A NEURAL NETWORKS APPLICATION FOR THE STUDY OF THE INFLUENCE OF TRANSPORT CONDITIONS ON THE WORKING PERFORMANCE

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Abstract. This paper presents a study about the factors that influence the working performances of workers in the automotive industry. These factors regard mainly the transportations conditions, taking into account the fact that a large number of workers live in places that are far away of the enterprise. The quantitative data obtained from this study will be generalized by using a neural network, software simulated. The neural network is able to estimate the performance of workers even for the combinations of input factors that had been not recorded by the study. The experimental data obtained from the study will be divided in two classes. The first class that contains approximately 80% of data will be used by the Java software for the training of the neural network. The weights resulted from the training process will be saved in a text file. The other class that contains the rest of the 20% of experimental data will be used to validate the neural network. The training and the validation of the networks are performed in a Java software (TrainAndValidate java class). We designed another java class, Test.java that will be used with new input data, for new situations. The experimental data collected from the study. The software that simulated the neural network. The software that estimates the working performance, when new situations are met. This application is useful for human resources department of an enterprise. The output results are not quantitative. They are qualitative (from low performance to high performance, divided in five classes).

1. Introduction

The relationships between job performance and job satisfaction, on one hand, and the transportations conditions and job performance, on the other hand, are the studies the most significant in industrial-organizational psychology. Landy [1] describe this relationship as the "Holy Grail" of industrial psychologists. The purpose of this article is to review the state of the literature concerning the relationship between: job performance and transportations conditions to study the mutual influences based on a theoretical model, using Artificial Neural Networks.

The article is organized into five major sections. First, we qualitatively review previous research on the job motivation-job satisfaction-job performance relationships. In this section, we recapitulate previous reviews of the literature and then consider various conceptualizations of the satisfaction-performance and transportation conditions and performance relationships. Second, we developed a theoretical model, a research approach and establish a list of evaluating criteria. Third, an Artificial Neural Networks are
designed based on the parameters. Fourthly, simulations with trained Artificial Neural Networks was made in order to study the relationships and the correlation between the parameters, for discrete values. Finally, we propose an improved model for the study and we provide some suggestions for future research.

2. Literature review

Job satisfaction is a positive emotional state resulting from the valuation of their work [2]. Optimistic attitude towards work leads to greater job satisfaction which in return perk up the performance of the individual [3]. Employee satisfaction is very important because discouraged workers are negatively affecting the desire to work [4]. "The neglect of job satisfaction reflects professional suspicion of what may be called subjective variables: variables that measure "what people say" rather than "what people do." Job satisfaction should be maximized, and the social reason for seeking to improve the quality of employment is to increase resultant satisfaction. This must be treated not only as a valued goal, but also as a dynamic process occurring primarily as an individual phenomenon but having significant implications for societal adaptivity as well [5]. The relevant theory to work redesign was made it by Herzberg two-factor theory of satisfaction and motivation [6,7]. The theory proposes that the primary determinants of employee satisfaction are factors intrinsic (i.e., recognition, achievement, responsibility, advancement). This specifies that a job will enhance work motivation and satisfaction only to the degree that "motivators" are designed into the work itself.

Over the time different micro-models have been developed to study the relationships between satisfaction and performance. Our study was focused on the analysis of the following two models:

**JOB SATISFACTION AND JOB PERFORMANCE ARE RECIPROCALLY**

Five studies were investigated on the relationship of reciprocity between job satisfaction and job performance. Two of these studies have suggested that performance resulted because of satisfaction, but not and vice versa [8,9]. Sheridan and Slocum [10] gave partial support for a reciprocal relationship and Wanous [11] consider a reciprocal relationship that depends on satisfaction type, figure 1.

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Figure 1. Job satisfaction and job performance are reciprocally
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For extrinsic satisfaction result satisfaction - performance, while for intrinsic satisfaction the relation is performance - satisfaction.

In conclusion four of the five studies suggest a causal effect of job performance in job satisfaction, and two of the five suggesting a causal effect of job satisfaction on performance at work.

**JOB SATISFACTION AND JOB PERFORMANCE IS MODERATED BY OTHER VARIABLES**

Many studies have hypothesized that performance should affect satisfaction at work to the extent that people are compensated based on their performance. The most frequently investigated moderator of the relationship satisfaction - performance is self-esteem. This mean that employees deemed to have value intrinsic rewards, such as the nature of work itself more than pay [12]. In this sense have been proposed a variety of relationships satisfaction - performance such as: job fit [13], need for achievement [14], career stage [15] etc., but very few of them have been tested, figure 2.
TRANSPORTATIONS CONDITIONS AND JOB PERFORMANCE

In order to establish the transportation parameters, a study was carried out through discussions with the employees, with the employer and with the persons involved in the transport of employees at the workplace. So, the influence parameters are derived from:

- the duration of the journey;
- the posture of the person while traveling;
- the comfort;
- feeling fatigued etc.

ARTIFICIAL NEURAL NETWORKS

Feed forward neural network are intelligent devices that learn to solve problems in the same way people solve them: they learn using examples [16]. Feed forward neural networks are also called multi-layered perceptron networks (MLP). They are composed from layers of interconnected artificial neurons (perceptrons). Each neuron from a layer is connected with all the neurons from the next layer. Every connection between two neurons has associated a real number (positive or negative) called weight, which is a measure of the strength of the connection.

Neural networks are excellent tools for pattern recognition. They do not need to know a mathematical model for the object to be recognized, they learn through examples. They are excellent tools for the classification of objects being widely used in industrial, medical, and military applications. A study about the use of feed forward neural networks in ergonomics is presented in [17, 18]. In our application, a feed forward neural network is used to classify the input parameters in four classes: very good, … In order to classify objects, a feed forward neural network typically needs to have three layers of neurons: the input layer, the hidden layer and the output layer.

The examples (patterns) from which the network learns, are used to calculate the weights. In a network that has NI input neurons, NH hidden neurons and NO output neurons, there are NI*NH+NH*NO weights [16]. Using a single training example, starting from its inputs, we can we can propagate it through the network (forward propagation) and we can calculate the outputs of the network. So, we
obtain an equation that has as variables, the weights of the network. But we have many different training examples and so, we can obtain a system of equations that has the same number of equations as the number of weights. But we cannot solve exactly this equations system, because all the equations are nonlinear (because all artificial neurons from the hidden and from the output layer are nonlinear devices, having exponential transfer functions). The only way to find the weights is iteratively and in this manner, the backpropagation algorithm, calculates the weights.

A trained neural network can be used to classify new sets of input data. In order, not to repeat the training every time a network is used for a classification, the weights calculated with the backpropagation algorithm, must be saved in an external file. So, before using the network for classifications, the weights from the external file have to be loaded into the neural network.

3. Research model

The proposed model for this study, figure 4, is based on the model presented in the literature review. The hypothesis that we made involves the study of the direct influence of the Transportation Conditions on Job Performance. In order to determine these influences were used an Artificial Neural Network.

![Figure 4. The research model based on the transportation conditions and job performance](image)

The research approach used for this study is shown in figure 5. That research approach starts with establishment of criteria for evaluation, data collection based on an investigation with a questionnaire and creating a database. An Artificial Neural Networks was designed based on the two parameters. The Artificial Neural Networks are trained, tested and validated. Application of trained Artificial Neural Networks on a new set of data in order to study the correlation between the three parameters.

![Figure 5. The research approach](image)
The evaluation criteria of the parameters “Job Performance” and “Transportation condition” are presented in table 1.

| Evaluation criteria of transport (Transportation condition parameters) |   |
|-----------------------------------------------------|---|
| TC1 The duration of the journey                      |   |
| TC2 The posture of the person while traveling        |   |
| TC3 The presence / absence of hollow or road abnormalities |   |
| TC4 The thermal comfort                             |   |
| TC5 The acoustic comfort                            |   |
| TC6 The level of air pollution                       |   |
| TC7 The humidity level, especially during the heat cycle |   |
| TC8 The driving style of the driver                 |   |
| TC9 The number of stops on the route                |   |
| TC10 Your profession requires physical effort       |   |
| TC11 Your profession requires intellectual effort    |   |
| TC12 Do you feel tired when you arrive at work      |   |

| Evaluation criteria of performance of employees (Job Performance parameters) |
|------------------------------------------------------------------------------|
| P1 Quality of work (accuracy)                                                 |
| P2 Labor efficiency (yield)                                                   |
| P3 Professional knowledge                                                     |
| P4 Responsibility                                                             |

4. The software application and results

The software application is used for the estimation of the four parameters: P1, P2, P3, P4. It consists of three software programs. Two of them are used for the pre-processing of input data and the third is the one that simulates the neural network.

All the initial input data, obtained from the questionnaires, are stored in a text file. Each line has 16 integer values. The first 12 values represent the input parameters (TC1, TC2… TC12) and the last 4 values represent the output parameters P1, P2, P3, P4. For every parameter, there are possible only 4 values: -2, -1, 1 or 2.

Here is an example for a typical line from this file (file_1.txt):

```
1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 -2 -2 -2 -2 -2
```

We decided to use a separate neural network for the estimation of each output parameter, so we have a neural network for the estimation of parameter A, another neural network for the estimation of parameter B, etc.

For the estimation of parameter A, we use only the first 13 values (12 inputs and one output) from every line of file_1.txt:

```
1 2 1 1 2 1 1 1 1 1 1 1 1 1 -2 -2 -2 -2 -2 -2
```

For the estimation of parameter B we use the first 12 input values, and the 14th:

```
1 2 1 1 1 1 1 1 1 -2 -2 -2 -2 -2 -2 -2 -1
```

In order to use this file for the training of the neural network, we had to pre-process it. The first pre-processing consisted in the elimination of duplicate lines, and this was done with the aid of a separate software program.

The algorithm used for the elimination of duplicate lines is the following:

```
Copy the first line from file_1.txt in the array of lines b [ ]
Set the current dimension of array b (nb), to 1
For i=2 to N repeat
  Begin
    Read the current line  crtlLine from file_1.txt
    If crtlLine  is not equal to b[ ]
      Add crtlLine in array b[nb]
      Set the current dimension of array b (nb), to nb+1
      Begin
        Read the current line  crtlLine from file_1.txt
      End
    End
  End
End
```
Set flag areSimilar as false
For j=1 to nb repeat
Begin
  if crtLine equals with the j line from array b then
    set flag areSimilar as true
  End for j
If flag areSimilar= false than copy crtLine in array b and increment nb
End for i
Copy all the array b[] in an output text file file_2.txt

The dimension of the obtained file (file_2.txt) is 28.
Now, all the lines from the file_2.txt are different.
This file file_2.txt was used as an input to another software program that we created in order to do the
second pre-processing. For an input value (and there are 12 input values in each record) that can have 4
different values (-2, -1, 1, 2) we binary code it using two bits, in the following manner:

0 0 for -2
0 1 for -1
1 0 for 1
1 1 for 2.

In this way, each of the 12 input data is coded using 2 bits, so, we will use in the input layer of the neural
network 24 neurons.
For the single output data from the current record that can also have 4 values (-2, -1, 1, 2), we code this
using 4 binary values, in the following manner:

-2 : 1 0 0 0
-1: 0 1 0 0
1: 0 0 1 0
2: 0 0 0 1

In this way, the neural network will have 4 output neurons.
The third program simulates the neural network.
The architecture of the network results from the way we coded the data, and is:

24 – 14 -4

We used from the available 28 records, table 2, resulted from the pre-processing 23 records as patterns
for the training process, and the other 5 records to test the accuracy of the network.

Table 2. The dataset used to train and test the network for the second experiment

| Pattern no. | 1  | 2  | 3  | 4  | 5  | 6  | 28 |
|-------------|----|----|----|----|----|----|----|
| Input parameters | TC1 | 1  | 1  | 2  | 1  | 1  | 1  | 1  |
| Transportation Condition | TC2 | 1  | 2  | 1  | 1  | 1  | 1  | 1  |
|                          | TC3 | 1  | 2  | 1  | 2  | 1  | 2  | 1  |
|                          | TC4 | 2  | 1  | 2  | -1 | 2  | 1  | 1  |
|                          | TC5 | 2  | 1  | 2  | 1  | 1  | 1  | 2  |
|                          | TC6 | 1  | 1  | 1  | -1 | 1  | 1  | 1  |
|                          | TC7 | -1 | 1  | 2  | 2  | 1  | 2  | 1  |
|                          | TC8 | -2 | 1  | 1  | 2  | 1  | 2  | 1  |
|                          | TC9 | 1  | 1  | 1  | -2 | 2  | 1  | 1  |
|                          | TC10| 1  | -2 | 1  | -1 | 1  | 2  | 2  |
|                          | TC11| 2  | -2 | 1  | 1  | 1  | 1  | 1  |
|                          | TC12| 2  | -2 | 1  | -2 | 1  | 1  | 1  |
| Output parameters | P1  | 2  | 2  | 2  | -1 | 2  | 2  | 1  |
| Job Performance         | P2  | 2  | -1 | 1  | 1  | 2  | 2  | 2  |
|                         | P3  | 2  | -2 | 2  | 1  | 1  | 1  | 1  |
|                         | P4  | 2  | -2 | 1  | 2  | 1  | 2  | 1  |
The error that we used for the training of the network is 1%.
The network learns all the training patterns in about 500 epochs. The algorithm used for the training (backpropagation algorithm) is the following:

Set $E$, the learning error (in our application is 1%)
Initialize all weights with small random values
Converged=false
While(not converged)
Begin
For all training patterns repeat
Begin
Forward propagate the inputs of the current pattern
Calculate the error of learning the current pattern
Backpropagate (modify all weights according to the delta rule)
End for
Calculate ERR, the error of learning all the training set of patterns
If( ERR<=$E$)converged=true
End while

After the network converges, all the calculated weights are saved in a text file.
In the testing phase, the input test data are forward propagated through the network, and the outputs are calculated.
Here are some experimental results obtained with this program, for two input test data:

First input test data:
First output:  Ideal: 0 Real: 0.002556441418702507
Second output: Ideal: 0 Real: 0.007147458227179302
Third output: Ideal: 0 Real: 0.006617343440648846
Fourth output: Ideal: 1 Real: 0.9659198790230381

Second input test data:
First output:  Ideal: 0 Real: 0.004862528784744236
Second output: Ideal: 0 Real: 0.0019752387364835675
Third output: Ideal: 0 Real: 0.0016502716524455837
Fourth output: Ideal: 1 Real: 0.995498458365162

It can be seen that the feed forward neural network correctly classifies the test data.
In the literature, we had identified the following factors of influence, in order to complete our model: time pressure (Bhagat, 1982), similarity in problem-solving styles (Goldsmith, McNeilly & Ross, 1989), affective disposition (Hochwarter, Perrewé, Ferris & Brymer, 1999).

5. Conclusions

This paper gives as a review and a study of the relationship between job performance and the transportation conditions.
Our study has found that the parameters are closely correlated.
We have decided do not use a classical approach because, in this case the number of employees involved in the study it would be great. By using ANN, the number of experiments it will be very low than because ANN are able to learn from examples and are able to make connections.
This is an obvious advantage because it is economical and once a network is trained, it can be used in various simulations.
This study allowed us to complete the initial research with other factors of influence.
In the future, we plan a more complex approach, so the results to be richer and the external influencing factors to be identified and characterized more precisely.
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