

INTERPRETABLE APPROACH TO RE-RANKING SYSTEM

P. A.D.L Samarakoon

208564X

Degree of Master of Science in Artificial Intelligence

Department of Computational Mathematics

Faculty of Information Technology

University of Moratuwa
Sri Lanka

May 2024

INTERPRETABLE APPROACH TO RE-RANKING SYSTEM

P. A.D.L Samarakoon

208564X

Thesis/Dissertation submitted in partial fulfillment of the requirements for the
degree of Master of Science in Artificial Intelligence

Department of Computational Mathematics
Faculty of Information Technology

University of Moratuwa
Sri Lanka

May 2024

DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date: 2024-07-16

The above candidate has carried out research for the PhD/MPhil/Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor:

Signature of the Supervisor: Date:

ACKNOWLEDGEMENT

I am deeply grateful to my supervisor, Dr. Subha Fernando, for her constant support and guidance throughout my research journey. Her timely feedback and insightful suggestions have been crucial in shaping this project and encouraging me to think critically about the subject matter.

Moreover, I am immensely grateful to my family and friends for their unwavering support and patience throughout my studies. Their genuine interest, understanding, and belief in me have been a driving force behind my success. I could not have achieved this without them.

Finally, I would like to extend my sincere gratitude to the faculty and staff of the Faculty of Information Technology's Department of Computational Mathematics for their direction and coordination.

Thank you all for your contributions to this work.

ABSTRACT

Recommendation systems plays a crucial role in the domain of Artificial Intelligence, with the expansion of internet widespread use of smart devices, the requirement to create advanced ranking and re-ranking recommendation systems have become a necessity for businesses to maintain their competitiveness. Interpretability of any machine learning system has now become a trend as well as a legal requirement in many industries that use machine learning models for analytical purposes. Recent advancements in interpretable machine learning systems including ranking systems shows significant potential in this domain. In this research, we developed an intrinsically interpretable re-ranking model based on Tensorflow Ranking Generalized Additive Model (TFR GAM) architecture to score previously recommended offers. This model was compared against an industry leading Neural Collaborative Filtering model which is a black box Model. The evaluation metrics used to compare two models were Normalized Discounted Cumulative Gain (NDCG), Hit Ratio and Precision. These were used at top 2 and top 3 which gave two variations for each metric. Even though performances of these metrics are between 40%-50% for all matrices, all metrics show that both the models performed in similar manner even though the TFR GAM model had an interpretable model architecture. Overall, in this study metrics suggest that for re-ranking tasks we can use the TFR GAM model which provides similar results to that of an industry leading NCF Model. The study also suggest future research directions to improve the model's performance, such as trying out different combinations for the number of hidden layers, activation functions, and regularization techniques. the study concludes that there is greater potential for further work in this area and continued research development could lead to significant advancement in this domain of interpretable models.

Keywords: Interpretable Models, Re-Ranking System, Recommendation Systems, Tensorflow Ranking, Learning to Rank

TABLE OF CONTENT

DECLARATION.....	3
ACKNOWLEDGEMENT.....	4
ABSTRACT.....	5
TABLE OF CONTENT.....	6
LIST OF FIGURES.....	9
LIST OF TABLES.....	10
LIST OF ABBREVIATIONS.....	11
LIST OF APPENDICES.....	12
CHAPTER 1.....	1
INTRODUCTION.....	1
1.1 Prolegomena.....	1
1.3 Background and Motivation.....	2
1.4 Problem Definition.....	4
1.5 Approach of Interpretable Learning to Rank System Development.....	5
1.6 System Requirement.....	6
1.7 Structure of the Thesis.....	6
1.8 Summary.....	6
CHAPTER 02.....	8
LITERATURE REVIEW ON INTERPRETABLE LEARNING TO RANK SYSTEMS.....	8
2.1 Introduction.....	8
2.2 Overview of Recommendation and Learning to Rank Systems.....	8
2.3 Historical Approaches of Recommendation and Learning to Rank Systems..	9
2.4 A Review of Current Systems of Recommendation and Learning to Rank Systems.....	12
2.5 Challenges in Recommendation and Learning to Rank Systems.....	15
2.6 Future and Next Steps of Recommendation and Learning to Rank Systems.	16
2.7 Summary of the Literature Analysis.....	17
2.8 Research Problem.....	18
2.9 Summary.....	19
CHAPTER 03.....	20
TECHNOLOGIES ADOPTED FOR LEARNING TO RANK AND RECOMMENDATION SYSTEMS.....	20
3.1 Introduction.....	20

3.2 Overview of the Technologies Used in Recommendation and Learning to Rank Systems.....	20
3.3 Machine Learning Technologies Used in Recommendation and Learning to Rank Systems.....	21
3.3.1 Introduction to Machine Learning Technology.....	21
3.3.2 Introduction to Deep Learning Technology.....	21
3.3.3 Introduction to Recommendation systems and Learning to Rank.....	22
3.3.4 Tensorflow Keras API.....	23
3.3.5 Neural Collaborative Filtering Model.....	24
3.3.6 TF-Ranking GAM Model.....	25
3.4 Cloud Architecture.....	27
3.5 Model Evaluation Methods.....	27
3.6 Summary.....	28
CHAPTER 04.....	29
APPROACH.....	29
4.1 Introduction.....	29
4.2 Hypothesis.....	29
4.3 Input.....	30
4.4 Output.....	31
4.5 Process.....	32
4.6 Features.....	33
4.7 Users.....	34
4.8 Summary.....	34
CHAPTER 05.....	35
DESIGN.....	35
5.1 Introduction.....	35
5.2 Data.....	35
5.3 Model Architecture.....	37
CHAPTER 06.....	42
IMPLEMENTATION.....	42
6.1 Introduction.....	42
6.2 Data Preprocessing.....	42
6.3 Model Development.....	45
6.3.1 NCF Model.....	45
6.3.2 TFR GAM Model.....	47
6.4 Evaluation Implementation.....	48
6.4 Summary.....	49
CHAPTER 07.....	50
EVALUATION.....	50

7.1 Introduction.....	50
7.2 Model Evaluation.....	50
7.3 Summary.....	52
CHAPTER 08.....	53
CONCLUSION AND FUTURE WORKS.....	53
8.1 Introduction.....	53
8.2 Conclusion.....	54
8.3 Future Works.....	55
8.4 Summary.....	56
REFERENCES.....	57
Appendix - A: TFR Model Architecture Source code.....	61
Appendix - B: NCF Model Architecture Source code.....	62
Appendix C: TFR Architecture.....	63

LIST OF FIGURES

Figure	Description	Page
3.1	NCF Architecture	22
3.2	TFR GAM Architecture	24
4.1	Process Design diagram	31

5.1	NDCG Formula	44
7.1	NCF Model Performance metrics	55
7.2	TFR GAM Model Performance metrics	55
7.3	Model Performance Metrics Summary	55

LIST OF TABLES

Table	Description	Page
2.1	Analysis of Literature Review	16
4.1	Feature Description	29
5.1	Input Data format after Snowflake preprocessing	34
5.2	NCF Model Architecture	42
5.3	TFR GAM Model Architecture	43

LIST OF ABBREVIATIONS

Abbreviation	Description
SNS	Simple Notification Service
TRCSL	Telecom Regulatory commission of Sri Lanka
RS	Recommendation System
LTR	Learn to Rank
GAM	Generalized Additive Model
NCF	Neural Collaborative Filtering
API	Application Programming Interface
AWS	Amazon Web Services
TF	Tensorflow
CNN	Convolutional Neural Network
RNN	Recurrent Neural Network
ReLU	Rectified Linear Unit
NDCG	Normalized Discounted Cumulative Gain

LIST OF APPENDICES

Appendix	Description	Page
Appendix A	TFR Model architecture Source code	61
Appendix B	NCF Model Architecture Source code	62
Appendix C	TFR Model Architecture	63