BUSITEMA UNIVERSITY

Pursuing Excellence

FACULTY OF ENGINEERING

DEPARTMENT OF TEXTILE AND GINNING ENGINEERING

PREDICTING ELECTRICITY CONSUMPTION IN THE RING FRAME USING A PROBABILISTIC NEURAL NETWORK

BY

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DECLARATION

I KIWANUKA ELIJAH declare to the best of my knowledge that this project report is as a result of my research and effort and it has never been presented or submitted to any institution or university for any academic award.

DATE .....

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APPROVAL

This project report has been submitted for examination with approval from the following supervisors:

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LIST OF ACRONYMS

ANN Artificial Neural Network

PNN Probabilistic Neural Network

SRNL Southern Range Nyanza Limited

SEC Specific Energy Consumption

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ABSTRACT

The main objective of the study was to predict electricity consumption in the frame using a probabilistic neural network. Predicting electricity consumption using the PNN was successful since the performance of the model shows its capability as shown below; Goodness of fit: SSE: 1.96, R-square: 0.9214, Adjusted R-square: 0.9211, RMSE: 0.07494.
Matlab programming was also successful as tool since it was able to perform its intended function during the prediction process. Basing on the success shown by PNN in predicting electricity consumption on a ring frame and because of the so many challenges faced using the other methods in predicting electricity consumption, I recommend the textile industries to employ the PNN model of prediction that will help in minimizing errors and save time. Also from the results, it shows that running low spinning speeds, using low efficiency motors and very high oil levels in the spindle bolster results in high electricity usage. Therefore, there is need always to optimize.

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CHAPTER ONE: INTRODUCTION

1.0 INTRODUCTION

Preamble

This chapter briefly gives the general information relevant to the research topic while clearly showing the problem of interest for the intended research. It also shows how the study will help reduce the challenges encountered in the study through the fulfillment of a number of objectives and activities listed therein.

1.1 *Background*

The Ring Spinning is the most widely used form of spinning due to significant advantages in comparison with the new spinning processes. (A. R. Horrocks, 2000) In relation to other spinning techniques, ring spinning offers the following advantages;

- It is universally applicable, i.e. any material can be spun to any required count
- It delivers a material with optimum characteristics, especially with regard to structure and strength.
- It is simple and easy to master
- The know-how is well established and accessible for everyone

The ring spinning machine is used in the textile industry to simultaneously twist staple fibers into yarn and then wind it onto bobbins for storage.

Electrical energy is the major type of energy used in the ring frame. On the ring frame, energy is used to run the bobbins on the spindles, running the motors and fans, rotation of the traveler around the ring and lightings among others.

High energy consumption is the biggest challenge with ring frame machines though they offer a number of advantages and which keeps it the most widely used spinning process. (Ashokkumar, 2013)

Many researches have been carried out to study the energy consumption of the ring frame in order to identify different energy saving opportunities. Different tools and models have been developed to curb the problem as explained below;

The different techniques used for predicting energy consumption of machines include regression analysis, decision tree, artificial neural networks (Geoffrey K.F. Tso, 2005) and modified Newton's model among others.

In decision tree modeling, an empirical tree represents a segmentation of the data that is created by applying a series of simple rules. These models generate set of rules which can be used for prediction through the repetitive process of splitting. The most common tree methods include chi-squared automatic interaction detection (CHAID), classification and regression trees (CART). A major advantage of the decision tree over other modeling techniques is that it produces a model which may represent interpretable rules or logic statements. Besides, classification can be performed without complicated computations and the technique can be used for both continuous and categorical variables. Furthermore, decision tree model results provide clear information on the importance of significant factors for prediction or classification. However, decision tree induction generally does not perform as well as neural networks for nonlinear data, and it is susceptible to noisy data.

Regression analysis is one of the most popular techniques for predictive modeling. The least-squares method is generally used for estimation purposes in the multiple-regression model. Once regression coefficients are obtained, a prediction equation can then be used to predict the value of a continuous output (target) as a linear function of one or more independent inputs. The popularity of the regression models may be attributed to the interpretability of model parameters and ease of use. However, the major conceptual limitation of all regression techniques is that one can only ascertain relationship but can never be sure about underlying causal mechanism.

Modified Newton's method provides electricity consumption data. It is obtained by combining standard error estimates with Newton's method algorithm. Newton's method is used to estimate the roots of a function using an iterative process. It utilizes the unconstrained nonlinear optimization technique for generating reliable estimates which are used for developing error corrector models used in forecasting. For a multivariate function, it attempts to find a minimum of a scalar function of several variables, starting at an initial estimate. (P. Ozoh, 2014)

The other technique is using Neural Network models. These were originally developed by researchers trying to mimic the neurophysiology of the human brain. The models are analytic

techniques modeled after the processes of learning in the cognitive system and the neurological functions of the brain and capable of predicting new observations (on specific variables) from other observations (on the same or other variables) after executing a process of so-called learning from existing data. The feed forward network is the simplest and most popular type of network. Training a neural network is the process of setting the best weights on the inputs of each of the units and back propagation (back prop) is the most common method for computing the error gradient for a feed forward network. Neural networks perform well in applications when the functional form is nonlinear. They are especially useful for prediction problems where mathematical formulae and prior knowledge on the relationship between inputs and outputs are unknown. Moreover, a preliminary step of feature selection before learning is needed. Artificial neural networks with hidden layers are better as classifiers for problems involving nonlinear decision hyper-surfaces, but are much harder to interpret. Probabilistic Neural Network (PNN) is applied to predict the electricity consumption for our data sets (Geoffrey K.F. Tso, 2005).

In this research, I developed a Probabilistic Neural Network model which is a type of ANN that can be used to predict the ring frame energy consumption and identify possible energy reduction opportunities of the ring frame.

1.2 *Problem statement*

In textile mills, electricity consumption is in increasing trend, due to modernized machines and continuous usage of the equipment in inefficient operating parameters. The energy cost is around 15 % to 20 % over the production cost and it stands next to raw material cost. (Ashokkumar, 2013) Textile mills spend big sums of money on the electric power used to run machines and this results in reduced overall profits. According, to Hasanbeigi 2010, the ring spinning machines are the leading consumer of energy with the ring frame machines using 41% of the total electrical energy used by a textile mill. (Hasanbeigi, 2010)

The problem of high energy consumption by the ring frame affects the factory owners because of the high energy costs, affects the end product consumers due to increased fabric prices owing to the high costs of production and affects the country's power supply due to high power consumption as a result of increasing number of textile mills.

Ring spinning being the most widely used spinning mechanism, measures have to be devised to provide optimum energy consumption.

1.3 *Objective of study*

1.3.1 Main objective

To design an Artificial Neural Network model for optimizing energy consumption in the ring frame.

1.3.2 Specific objective

a) To identify energy reduction opportunities for a ring frame.
b) To verify the designed model for its effectiveness.
c) To validate the Probabilistic Neural Network as compared with Linear Regression.

1.4 *Scope of the study*

This study was limited to the design, validation and verification of the PNN model. The project also covers the necessary procedures leading to the designing of the model.

The tests and data analysis were carried out from Southern Range Nyanja Limited (SRNL).

1.5 *Justification of the study*

The designed model identifies energy saving opportunities which can help in reduction of energy consumption by textile mills. This results in decrease in both the fabrics' costs of production and the general power usage thus increasing the resulting profits and power fluctuations for countries like Uganda which can't generate enough Electricity.

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