UNIVERSITY OF CAPE COAST

DYNAMIC BATCH-SENSITIVE ADAM OPTIMISER FOR VEHICULAR ACCIDENT INJURY SEVERITY PREDICTION

CANDIDATE'S NAME

Year eg. 2026

UNIVERSITY OF CAPE COAST

DYNAMIC BATCH-SENSITIVE ADAM OPTIMISER FOR VEHICULAR ACCIDENT INJURY SEVERITY PREDICTION

BY

CANDIDATE'S NAME

Thesis submitted to the Department of Computer Science and Information Technology of the School of Physical Sciences, College of Agriculture and Natural Sciences, University of Cape Coast, in partial fulfillment of the requirements for the award of Master of Philosophy degree in Computer Science.

Month, Year. eg. [JULY, 2026]

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature: _____ Date: _____

Name: CANDIDATE'S NAME

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature: _____ Date: _____

Name: Name of Supervisor, eg. Dr. Charles Roland Haruna

Co-Supervisor's Signature: _____ Date: _____

Name: Name of Co-Supervisor, eg. Prof. John Kuma

ABSTRACT

Road traffic accidents with varying injury severities pose a significant public safety challenge and demand an accurate predictive framework for effective emergency response. This study investigates the application of deep learning techniques to predict the severity of accident injuries using a Bidirectional Long Short-Term Memory (Bi-LSTM) network enhanced with a novel Dynamic Batch-Sensitive Adam (DBS-Adam) optimiser. By dynamically adjusting learning rates based on batch difficulty, the DBS-Adam optimiser accelerates convergence while improving model stability during training. To address the inherent class imbalance in accident severity data, SMOTE-ENN resampling was employed in conjunction with focal loss to emphasise hard-to-classify cases. Four experimental configurations were implemented, including comparisons with baseline Bi-LSTM models and alternative neural network architectures. The results indicate that the proposed framework achieves superior performance, with a test accuracy of 94.87%, precision of 96%, recall of 95%, F1-score of 95%, and a minimal loss of 0.0088, significantly outperforming traditional optimisers and baseline approaches. Furthermore, the model demonstrates robust generalisation capabilities across different accident scenarios. The application of this enhanced Bi-LSTM framework demonstrates considerable effectiveness in real-time accident severity classification. It enables effective real-time accident severity classification for targeted emergency response and road-safety interventions, demonstrating the value of DBS-Adam for learning from imbalanced sequential data.

KEY WORDS

Adam Optimiser

Bi-LSTM

Dynamic Batch-Sensitive Adam

Injury Severity

Neural Network

Optimization

Vehicular Accident Injury Severity

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To my father, Mr. Emmanuel Asare, and sister, Miss Caroline Asare, your constant belief in me, love, and sacrifices have meant everything. I also appreciate my colleagues for their collaboration, motivation, and shared commitment along the way.

DEDICATION

To my father, Emmanuel Asare, and sister, Caroline Asare, for your love and unwavering support.

Contents

DECLARATION ii

ABSTRACT iii

KEY WORDS iv

ACKNOWLEDGEMENTS v

DEDICATION vi

LIST OF ABBREVIATIONS xii

INTRODUCTION 1

- Background to the Study 1
- Statement of the Problem 1
- Purpose of the Study 1
- Research Objectives 2
- Research Questions 2
- Justification 2
- Significance of the Study 2
- Delimitations 2
- Limitations 2
- Organisation of the Study 3

LITERATURE REVIEW 4

- Introduction 4
- Theoretical Review 4
  - [Name of Theory/Model One] 4
- Conceptual Review 5
- Empirical Review 5

Conceptual Framework 5
Chapter Summary 6

METHODOLOGY 7
Introduction 7
Research Design 7
Population / Study Area 7
Sample and Sampling Procedure / Dataset Description 7
Data Collection Instruments / Procedure 8
Data Processing and Analysis 8
Ethical Considerations 9
Chapter Summary 9

RESULTS AND DISCUSSION 10
Introduction 10
[Results for Objective/Question One] 10
[Results for Objective/Question Two] 10
Discussion of Findings 11
Chapter Summary 11

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 12
Overview 12
Summary 12
Conclusions 12
Recommendations 12
Suggestions for Further Research 12

REFERENCES 13

APPENDICES 14
APPENDIX A: DATA COLLECTION INSTRUMENT 14
APPENDIX B: SUPPLEMENTARY RESULTS 15
APPENDIX C: SOURCE CODE 16

List of Tables

Page

1 Example table caption goes above the table like this 8

2 Example structure for comparing results across conditions . 11

3 Example Likert-scale item layout for a questionnaire 14

4 Example hyperparameter settings used for model training . . 15

List of Figures

Page

1 Example feed-forward artificial neural network architecture, showing an input layer, two fully-connected hidden layers, and an output layer (Researcher's construct, 2026) 4

2 Example conceptual framework relating the study's independent variables, process/model, and dependent variable (Researcher's construct, 2026) 6

3 Example feature/variable importance chart (Researcher's construct, 2026) 8

4 Reference ROC curve for a chance-level classifier (AUC = 0.5) 9

5 Example confusion matrix for a three-class classification result (Researcher's construct, 2026) 10

6 Example training and validation loss curves across epochs (Researcher's construct, 2026) 15

LIST OF ABBREVIATIONS

AdaBound	Adaptive Learning Rate Bound
ADAM	Adaptive Moment Estimation
ADASYN	Adaptive Synthetic Sampling
AMSGrad	Adaptive Moment Estimation with Gradient Rectification
ANN	Artificial Neural Network
ANOVA	Analysis of Variance
ARIMA	AutoRegressive Integrated Moving Average
Bi-LSTM	Bidirectional Long Short-Term Memory
CNN	Convolutional Neural Network
DBS	Dynamic Batch Sensitivity
KSA	Kingdom of Saudi Arabia
LMIC	Low- and Middle-Income Countries
LSTM	Long Short-Term Memory
MAPE	Mean Absolute Percentage Error
ML	Machine Learning
MLP	Multi-Layer Perceptron
PCA	Principal Component Analysis
ReLU	Rectified Linear Unit
RMS	Root Mean Square
RMSprop	Root Mean Square Propagation

CHAPTER 1

INTRODUCTION

This chapter presents an overview of the study. It begins by situating the research within its broader context, before narrowing to the specific problem under investigation. Thereafter, it outlines the purpose, objectives, and research questions guiding the study, followed by the justification and significance of the work. The chapter also delineates the boundaries within which the study was conducted, acknowledges the limitations encountered, and concludes with an outline of how the remainder of the study is organised.

Background to the Study

Introduce the broad research area, moving from the wider (global/national) context down to the specific setting of this study, and end by leading naturally into the problem being addressed.

Statement of the Problem

State, with supporting evidence and citations, the specific gap, inconsistency, or unresolved issue that this study addresses. This should make it clear why the study is necessary.

Purpose of the Study

One or two sentences stating, in broad terms, what the study sets out to do; this usually mirrors the thesis title.

Research Objectives

A numbered list of specific, measurable objectives, each starting with an action verb, e.g. ”To evaluate...”, ”To determine...”, ”To compare...”.

Research Questions

Questions that correspond one-to-one with the objectives above, phrased as questions the study will answer.

Justification

Explain the practical, theoretical, or methodological rationale for undertaking this study now, in this context.

Significance of the Study

Describe who benefits from the findings and how, for instance, policymakers, practitioners, industry, future researchers, or the institution.

Delimitations

State the boundaries deliberately set for the study (scope of population, geography, time period, variables considered) and briefly justify them.

Limitations

Acknowledge constraints beyond the researcher’s control that may affect the study (e.g. data availability, sample size, generalisability) and how they were mitigated.

Organisation of the Study

Briefly outline what each subsequent chapter covers, in one sentence per chapter.

CHAPTER 2

LITERATURE REVIEW

Introduction

State the purpose of the chapter and preview the areas of literature it covers and the order in which they are reviewed.

Theoretical Review

Review the theory or theories underpinning the study. Use a separate sub-heading for each theory or model. Figure 1 shows an example diagram that could accompany a theoretical review of neural network-based approaches — replace or remove it if your chosen theory does not require one.

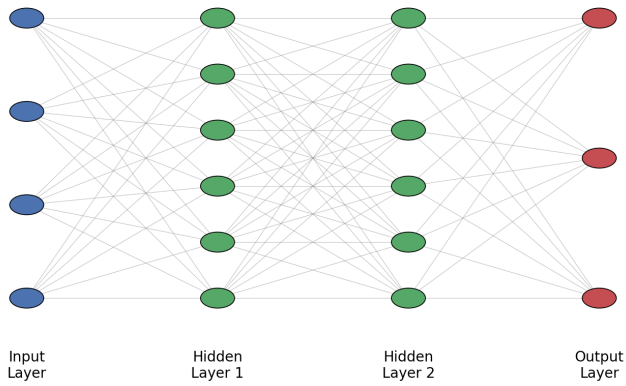


Figure 1: Example feed-forward artificial neural network architecture, showing an input layer, two fully-connected hidden layers, and an output layer (Researcher's construct, 2026)

[Name of Theory/Model One]

Explain what the theory/model is, who proposed it, and why it is relevant to this study.

Conceptual Review

Define and discuss the key concepts and variables used in the study, drawing on how prior authors have defined and operationalised them.

Empirical Review

Review prior studies relevant to each research objective/question, organised thematically (by objective or variable) rather than study-by-study. Compare methods and findings, and note agreements or disagreements across studies.

Citations are generated from `references.bib` in APA 7th Edition style — never type them by hand. Use `\parencite{key}` for a parenthetical citation and `\textcite{key}` for a narrative one. For example, prior work has combined recurrent architectures with adaptive optimisation for sequence classification tasks (Hochreiter & Schmidhuber, 1997; Kingma & Ba, 2015). Where multiple sources support the same statement, they are placed in the same parentheses, arranged alphabetically and separated by semicolons automatically. Where the author is part of the sentence, the citation is written narratively — for instance, Yuan et al. (2019) examined a related sequence modelling problem, while Sameen and Pradhan (2017) focused on a recurrent-network approach to a related classification task. Works with three or more authors are shortened to the first author followed by "et al." automatically. Class imbalance in such data is commonly addressed through synthetic oversampling (Chawla et al., 2002), an approach recently combined with an adaptive optimiser for injury severity prediction (Asare Kyei et al., 2026).

Conceptual Framework

Present, usually with a diagram, how the variables/constructs in the study relate to one another, and explain the diagram in the text that follows it.

Figure 2 shows a generic independent-variable / process / dependent-variable framework — replace the bracketed labels with the actual constructs used in this study.

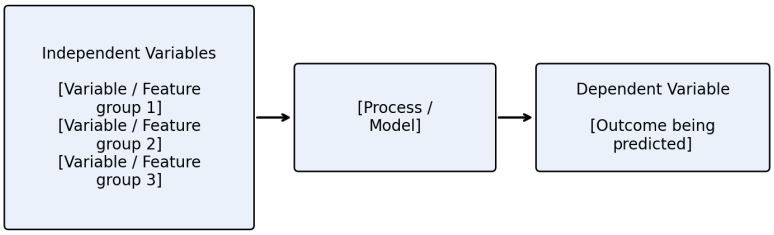


Figure 2: Example conceptual framework relating the study's independent variables, process/model, and dependent variable (Researcher's construct, 2026)

Chapter Summary

A short closing paragraph summarising the key themes covered and clearly restating the gap in the literature that this study fills.

CHAPTER 3

METHODOLOGY

Introduction

Briefly describe what the chapter covers: research design, population/data, procedures, and analysis.

Research Design

State and justify the research design/approach used (e.g. quantitative, experimental, correlational, design science) and explain why it fits the study's objectives.

Population / Study Area

Describe the population, organisation, or context the study draws from, and its relevant characteristics.

Sample and Sampling Procedure / Dataset Description

Describe how the sample or dataset was obtained or selected, its size, and its source. Where relevant, summarise its attributes in a table (see Table 1 below).

Where relevant features or variables have been ranked by importance, this can also be presented as a chart, as shown in Figure 3.

Table 1: Example table caption goes above the table like this

Column heading A	Column heading B	Column heading C
Row 1, value Row 2, value	Row 1, value Row 2, value	Row 1, value Row 2, value

Source: Researcher's construct, 2026

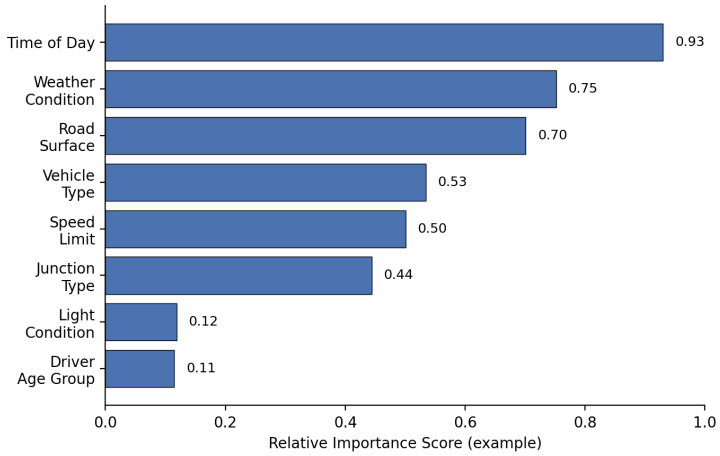


Figure 3: Example feature/variable importance chart (Researcher's construct, 2026)

Data Collection Instruments / Procedure

Describe the tools, instruments, or data sources used, and the exact procedure followed to gather the data.

Data Processing and Analysis

Describe how raw data was cleaned and processed, and the specific statistical or computational methods, software, and tools used to analyse it, in enough detail for the study to be replicated. Where the study involves predictive modelling, this section should also define the evaluation metrics used to assess performance, as shown in Equations (1)–(4).

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \tag{1}$$

$$\text{Precision} = \frac{TP}{TP + FP} \tag{2}$$

$$\text{Recall} = \frac{TP}{TP + FN} \tag{3}$$

$$F1 = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}} \tag{4}$$

Where a classifier's discrimination ability is of interest, a Receiver Operating Characteristic (ROC) curve and its Area Under the Curve (AUC) may also be reported, as illustrated in Figure 4 for a classifier with no discriminative power (AUC = 0.5); a well-performing model's curve should bow toward the top-left corner, with an AUC well above 0.5.

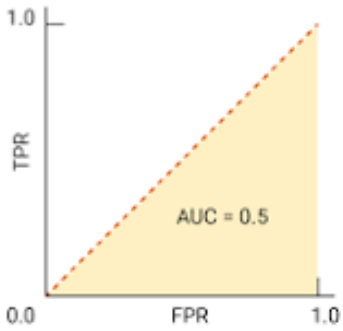


Figure 4: Reference ROC curve for a chance-level classifier (AUC = 0.5)

Ethical Considerations

State how ethical issues were handled — informed consent, confidentiality, data protection, and any institutional/ethics approvals obtained.

Chapter Summary

Close with a short paragraph restating what the chapter covered and bridging into the next chapter.

CHAPTER 4

RESULTS AND DISCUSSION

Introduction

State how the chapter is organised — typically results are presented in the order of the research objectives/questions, followed by a discussion.

[Results for Objective/Question One]

Present the results relevant to this objective, using tables and figures as needed (formatted per the examples in Chapter Three). Describe what the results show, without yet interpreting them. Figure 5 shows the type of confusion matrix that might accompany a classification result — replace it with the actual result obtained.

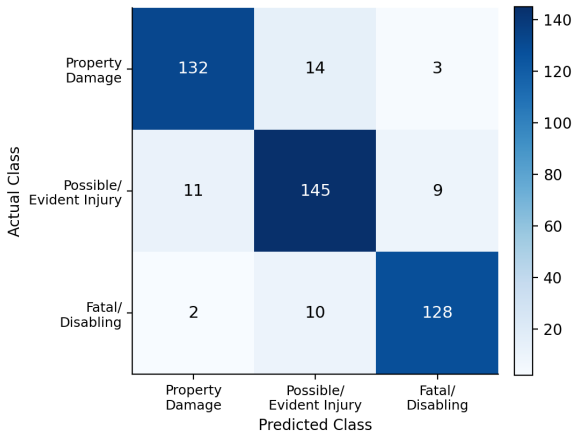


Figure 5: Example confusion matrix for a three-class classification result (Researcher's construct, 2026)

[Results for Objective/Question Two]

Repeat with one sub-section per remaining objective/research question. Table 2 shows an example structure for presenting comparative results

across model configurations or conditions.

Table 2: Example structure for comparing results across conditions

Condition	Metric A	Metric B
Condition 1	[value]	[value]
Condition 2	[value]	[value]
Condition 3	[value]	[value]

Source: Researcher's construct, 2026

Discussion of Findings

Interpret the results in light of the literature reviewed in Chapter Two — state whether they agree or disagree with prior findings, and offer possible explanations.

Chapter Summary

Close with a short paragraph restating what the chapter covered and bridging into the next chapter.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

Briefly restate the purpose of the study and its main research objectives, setting the stage for the summary, conclusions, and recommendations that follow.

Summary

Briefly restate the purpose, objectives, and methodology, followed by a concise summary of the key findings for each objective.

Conclusions

State the conclusions that logically follow from the findings, directly answering each research question.

Recommendations

Give practical recommendations arising from the conclusions, directed at the relevant stakeholders (e.g. policymakers, practitioners, the institution).

Suggestions for Further Research

Identify gaps or new questions raised by this study that future researchers could pursue.

REFERENCES

Asare Kyei, D., Saadia-Yussiff, A., Asante-Mensah, M. G., Lateef-Yussiff, A., Haruna, C. R., & Emmanuel, D. (2026). *Novel dynamic batch-sensitive Adam optimiser for vehicular accident injury severity prediction*. arXiv. https://doi.org/10.48550/arXiv.2605.15083

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Yuan, J., Abdel-Aty, M., Gong, Y., & Cai, Q. (2019). Real-time crash risk prediction using long short-term memory recurrent neural network. *Transportation Research Record*, *2673*(4), 314–326. https://doi.org/10.1177/0361198119840611

APPENDIX A

DATA COLLECTION INSTRUMENT

Place the questionnaire, interview guide, observation checklist, or data-extraction form used for the study here, exactly as it was administered. Refer to it from the methodology chapter, e.g. “see Appendix A”.

Section A: Background Information

1. Gender: Male [ ] Female [ ]
2. Age group: 18–25 [ ] 26–35 [ ] 36–45 [ ] 46+ [ ]
3. Years of driving experience: _____

Section B: [Construct/Variable Name]

Indicate your level of agreement with each statement (1 = Strongly Disagree, 5 = Strongly Agree).

Table 3: Example Likert-scale item layout for a questionnaire

Statement	1	2	3	4	5
[Statement one]	[ ]	[ ]	[ ]	[ ]	[ ]
[Statement two]	[ ]	[ ]	[ ]	[ ]	[ ]
[Statement three]	[ ]	[ ]	[ ]	[ ]	[ ]

Source: Researcher’s construct, 2026

APPENDIX B

SUPPLEMENTARY RESULTS

Present detailed results that support Chapter Four but are too long for the main text — full hyperparameter settings, extended tables, per-class metrics, or additional plots. Table 4 and Figure 6 show the expected formatting.

Table 4: Example hyperparameter settings used for model training

Hyperparameter	Value
Learning rate	[value]
Batch size	[value]
Number of epochs	[value]
Optimiser	[value]
Dropout rate	[value]

Source: Researcher's construct, 2026

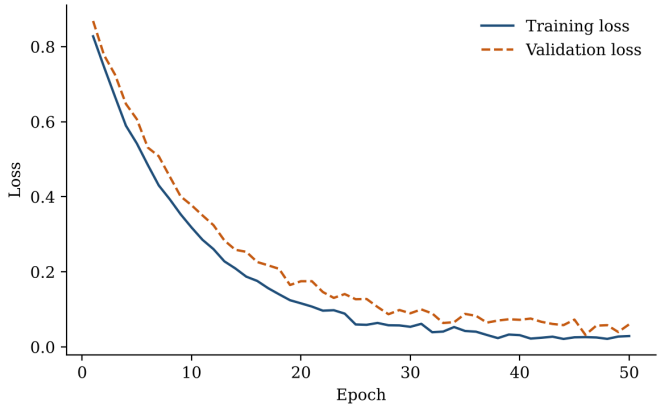


Figure 6: Example training and validation loss curves across epochs (Researcher's construct, 2026)

APPENDIX C

SOURCE CODE

Include key source code (not the full project) needed to reproduce the main results. Code is single-spaced in a monospaced font. Point readers to a repository for the complete code where applicable.

```
import tensorflow as tf

def build_model(input_shape, num_classes):
    model = tf.keras.Sequential([
        tf.keras.layers.Input(shape=input_shape),
        tf.keras.layers.Bidirectional(
            tf.keras.layers.LSTM(64)),
        tf.keras.layers.Dropout(0.3),
        tf.keras.layers.Dense(num_classes,
                              activation="softmax"),
    ])
    return model
```

APPENDIX D

ETHICAL CLEARANCE

Insert the ethical clearance letter, introductory letter, or data-access permission here (scanned as an image or PDF page), for example: