

DATA ANOMALY DETECTION IN MARITIME TRAFFIC MANAGEMENT USING DEEP LEARNING



RAMSHA MASHOOD
02-241191-015

**A THESIS SUBMITTED IN FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF
MASTERS OF SCIENCE (SOFTWARE ENGINEERING)**

DEPARTMENT OF SOFTWARE ENGINEERING

BAHRIA UNIVERSITY KARACHI CAMPUS

FALL 2021

DECLARATION

Approval for Examination

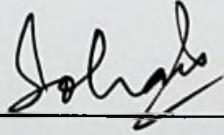
Scholar's Name: Engr.Ramsha Mashood

Registration No. 57901 Program of Study: MS (Software

Engineering) Thesis Title: Data Anomaly Detection in Maritime Traffic Management

using Deep Learning It is to certify that the above scholar's thesis has been completed to my satisfaction and, to my belief, its standard is appropriate for submission for examination. I have also conducted plagiarism test of this thesis using HEC prescribed software and found similarity index _____% that is within the permissible limit set by the HEC for the MS degree thesis.

I have also found the thesis in a format recognized by the BU for the MS thesis.

Principal Supervisor's Signature: 

Date: 3rd February, 2022

Name: Dr.Sohaib Ahmed

Author's Declaration

I, **Engr. Ramsha Mashood** hereby state that my MS thesis titled “ **Data Anomaly Detection in Maritime Traffic Management using Deep Learning** is my own work and has not been submitted previously by me for taking any degree from this university **Bahria University Karachi** or anywhere else in the country/world. At any time if my statement is found to be incorrect even after my graduation, the University has the right to withdraw/cancel my MS degree.

Name of scholar: **Engr. Ramsha Mashood**

Date: **3rd February, 2022**

ACKNOWLEDGMENT

My highest gratefulness is to Allah s.w.t, the one who is great and merciful. Allah s.w.t always opened doors for me which were closed, and I am always in great need of his mercy. Thank my mentor, guide, and supervisor, Dr.Sohaib Ahmed (Principal School of Engineering and Applied Sciences), for his guidance, quick response, and kindness throughout my research. His humble concern, research efforts, and research work are my real motivation. I want to pay special thanks to Dr.Osama Rehman (HOD Software Engineering) for encouraging me to complete my task on time. I am also very thankful to the faculty members, lab Engineers with other non-teaching staff for helping me in different scenarios.

I am also thankful to my colleagues Engr.Ayesha Khan for her moral support and help. While thanks to my other friends, Tooba Zahid, Tooba Mehtab, and Monaliza, for their support in thesis Writing.

My sincere thanks to my parents, who made me what I am today and supported me throughout this research. Thanks to my in-laws, who motivate me during this journey. Last but not least, I would like to express my deep love to my husband and my son, whose genuine love, invaluable concern, and sacrifices surpass all the others. Respect and prayers for my other family members and for all those there to motivate me and encourage me to complete my research.

ABSTRACT

Pandemics and the current world situation affected overall world business. The maritime industry currently depends on different vessel management systems that use Automatic Identification System (AIS) messages to manage Ship activities. AIS messages include both Static and Dynamic data, which contains information related to the position, Heading, and Ship features as AIS data is in massive volume, so the possibility of missing data and anomalous information is present. Different Machine Learning and deep learning algorithms are used to train and detect anomalies to identify those anomalies related to ship classification and ship messages.

CCN, SVM, Random Forest and other deep learning algorithm are used to identify anomalies regarding the position and ship flows. While SQL, PostGre are used for storage purposes. The main goal is to identify which Database is best to store AIS data and which deep learning algorithm performs better to identify anomalies in Ship classification and transceiver class data.

This thesis proposes a solution regarding the storage of AIS data to MongoDB database and identifying anomalies in ship classification and Transceiver class using Deep Learning Algorithm. This approach includes Long Short-Term Memory (LSTM), Convolution Neural Network (CNN), and Artificial Neural Network (ANN) deep Learning algorithm for identifying anomalies in Maritime Traffic Management System.

So, we can conclude that the CNN model provides the highest accuracy, approximately 81%, while other deep learning algorithms like LSTM have 72% and ANN have 79.95% accuracy. The total time consumed to get 1658575 rows takes approximately 0.04sec using MongoDB cloud Database.

TABLE OF CONTENTS

DECLARATION	2
ACKNOWLEDGMENT	5
ABSTRACT	6
TABLE OF CONTENTS	7
LIST OF TABLES	10
LIST OF FIGURES	11
LIST OF ABBREVIATIONS	12
1. INTRODUCTION	1
1.1. Problem Statement	2
1.2. Research Objective	2
1.3. Research Contribution	3
1.4. Research Scope	3
1.5. Organization of Thesis	3
2. LITERATURE REVIEW	4
2.1. Maritime Traffic Management Systems	4
2.2. Concept of Anomalies	5
2.3. Anomalies in Maritime Traffic Management System	6
2.4. Automated Identification System (AIS) Data in Maritime Traffic Management	6
2.5. Types of AIS Data in Maritime Traffic Management	7
2.5.1. Static Data	7
2.5.2. Dynamic Data	8
2.6. Data Bases in Maritime Traffic Management	9
2.6.1. Microsoft Structured Query Language (MSSQL)	9
2.6.2. Postgre	9
2.6.3. Hadoop- Apache Spark	10
2.6.4. Hadoop –Map Reduce	10
2.7. Machine Learning in Anomaly Detection of Maritime Traffic Management System ...	11

2.7.1.	Support Vector Machine (SVM).....	12
2.7.2.	Bayesian Networks Models	12
2.7.3.	Naïve Bayes Classifier	12
2.7.4.	Clustering Algorithm Db-Scan	13
2.7.5.	Gaussian Mixture Model (GMM).....	13
2.7.6.	Artificial Neural Networks (ANN)	13
2.7.7.	Random Forest	13
2.7.8.	Convolutional Neural Networks (CNN)	14
2.7.9.	Long Short-Term Memory (LSTM)	14
2.7.10.	Recurrent Neural Network (RNN)	14
2.8.	State-of-the-Art	15
3.	METHODOLOGY	18
3.1.	Data collection.....	19
3.2.	Software used for AIS Data Storage and Analysis	20
3.3.	MongoDB Database	21
3.4.	Data Preprocessing	23
3.5.	Training Architecture	24
3.6.	Modelling Classifier	25
3.6.1.	Long Short-Term Memory	25
3.6.2.	Convolutional Neural Network.....	25
3.6.3.	Artificial Neural Network	25
3.7.	Performance metrics used for evaluation	26
3.7.1.	Accuracy	26
3.7.2.	F1-score.....	26
4.	EXPERIMENTS AND RESULTS	28
4.1.	MongoDB data Performance.....	28
4.2.	Data Description:.....	29
4.3.	Correlation of Variables:	30
4.4.	Histogram Representation of AIS	31
4.5.	CNN Implementation	31
4.6.	LSTM Implementation	33

4.7.	ANN Implementation	34
4.8.	Performance Summary	35
4.9.	Discussion	36
5.	CONCLUSION AND FUTURE WORK	38
5.1.	Conclusion.....	38
5.2.	Limitations	38
5.3.	Future Work	38
6.	REFERENCE.....	39