\ x_{N_{i-1}}^i \end{pmatrix} = \begin{pmatrix} {}^T W_1^i \\ {}^T W_2^i \\ \vdots \\ {}^T W_{M_i}^i \end{pmatrix} . X^i$$

We put:

$$W^i = \begin{pmatrix} w_{01}^i & w_{02}^i & & w_{0M_i}^i \\ w_{11}^i & w_{12}^i & \cdots & w_{1M_i}^i \\ \vdots & \vdots & & \vdots \\ w_{N_{i-1}1}^i & w_{N_{i-1}2}^i & & w_{N_{i-1}M_i}^i \end{pmatrix} = \left(w_{kj}^i\right)_{\substack{0 \le k \le N_{i-1} \\ 1 \le j \le M_i}}$$

So:

$$S^i = {}^T W^i . X^i$$

The outputs of the M_i neurons of the layer are then written:

So:

$$Y^i = \begin{pmatrix} y_1^i \\ y_2^i \\ \vdots \\ y_{M_i}^i \end{pmatrix}$$

$$Y^i = \begin{pmatrix} y_1^i \\ y_2^i \\ \vdots \\ y_{M_i}^i \end{pmatrix} = \begin{pmatrix} \varphi(S_1^i) \\ \varphi(S_2^i) \\ \vdots \\ \varphi(S_{M_i}^i) \end{pmatrix} = \varphi \begin{pmatrix} S_1^i \\ S_2^i \\ \vdots \\ S_{M_i}^i \end{pmatrix} = \varphi(S^i)$$

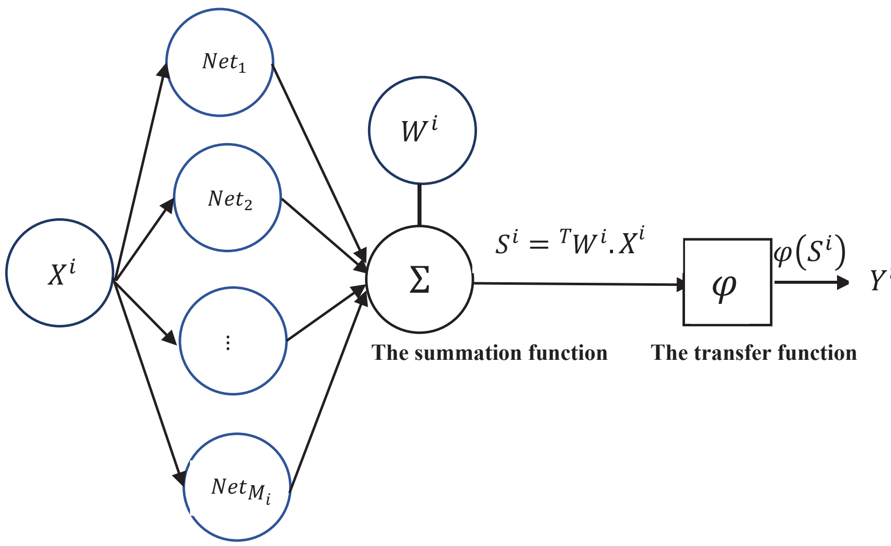
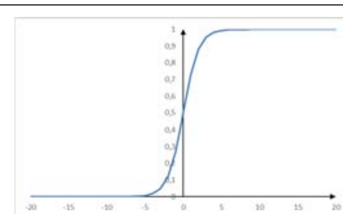
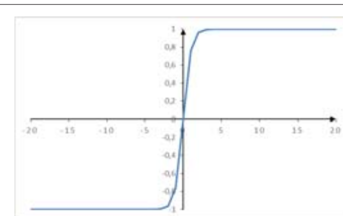
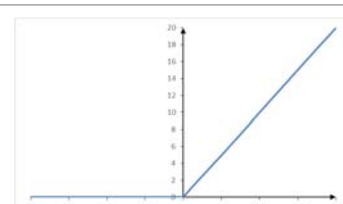


Figure. 3. Architecture and functioning of ANN (Source : Author).

Table 1. The list of activation functions (Source: Author).

The function title	The function	The Graphic Representation
Sigmoid	$\sigma(x) = \frac{1}{1 + e^{-x}}$	
Hyperbolic tangent	$Tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$	
ReLu	$ReLu = Max(0, x)$	

3.4 Activation function

The transfer function or activation function or thresholding function, also called the activation function, is the function used to propagate information from layer to layer. The most common functions cited in the literature are listed in the following table (Table 1):

3.5 Error functions

To calculate the correct weights (parameters), the error between the expected output and the output produced by the network must be calculated. Methods for calculating the error include:

- $\boldsymbol{R-square}$:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \widehat{y_i})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

With:

y_i : *the exact value*

$\bar{y}$: the average of the values of y_i

$\widehat{y_i}$: *the value we have predicted*

- ***Mean Absolute Error*** « ***MAE*** »

Mean Absolute Error « MAE » :

$$Error = \frac{1}{m}\sum_{i=1}^{m}|y_i - \widehat{y_i}|$$

m The number of individuals or objects to be predicted or the number of observations.

Mean Squared Error « ***MSE*** »:

$$Error = \frac{1}{2m}\sum_{i=1}^{m}(y_i - \widehat{y_i})^2$$

3.6 Learning the artificial neural network

The vast majority of neural networks have a "training" algorithm which consists of modifying the synaptic weights according to a set of data presented as input to the network. The purpose of this training is to allow the neural network to learn from the examples. If the training is carried out correctly, the network is able to provide output responses very close to the original values of the training dataset. But the interest of neural networks lies in their ability to generalise from the test set. It is therefore possible to use a neural network to create a memory; this is known as neural memory.

Supervised learning occurs when the network is forced to converge to a specific final state as it is presented with a pattern.

In contrast, in unsupervised learning, the network is left free to converge to any final state when presented with a pattern.

ANN learning can be achieved, among other things, by:

i) Changing weights,
ii) Modification of the network structure (creation or deletion of neurons or connections, or layers),
iii) The use of appropriate attractors or other appropriate steady state points,
iv) The choice of activation functions.

Since backpropagation training is a gradient descent process, it can get stuck in local minima in this weight space. It is because of this possibility that neural network models are characterised by high variance and instability.

- **Back-propagation**

Backpropagation consists of backpropagating the error committed by a neuron to its synapses and the neurons connected to them. For neural networks, the backpropagation of the error gradient is usually used, which consists of correcting errors according to the importance of the elements that have actually participated in the making of these errors: the synaptic weights that contribute to generating a large error will be modified more significantly than the weights that have generated a marginal error.

- **How to choose the number of layers and neurons**

The number of neurons and layers directly influences the performance of an ANN in terms of prediction quality. Indeed, to determine the number of hidden layers, we can follow a process that consists in starting with a single hidden layer and adapting it to reach the ideal architecture.

So if one layer does not produce satisfactory results, then we automatically have to think about adding another until we get satisfactory results. The same goes for the number of neurons, we try to modify it until we get the desired results. The number of neurons in each layer must not exceed the number of input variables. So, you have to think about doing several tests to arrive at a relevant and powerful ANN in terms of accuracy in predicting the output variables.

On the other hand, the more layers you increase the capacity of the network, the more you risk overlearning if you exaggerate in terms of the number of layers or neurons, and the same thing if you decrease the number of layers, you risk underlearning.

To avoid the problem $d'underffiting$ and $d'overffiting$ we try to divide the data into 4 parts and try to alternate the combinations between these parts. By applying this technique, we will have a perfect test of the data since all parts will be used for the test.

4 METHODOLOGY, METRICS AND DATA

4.1 Methodology

The aim of this empirical study is to build a model that can be implemented as a decision support tool for recruiters to effectively hire suitable candidates. However, the proposed methodology (Figure 4) includes the construction of a prediction model based on Artificial

Intelligence, for which we adopted the process of data mining techniques.

This process is initially based on the preparation of the data, followed by the splitting of the data into two proportions; the first is intended to train the prediction model, while the second serves as a test proportion for the accuracy of the resulting model.

4.2 Metric

To evaluate the model obtained from the modelling process, it is necessary to define some metrics to assess the performance of the model obtained. This is done by filling in the confusion matrix using the test data set. Given that the test data set represents 25% of the overall data and the training set represents 75% of the overall data.

However, the confusion matrix (Table 2) allows us to indicate the number of correct predictions for each class and the number of incorrect predictions for each class organised according to the predicted class. Each row of the table corresponds to a predicted class, and each column corresponds to an actual class.

Table 2. Confusion matrix.

	Positive prediction	*Negative prediction*
Positive	True Positives (TP)	False positives (FP)
Negative	False Negative (FN)	True Negatives (TN)

With:

→ True Positives: items that are true and correctly classified.

→ False Positives: items that are true and are misclassified.

→ True negatives: items that are false and are correctly classified.

→ False negatives: items that are negative and misclassified.

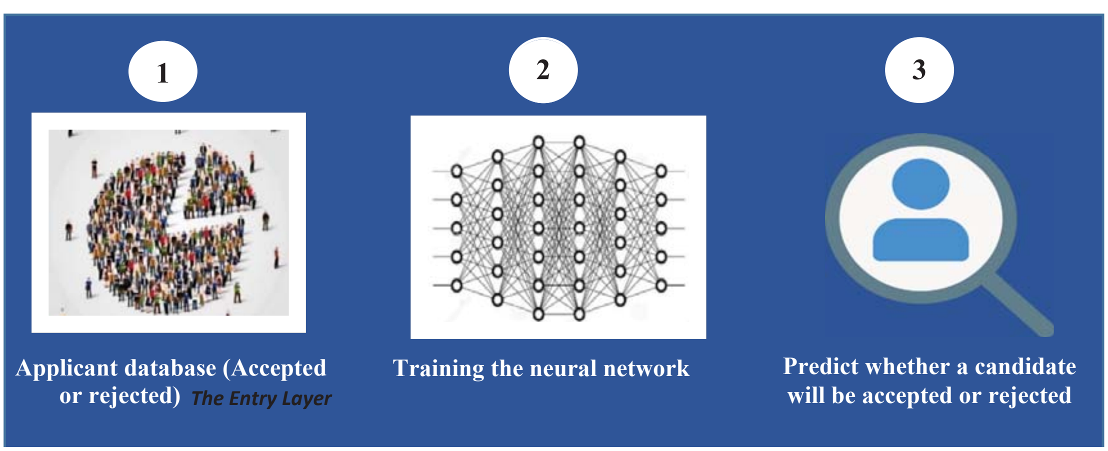


Figure 4. The modelling process using artificial neural networks (Source: Author).

From this confusion matrix the following ratios can be calculated:

$$\textbf{Accuracy} = \frac{TN + TP}{TP + TN + FP + FN}$$

$$\textbf{Precision} = \frac{TP}{TP + FP}$$

$$\textbf{Recall} = \frac{TP}{TP + FN}$$

4.3 Data

In the data preparation stage, we used a database that includes 1000 rows of applicants from a recruitment agency. In addition, this database has 8 explanatory variables and only one dichotomous variable to be explained which takes 2 binary values (Accept / Reject), so we coded all categorical variables according to the table below (See Table 3):

5. RESULTS

After preparing the data for the modelling, we proceeded to the application of the ANN; for this we defined the number of layers and parameters to build our network (See Figure: 5)

The function *fit()* function is used to train our model over 50 iterations, allowing us to

Table 3. Coding of explanatory variable values.

Code	1	2	3	4	5
Speciality	Computer Science	Finance	Secretariat	Management	Right
Current Status	Unemployment	Assets			
French level	A1	A2	B1	B2	C1
English level	A1	A2	B1	B2	C1
Computer level	Beginner	Medium	Advanced	Excellent	
Decision	Reject (0)	Accept (1)			

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 dense_3 (Dense)             (None, 8)                 72

 dense_4 (Dense)             (None, 6)                 54

 dense_5 (Dense)             (None, 1)                 7

=================================================================
Total params: 133
Trainable params: 133
Non-trainable params: 0
_________________________________________________________________
```

Figure 5. The architecture of our neural network.

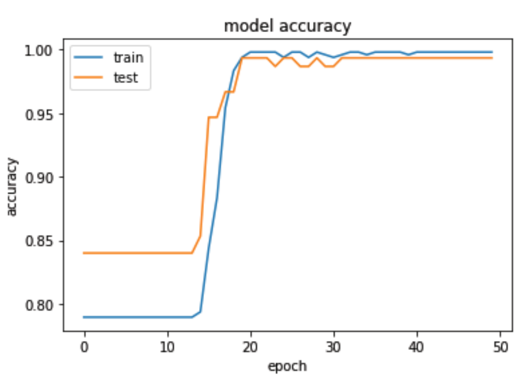


Figure 6. The evolution of the error of our model.

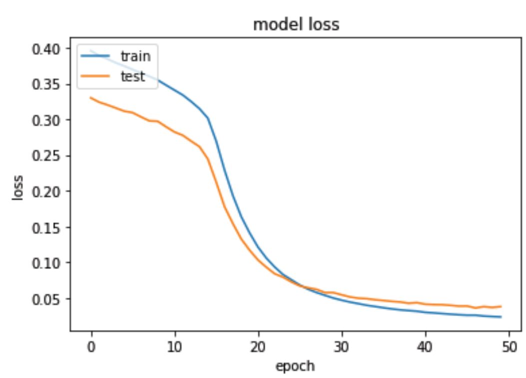


Figure 7. The evolution of the accuracy of our model.

choose the right values for the weight matrix *W*. The calculations are performed using the gradient descent method. The training data used are stored on *X_train* (starting values) and *Y_train* (expected arrival values). Figures 6 and 7 show the evolution of the accuracy and the error (loss) of the model in the training phase.

We can see from Figure 6 that the error decreases and the accuracy increase with iterations, as the training algorithm continuously updates the weights and biases in the neural network according to the training data. We can also see from Figure 7 that the accuracy curves (blue and orange) are very close for both Test and Train data sets, which means that the model has been well trained. We also notice in Figure 6 that the error (loss) curves for the Test and Train data sets decrease towards 0, which means that the model performs well.

Thus, we calculated the metric *Accuracy* for the training and test data and obtained an accuracy equal to 99,33% using the test data (see Figure 8).

Indeed, according to the value of the metric obtained, we can conclude that our model has a fairly high level of predictability, which will help us to make accurate predictions of the recruitment decision.

6. CONCLUSION

Selecting and hiring the right candidate is a daunting task for the company. Therefore, companies are looking for tools that can collect, sort and analyse a large amount of information about candidates to assess their personality and skill level, which is what Artificial Intelligence provides to improve this hiring process.

It is in this context that our paper is written, we have tried to detect the importance of using these techniques in the construction of a model capable of predicting the recruitment decision of new candidates for a company. For this purpose, we have relied on the use of the Artificial Neural Network (ANN) method, so we have exploited a database that includes a range of explanatory variables that describe the level of competence of candidates.

After following the process adopted by data mining techniques, we were able to achieve a result that reflects the performance of Artificial Intelligence techniques, and the accuracy obtained at the end of the modelling process, which exceeds 99%, reveals the robustness of the model obtained, which will improve the hiring process for companies.

REFERENCES

[1] C. E. A. Pah and D. N. Utama, “Decision support model for employee recruitment using data mining classification,” International Journal, vol. 8, no. 5, 2020.

[2] D. Alao and A. Adeyemo, “Employee attrition analysis using decision tree algorithms”,Computing, Information Systems, Development Informatics and Allied Research Journal, vol. 4, no. 1, pp. 17–28, 2013.

[3] Dana Pessach, Gonen Singer, Dan Avrahami, Hila Chalutz Ben-Gal, Erez Shmueli, Irad Ben-Gal, “Employees recruitment: A prescriptive analytics approach via machine learning and mathematical programming”, Decision Support Systems 134 (2020).

[4] Josh Tullier, “The Use of Artificial Intelligence to Recruit Employees”, Citations Journal of Undergraduate Research, Volume 18, 2021.

[5] Linkai Qi a, Kai Yao, “Artificial Intelligence enterprise human resource management system based on FPGA high performance computer hardware”, Microprocessors and Microsystems 82 (2021).

[6] S. Singh and V. Kumar, “Analysis of engineering students’ performance for recruitment using classification data mining techniques”, International Journal of Computer Science, Engineering and Technology, vol. 3, no. 2, p. 31, 2013.

[7] Samrat Singh, Dr. Vikesh Kumar, “Performance Analysis of Engineering Students for Recruitment Using Classification Data Mining Techniques”, Samrat Singh et. al IJCSET February 2013, Vol. 3, Issue 2, 31–37.