Faculty of Engineering & Technology

Department of Electrical & Computer Engineering

Accelerated DLRM-based E-commerce Recommendation System

Prepared By:

Ibraheem Alyan 1201180

Mohammad Abu-Shelbaia 1200198

Nidal Zabadi 1200153

Supervised By:

Dr. Ahmed Shawahna

A Graduation Project submitted to the Department of Electrical and Computer Engineering in partial fulfillment of the requirements for the degree of B.Sc. in Computer Engineering

Birzeit

December 19, 2023

Abstract

المستخلص

أكتب هنا

Table of Contents

English Abstract **I**

Arabic Abstract **II**

Table of Contents **III**

List of Tables **V**

List of Figures **VI**

1 Introduction and Motivation **1**

1.1 Motivation 1

1.2 Problem Statement 2

1.3 Methodology 2

1.4 Contribution 2

1.5 Report Outline 2

2 Background **3**

2.1 Transformer 3

2.1.1 Model Architecture 3

2.1.2 Scaled Dot–Product Attention 3

2.1.3 Multi–Head Attention 3

2.1.4 Self–Attention and Multi–Head Self–Attention 3

2.1.5 Feed Forward Network 3

2.2 Vision Transformer (ViT) 3

2.3 Lightweight ViT 3

3 Literature Review—ViT Acceleration Techniques **4**

3.1 Pruning 4

3.2 Quantization 4

3.3 Low-Rank Approximation 4
3.4 Knowledge Distillation 4
3.5 Lightweight ViT 4
3.6 Transformer Acceleration on Hardware 4

4 Proposed Work **5**

5 Project Plan **6**

6 Conclusion and Future Work **7**

Bibliography **8**

List of Tables

List of Figures

Chapter 1

Introduction and Motivation

Contents

1.1 Motivation **1**
1.2 Problem Statement **2**
1.3 Methodology **2**
1.4 Contribution **2**
1.5 Report Outline **2**

1.1 Motivation

The exponential growth of e-commerce has introduced an enormous amount of choice, where consumers face overwhelming product options. To address this challenge, personalized recommendation systems have become essential for enhancing the shopping experience, and increasing the conversion rate for any e-commerce platform.

In contrast to conventional collaborative filtering[1], content-based[1], or popularity-based recommendation systems, our AI-based solution offers distinct advantages. Firstly, AI makes it possible to provide per-user personalized recommendations, which are tailored to their unique preferences and behaviors, enhancing user engagement and satisfaction. AI systems can also intelligently recommend comparable or complementary products or content to increase revenue through cross-selling. Furthermore, AI takes into account the impressions and interactions of users with items, allowing for a more dynamic and accurate understanding of user preferences. Using AI leads to improved recommendation accuracy and relevancy, leading to increased conversion rates and business growth.

Statistics from different use cases of recommendation systems:

- On average, an intelligent recommender system delivers a 22.66% lift in conversions rates [2] for web products.
- IKEA experienced a 30% increase in click-through rate, 2% surge in average order value [3] using Google Recommendations AI [4]
- Lotte Mart increased new product purchases by 1.7x [5] using Amazon Personalize [6]

In summary, our project's motivation is elevating the e-commerce experience, driving business success, and harnessing cutting-edge AI technologies to create a recommendation system that is both high-performing and scalable.

1.2 Problem Statement

1.3 Methodology

1.4 Contribution

1.5 Report Outline

Chapter 2

Background

Contents

2.1 Transformer 3
2.1.1 Model Architecture 3
2.1.2 Scaled Dot–Product Attention 3
2.1.3 Multi–Head Attention 3
2.1.4 Self–Attention and Multi–Head Self–Attention 3
2.1.5 Feed Forward Network 3
2.2 Vision Transformer (ViT) 3
2.3 Lightweight ViT 3

2.1 Transformer

2.1.1 Model Architecture

2.1.2 Scaled Dot–Product Attention

2.1.3 Multi–Head Attention

2.1.4 Self–Attention and Multi–Head Self–Attention

2.1.5 Feed Forward Network

2.2 Vision Transformer (ViT)

2.3 Lightweight ViT

Chapter 3

Literature Review—ViT Acceleration Techniques

Contents

3.1 Pruning 4
3.2 Quantization 4
3.3 Low-Rank Approximation 4
3.4 Knowledge Distillation 4
3.5 Lightweight ViT 4
3.6 Transformer Acceleration on Hardware 4

3.1 Pruning

3.2 Quantization

3.3 Low-Rank Approximation

3.4 Knowledge Distillation

3.5 Lightweight ViT

3.6 Transformer Acceleration on Hardware

Chapter 4

Proposed Work

Chapter 5

Project Plan

Chapter 6

Conclusion and Future Work

Bibliography

[1] Nvidia Glossary, "Recommendation System." https://www.nvidia.com/en-us/glossary/data-science/recommendation-system/. Accessed: 2023-12-19.

[2] Salesforce Marketing Cloud, "Predictive intelligence benchmark report." https://brandcdn.exacttarget.com/sites/exacttarget/files/deliverables/etmc-predictiveintelligencebenchmarkreport.pdf, 2014.

[3] Google Cloud Summit, "Ikea's approach to building a powerful recommendations engine." by Google Cloud Events https://www.youtube.com/watch?v=PyjC0wRRtBg, 2021.

[4] Google Cloud, "Google Recommendations AI." https://cloud.google.com/recommendations. Accessed: 2023-11-9.

[5] Sungoh Park and Kyoungtae Hwang, "Increasing customer engagement and loyalty with personalized coupon recommendations using Amazon Personalize," *AWS Machine Learning Blog*, 2020.

[6] AWS, "AWS Personalize." https://aws.amazon.com/personalize/, accessed: 2023-10-4.