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# Antibiotic Susceptibility Prediction Using JustNN

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***Abstract:*** *In this research, an Artificial Neural Network (ANN) model was developed and validated to predict efficiency of antibiotics in treating various bacteria types. Attributes that were taken in account are: organism name, specimen type, and antibiotic name as input and susceptibility as an output. A model based on one input layer, one hidden layer, and one output layer concept topology was developed and trained using a data from Queensland government's website. The evaluation shows that the proposed ANN model using JNN tool is capable of correctly predicting the susceptibility of organisms to the antibiotics with 94.17% accuracy.*

**Keywords**: Artificial Neural Networks, antibiotic susceptibility, ANN, JNN

## 1. INTRODUCTION

An antibiotic is a chemical produced by living organisms to protect themselves from attacking bacteria or viruses. People made use of antibiotics in fighting infectious diseases. Many antibiotics nowadays are synthetic or semisynthetic. Bacteria respond to antibiotics in different ways, i.e. they are resistive or sensible or moderate sensible to a particular antibiotic. There are many methods to test the antibiotic susceptibility. The most famous one is the Kirby-Bauer test (or the disc diffusion test). But these methods may last from few hours to many days until they yield the results. To make things easier we seek to computerize antibiotic susceptibility test.

This study seeks to automate the measure process of antibiotic susceptibility using artificial neural network technology.

We used the JustNN tool to train the ANN on the "antibiogram-2013" dataset provided by Queensland government website: www.qld.gov.au.

The objective of this study is: to make the antibiotic susceptibility test easy for physicians and scientists,

## 2. LITERATURE REVIEW

a) Michael Hombach and others made a study to assess the rapid fully automated disc diffusion for rapid antibiotic susceptibility test results. They claimed: "We have evaluated a fully automated system for its potential for early reading of disc delusion diameters after 6–12h of incubation. We assessed availability of results, methodological precision, categorical agreement, and interpretation errors as compared with an 18h standard. In total, 1028 clinical strains (291 Escherichia coli, 272 Klebsiella pneumoniae, 176 Staphylococcus aureus and 289 Staphylococcus epidermidis) were included in this study. Disc delusion plates were streaked, incubated and imaged using the WASPLab automation system"[1].

b) Kiran Desai proved that “support vector regression (SVR)” is an attractive alternative to artificial neural networks for the development of soft-sensors in bioprocesses [2].

c) I.A Basheer et al. praised ANN technology saying: "The attractiveness of ANNs comes from their remarkable information processing characteristics pertinent mainly to nonlinearity, high parallelism, fault and noise tolerance, and learning and generalization capabilities. This paper aims to familiarize the reader with ANN-based computing (neurocomputing) and to serve as a useful companion practical guide and toolkit for the ANNs modeler along the course of ANN project development. The history of the evolution of neurocomputing and its relation to the field of neurobiology is briefly discussed. ANNs are compared to both expert systems and statistical regression and their advantages and limitations are outlined. A bird’s eye review of the various types of ANNs and the related learning rules is presented, with special emphasis on backpropagation (BP) ANNs theory and design. A generalized methodology for developing successful ANNs projects from conceptualization, to design, to implementation, is described. The most common problems that BPANNs developers face during training are summarized in conjunction with possible causes and remedies. Finally, as a practical application, BPANNs were used to model the microbial growth curves of S. flexneri. The developed model was reasonably accurate in simulating both training and test time-dependent growth curves as affected by temperature and pH" [3].

d) Guoqiang Zhang et al. present a state-of-the-art survey of ANN applications in forecasting. The purpose of the paper is to provide (1) a synthesis of published research in this area, (2) insights on ANN modeling issues, and (3) the future research directions [26].

e) Sovan Lek et al. made a good paper to present some of the most important papers of the first workshop about ANNs in ecological modeling [4].

f) M.W Gardner et al. wrote a paper to present a general introduction and discussion of recent applications of the multilayer perceptron, one type of artificial neural network, in the atmospheric sciences [5].

## 3. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANN) are tiling the way for life-shifting applications to be developed for use in all areas of the economy. Artificial Intelligence (AI) podiums that are built on ANN are distracting the traditional way of doing things [6-10]. From interpreting web pages into other languages to taking virtual assistant order groceries online to chatting with chatbots to resolve problems, AI podiums are simplifying transactions and making facilities reachable to all at small costs.

ANN are built similar to the human brain [11-20], with neuron nodes connected like a web. The human brain has billions of cells called neurons. Each neuron is consist of a cell body that is accountable for processing information by carrying information as inputs giving out outputs from the brain. ANN has thousands of artificial neurons called processing units, which are connected by nodes [21-30]. These processing units are consists of input and output units. The input units receive numerous forms and structures of information based on an interior weighting system and the neural network tries to learn about the information accessible in order to create one output report[31-40]. As humans need rules and guidelines to produce a result, ANNs likewise use a set of learning rules called backpropagation, an abbreviation for backwards propagation of error, to faultless their output results [41-44].

An ANN firstly goes through a training stage where it learns to identify patterns in data, whether visually, aurally or textually. Throughout this supervised stage, the network matches its actual output produced with what it was meant to produce, i.e. the wanted output. The difference among both results is attuned using backpropagation. This means that the network works backwards going from the output unit to the input units to be able to amend the weight of its connections among the units till the difference among the real and wanted result yields the lowest potential error[45-49].

ANN have been practical in all areas of operations. Email service suppliers use ANN to discover and delete spam from a user's inbox; help managers to forecast the direction of a company's stock; Credit rating firms use it to enhance their credit scoring approaches; e-commerce platforms use it to personalize recommendations to their customers; chatbots are developed with ANN for natural language processing; deep learning algorithms use ANN to predict the likelihood of an incident; and the list of ANN incorporation goes on across multiple areas, businesses and countries[51-55].

## 4. METHODOLOGY

### 4.1 Search for appropriate dataset.

Antimicrobial susceptibility data extracted from the Queensland Health Pathology reporting system. The data provide information about the level of resistance certain organisms have to antimicrobial agents typically used to treat infections.
The "antibiogram-2013" dataset contains 358 records with 5 attributes: "organism", "specimen type", "antibiotic", "% susceptible", and "number of isolates tested". It assigns a percentage of antibiotic-susceptibility to each organism in blood, urine, and other specimens, (e.g. the organism "Streptococcus pneumonia" that is found in "blood" specimen is 91% susceptible to the "erythromycin" antibiotic. This result was calculated after 178 isolates were tested)[web: data.qld.gov.au/dataset].

### 4.2 Normalize output column in the dataset.

In this step we didn't alter the attributes arrangement but we applied the normalization formula:

$$Xi = \frac{X\max - Xi}{X\max - X\min}$$

on the output attribute "% susceptible".

Table 1: Attributes of the Dataset

| No. | Attributes | Data type | Chosen as |
|---|---|---|---|
| 1. | organism | Text | Input |
| 2. | specimen type | Text | Input |
| 3. | antibiotic | Text | Input |

| | | | |
|---|---|---|---|
| 4. | % susceptible | Real | Output |
| 5. | isolates tested | Integer | Input |

### 4.4 Building the ANN Model

We have used Just Neural Network (JNN) tool [56] to build a multilayer ANN model. The first step after normalizing the data, it was imported into JNN environment (As in Figure 1). We have sat the parameters of the proposed model as follows: Learning Rate 0.39 and the Momentum to be 0.51, and Average Error rate to be 0.01 (as shown in Figure 2).

The proposed model consists of 3 Layers: Input Layer with 4 nodes, the Hidden Layer with 5 nodes, and Output Layer with one node as can be seen in Figure 3.

### 4.5 Evaluating the ANN model

The Antibiogram dataset consists of 358 samples with 5 attributes as in Table 1. We divided the imported dataset into two groups (Training and Validation) randomly using the JNN tool. The Training consists of approximately 67% (238 samples) and the validation set consists of 33% of the dataset (120 samples). After making sure that the parameter control was set properly, we started training the ANN model and kept eye on the learning curve, loss error and validation accuracy. We trained the ANN model for 2481 cycles. The best accuracy we got was 94.17% (as seen in Figure 4). We determined the most influential factors in the Antibiogram dataset as in Figure 5. Figure 6 shows the summary of the proposed model.

The following figure shows the architecture of the neural network with one input layer, one hidden layer (contains four neurons), and one output layer.

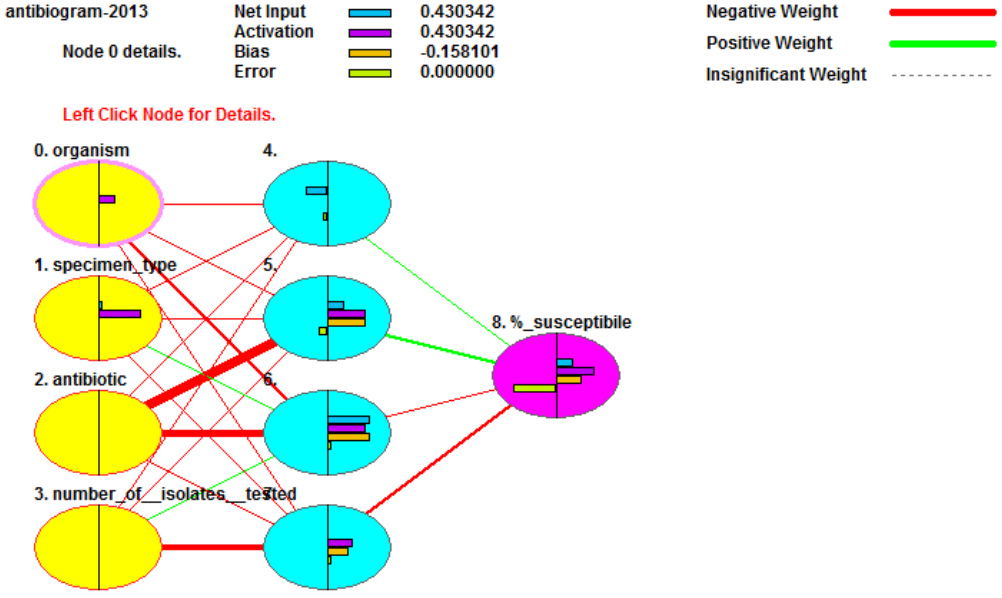


**Figure 3:** Final ANN model design.

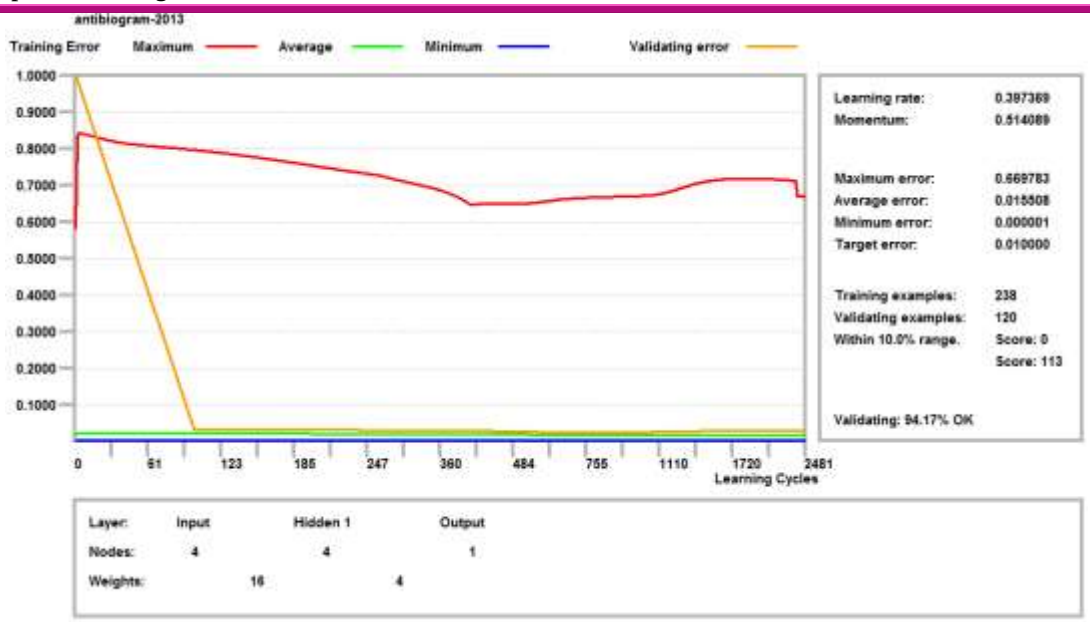


**Figure 4: A**NN model raining and validation

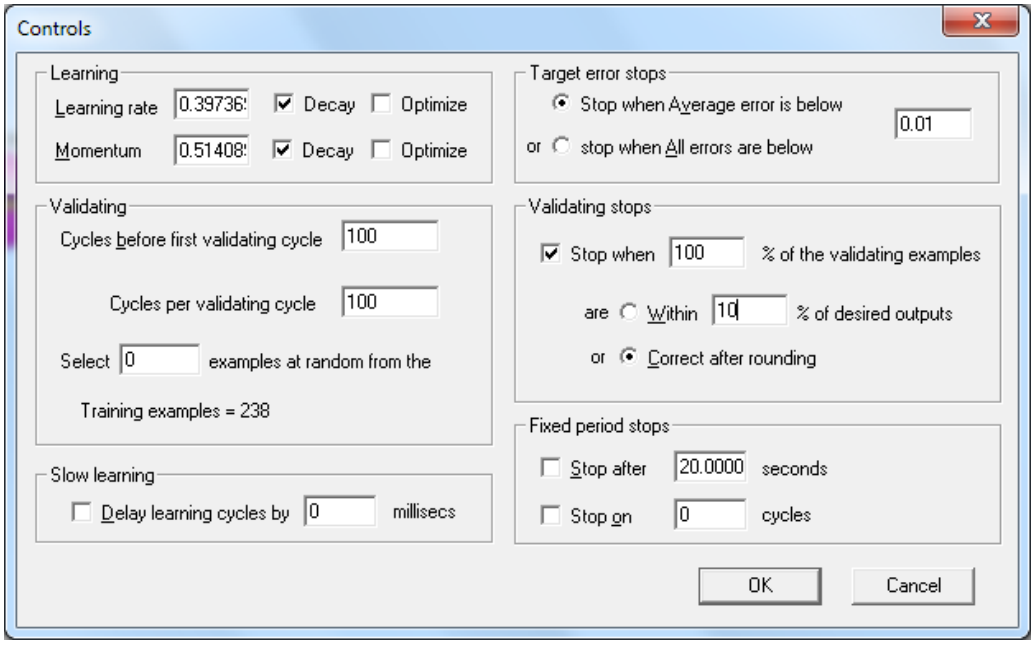


Figure 2: Setting Parameters of the proposed model

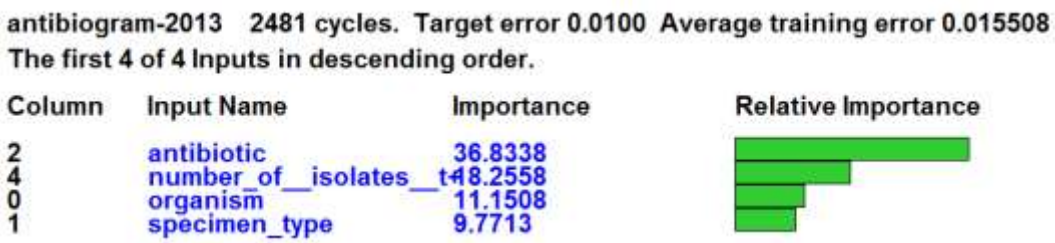


**Figure 5:** Most influential filed in the dataset

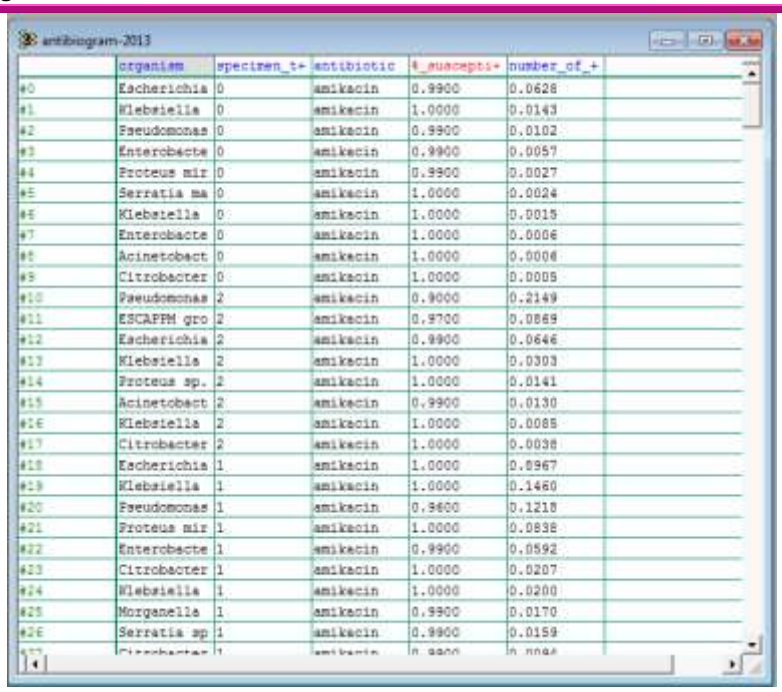


Figure 1: Imported Normalized dataset to JNN environment


**Figure 6:** Detail of the proposed Model

## 5. CONCLUSION

An artificial Neural Network model for predicating Antibiogram dataset was presented. The model used feed forward backpropagation algorithm for training the proposed ANN model using JNN tool. The factors for the model were obtained from dataset which represents Antibiogram dataset. The model was tested and the accuracy rate was 94.17%. This study showed that artificial neural network is capable of predicating Antibiogram dataset accurately.

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