MAKERERE UNIVERSITY

DESIGN OF A MACHINE LEARNING BASED SYSTEM FOR PHARMACEUTICAL PURCHASES

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Degree of Bachelor of Science in Telecommunications Engineering
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Declaration

ABRAHAM KAKOOZA JERRY

Academic Integrity Pledge:

I HAVE ABIDED BY THE MAKERERE UNIVERSITY ACADEMIC INTEGRITY POLICY ON THIS ASSIGNMENT.

Signature ____________________ *Date* ____________________

Dedication

I dedicate this to my parents who have been there for me in this entire study period both emotionally and financially .

Acknowledgments

Add acknowledgments.

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Abstract

To obtain inherent laws from vast amounts of pharmaceutical sales data and to provide valuable information to pharmacy managers, this work validates different methods and approaches to perform a sales forecast. Part of the data is used to train a neural network algorithm, with backpropagation for some methods, step by step, where shallow nets face selected scenarios, with different space-time data considerations.

In each method, by using a sum of square differences, and a peak search procedure, a reasonable quality in the obtained abstract representations is pursued. First, an auto-encoder is trained to develop in its hidden layer neural data abstractions about a random-moving window. Thereafter by using the abstraction of the net plus recently captured information, a second shallow net is trained to produce its own one-day ahead estimates, using new timing and data procedures. After training, the whole stacked system's performance is compared with the naive forecast scenario's mean square error and if it's a better value, the method is used to produce stable daily forecasting for assorted products and periods. The system has been tested in real-time with real data.

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List of Abbreviations

ARIMA	Auto Regression Integrated Moving Average
LSTM	Long Short Term Memory
MSE	Mean Square Error
KPI	Key Performance Indicator
API	Application Programming Interface

Chapter 1

Introduction

1.1 Background

One of the responsibilities of pharmacies in Uganda is to have a minimum stock of medicines.This ensures patients can have it when prescribed.

In addition, pharmacies need to get a good forecast of the medication needs due to the short term validity of many medicines and the need to control stock levels.This avoids excessive costs and loss of customers due to stock outages.

A good sales forecast is usually associated with striking a balance between stock costs and adequate satisfaction of customer demand.People act on the basis of forecasting models whether they are on paper or in their heads. You are better off quantifying these estimations so you can discuss them rationally as opposed to making them based on intuition.

To specific case of pharmacies in Uganda, the problem is of particular importance due to the short cycle life of many products and the importance of quality which is in turn strongly linked to public health.

During our research study of Soteria Pharmacy procurement process with an interview of Ms.Brenda the incharge of this, we realised she uses personal judgement of current stock levels athand and the rate at which people come in to ask for a ceratin drug then determine how much more stock should be purchased.Given her difficulties in accurately predicting the future sales,this report explores the product sales forecast at the indiviual level of this Pharmacy.I made a forecast for 5 sold drugs.The forecast was based on analysis of historical data for a period of 24 months and future results analyses of 50 days determined.ARIMA and

LSTM methods were used in the sales forecast of which the best model was recommended including a conclusive way of improving our results.

1.2 Aims and Objectives

The main aim of the research project was to precisely predict sales of drugs and medical supplies.

The specific objectives were:

- To collect datasets of previous sales and purchases from Soteria Pharmacy.
- To train and validate datasets with ARIMA and LSTM models.
- To optimize the best model algorithm for accurate performance.
- To develop a web API for pharmacies.

1.3 Contributions of the Project

The following major contributions have been accomplished during the course of this research:

1. Performed a data cleaning task, analysis and training with the various Machine learning models and came up with a graphical output.
2. Developed a robust neural network model that could accurately predict future sales for a period of 50 days using a 2 year period worth of sales and purchases information.
3. Proposed a multivariate input approach with other characteristics such as precipitational weather information and promotional sales.

1.4 Organization of the Report

This report has 3 chapters.

- Introduction
- Analysis and Findings which characterizes essential concepts, an overview of the categories and description of the main methods associated with the several techniques of time series analysis.

- Conclusion presents some final considerations and future work proposals.

Chapter 2

Literature Review

2.1 Introduction

People act on the basis of forecasting models whether they are on paper or in their heads. One is better off quantifying these estimations so as to discuss them rationally as opposed to making them based on intuition. For pharmaceutical distribution companies, it is essential to get good estimates of drugs, due to the short shelf life of many medicines and the need to control stock levels, to avoid excessive inventory costs while guaranteeing customer demand satisfaction, and thus decreasing the possibility of a loss of customers due to stock outages. Stock management, transportations, and financial spends contain a high percentage of total pharmaceutical companies' expenses. As a rule, companies pay immediately when buy medications from manufacturers, and then sales compensate these spend gradually. This gap is a danger of unplanned expenses to occur. Therefore, the majority of distributors in this industry look for modern and precise forecasting methods of future sales to decrease purchase and storage costs and to increase profit by meeting clients' needs timely. Common existing forecasting methods are ineffective for pharmaceutical companies because these methods require a large dataset of each medication sales. In its turn, medications are constantly replaced by analogs or refreshed to enhance pharmacological effects or reduce collateral effects.

2.2 Literature Review

Consequently, it is required to build an accurate forecasting model of pharmaceutical preparations sales using one of the machine learning methods taking into account constant medications refreshment and a lack of previous sales data [1].

Before digital technology dominated the world, the forecasting process was done manually by experienced individuals in the domain. This intuition required a lot of experience and was prone to error. Due to this reason, they started realizing the need for automating the pharmacy sales forecasting process. Thus, research and experiments were carried out with statistical, machine learning, deep learning, and ensemble techniques to achieve more accurate sales forecasts. [2] Algorithms to illustrate inherent laws in large amounts of data and to forecast future data patterns have been researched since 1920. However no breakthroughs till 1980. [3] In the deep learning world, state-of-the-art performance has gained a good reputation in fields like object recognition, [4] speech recognition [5], natural language processing [6], physiological effect modeling [7], and many others. More recently papers on time-series prediction or classification with deep neural networks have been reported. [8–11] Aimed at obtaining inherent laws of historical data series in pharmaceutical sales, and forecasting the demand, controlling the inventory, reducing the costs, and improving the service level, this paper designs research on the data records from a pharmacy and presents different forecasting algorithms. The testing results provide support for the fact that these algorithms greatly improve the forecast accuracy from the naive forecasting method.

2.3 Summary

Chapter 3

Add another Chapter

3.1 Introduction

3.2 Mathematical Preliminaries

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Chapter 4

Numerical Results

Table 4.1: Simulation Parameters

Parameters	Values
Network size	$A = 5\,\mathrm{km} \times 5\,\mathrm{km}$
Total BS bandwidth	$\mathcal{B} = 20\,\mathrm{MHz}$
BS and user densities	$\lambda_b = 1.6 \times 10^{-5}\ \mathrm{m}^2$, $\lambda_u = 2\lambda_b$
Transmit power	$P_t = 21\,\mathrm{dBm}$
Pathloss parameters	$L = -33\,\mathrm{dB}$, $\alpha = 4$
Power parameters	$\mathcal{N}_b = 2$, $P_0 = 6.8\,\mathrm{W}$, $\Delta = 4$, $P_{sl} = 4.3$
Additive noise parameters	$F = 10$, $T_a = 300\,\mathrm{K}$

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Chapter 5

Conclusions and Future Works

5.1 Conclusions

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5.2 Ideas for Future Work

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Appendix A

Appendix

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