成都理工大学中英合作办学
CDUT Sino-British Collaborative Education

OXFORD BROOKES UNIVERSITY

UNDERGRADUATE PROJECT PROPOSAL

Project Title:	**Book Recommendation Using Deep & Cross Network**
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Module Code:	**CHC 6096**
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1 Introduction

1.1 Background

The problem of information overload is a result of the Internet's quick expansion in terms of both reach and size. Too much information is offered at once, making it difficult for users to sift through it and decreasing the effectiveness of information use[1] A particularly promising solution to the problem of information overload is to use recommender systems, which are important information filtering tools.

Customer needs are often ambiguous, so if merchants can recommend products that meet the ambiguous needs of users, they can transform the potential needs of users into real needs, to achieve the purpose of increasing product sales. Amazon's book recommendations, Apple Music's recommendations, and Taobao's product movie news use recommendations have all used these methods and achieved significant benefits.[2].

The now widely quoted definition of the Recommender System was given by Resnick & Varian [3] in 1997: "It is the use of e-commerce sites to provide customers with product information and recommendations to help users decide what products they should buy, simulating a salesperson helping the customer through the buying process".

Recommender systems can help companies better serve their users while increasing their profits, making it easier for users to get the things they are interested in. More efficient and accurate recommendations will have an amazing impact.

According to Singhal A et al., most deep learning methods are enhancing collaborative filtering methods and are greatly improved compared to matrix decomposition methods[4]. So, in my next job, I'll use deep and cross-network (DCN) deep learning models to build a recommender system that can be used to recommend books more efficiently. The rest of the report is structured as follows.

1.2 Aim

The aim of my project is to build and train a book recommendation system using a deep learning model.

1.3 Objectives

My objectives are as follows:

A). completes the research, study, and research of the recommender system.

B). completes the learning and research of deep learning.

C). collects appropriate data for analysis and evaluation.

D). uses suitable deep learning models in combination with recommender systems.

E). implemented and tested.

1.4 Project Overview

1.4.1 Scope

The purpose is to use a model of deep learning called Deep & Cross Network (DCN) [5]to train and build a book recommendation system. And DCN can effectively capture the interaction of limited effective features, learn highly nonlinear interactions, do not require manual feature engineering or traversal search, and have low computational cost.

1.4.2 Audience

Book recommendation solves the rapid selection of massive products for users. And for a book website to generate more purchases is real money.

And recommending books that are more in line with the user's appetite can undoubtedly increase user stickiness, improve user retention, and better attract users, then the accompanying advertising revenue will also increase. It's also a win-win.

The core need of the Internet is growth, and recommender systems are at the heart of growth.

The main problem to be solved by the recommender system is how users can efficiently obtain content of interest when they are overloaded with information.

2 Background Review

Devika, P. *et al.* proposes a book recommendation system based on the combination of content filtering, collaborative filtering, and association rule mining[6]. Wadikar DKumari NBhat R et al. proposes a topic-based book recommendation platform that uses convolutional neural networks (CNNs) for book recommendation. The suggested

recommendation system will give its users the ability to view and search for books and use a convolutional neural network (CNN), which will list the highly purchased and highly rated books based on the topic name as input[7] Li, B. et al. propose GRec, a graph neural network (GNN)-based approach for recommending potentially useful TPLs for application development. GREc models mobile applications, TPLs, and their interactions into an application library diagram. It then extracts application library interaction information from the application library diagram to make more accurate TPL recommendations[8] According my research ,I find 3 method to accomplish the book recommendation system , the first one use traditional recommendation ways like Association rule, Collaborative filtering, Content based filtering, and other approaches are using the deep learning , such as convolutional neural networks (CNNs) and graph neural network (GNN), I found that recommender systems based on deep learning methods are more efficient and accurate, so I decided to develop a recommender system model using the improved deep learning model Deep & Cross Network (DCN).

3 Methodology

3.1 Approach

A brief description of the principle of the Deep & Cross Network model

The Deep & Cross Network model we will refer to as the DCN model below:

A DCN model starts with an embedding and stacking layer, followed by a crossover network and a deep network parallel to it, followed by a final combinatorial layer that combines the outputs of both networks. The complete network model is shown in the figure:

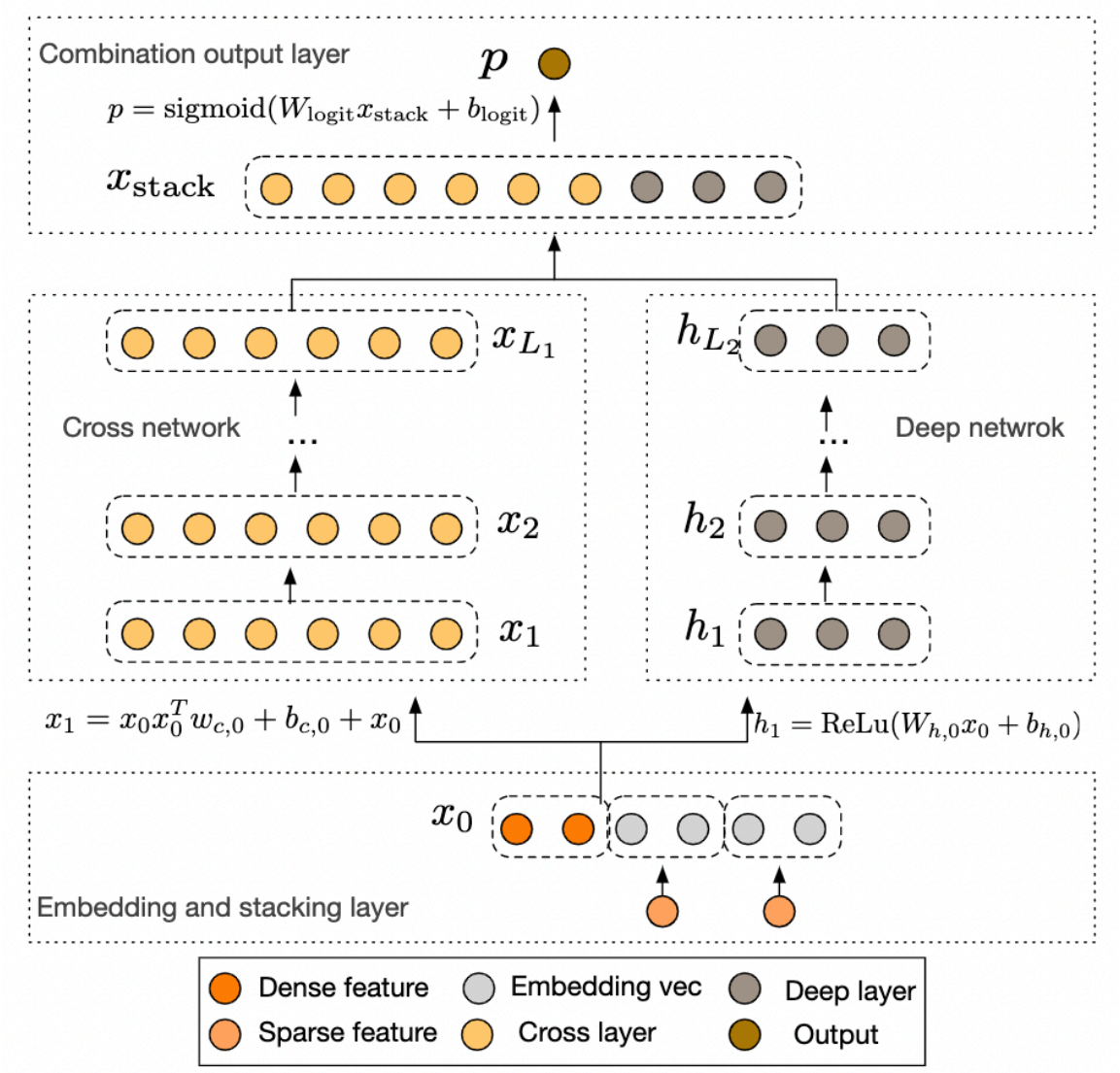

Figure1: Network Model

Embed and stack layers

The authors consider input data with discrete and continuous characteristics. In network-scale recommendation systems, such as CTR prediction, the input is mainly categorical features, such as "country=USA". These features are usually encoded as a single heat vector such as "[0,1,0]"; However, this often leads to excessive high-dimensional feature space for large vocabulary.

To reduce the dimensionality, we use an embedding process to convert these discrete features into a dense vector of real values (often called an embedding vector):

$$x_{embed,i} = W_{embed,i} x_i$$

Then, we superimpose the embedding vector with the continuous eigenvector to form a vector:

$$x_0 = \left[x_{embed,1}^T \cdots\cdots x_{embed,k}^T, x_{dense}^T\right]$$

The stitched vector X0 will serve as input to our Cross Network and Deep Network

Cross Network

The core idea of crossover networks is to apply explicit feature intersections in an efficient way. A crossover network consists of intersecting layers, each with the following formula:

$$x_{l+1} = x_0 x_l^T w_l + b_l + x_l = f(w_l, b_l, x_l) + x_l$$

A visualization of a cross-layer is shown in the figure:

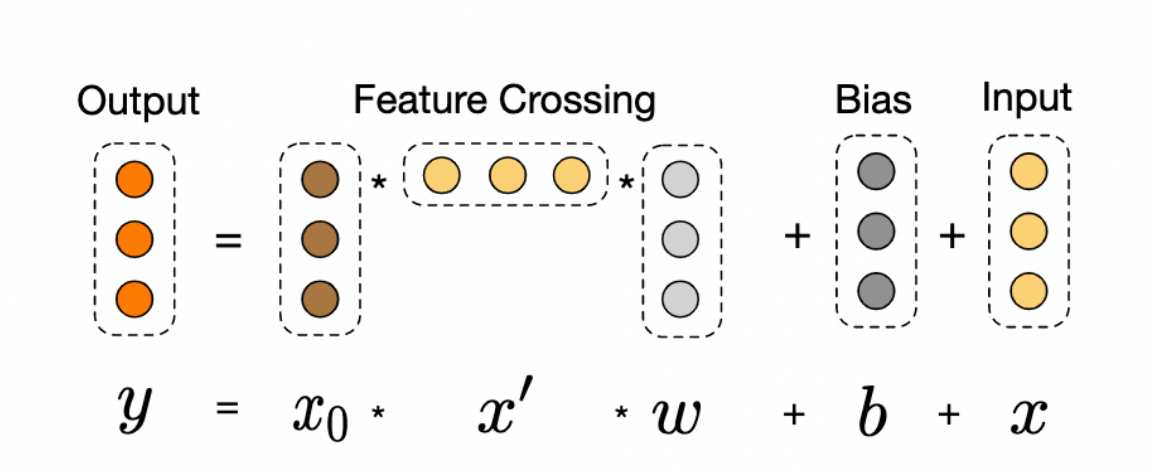

Figure2: visualization of a cross-layer

The special structure of the intersection network makes the degree of intersection features increase with the increase of layer depth. The highest degree of polynomial (in terms of input X0) is the L-layer crossover network L+1. If Lc is used to represent the

number of intersections, d is used to represent the input dimension. Then, the number of parameters involved across the network parameters is $d*l_c*2$ (w and b).

A few parameters of the cross-network limit the model capacity. To capture highly nonlinear interactions, the model introduces a deep network in parallel.

Deep Network

A deep network is a fully connected feedforward neural network, and each depth layer has the following formula:

$$h_{l+1} = f(W_l h_l + b_l)$$

Combination Layer

The link layer connects the outputs of the two parallel networks and passes through a full link layer to get the output:

$$\rho = \sigma([x_{L1}^T, x_{L2}^T]w_{logits})$$

DCN can effectively capture the interaction of limited effective features, learn highly nonlinear interactions, do not require manual feature engineering or traversal search, and have low computational cost.

The main contributions of the paper include:

a) A new crossover network is proposed to explicitly apply feature intersection at each layer, effectively learning bounded predicted crossover features without manual feature engineering or exhaustive search.

b) Simple and effective across networks. By design, each layer has the highest polynomial series and is determined by the layer depth. The network consists of all the intersections, which have different coefficients.

c) Cross-network memory is efficient and easy to implement.

d) Experimental results show that the crossover network (DCN) has nearly an order of magnitude less parameters than DNN on LogLoss.

3.2 Technology

These are the hardware and software that I'm going to use in the project

HARDWARE	SOFTWARE
MACBOOK PRO 16 INCHES SOC: M1 PRO	Colab Pytorch environment Google drive Mysql Computer language: python

Table1：tools

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3.3 Version management plan

I will use Google Drive to save and manage my software versions as with colab. I think this is the most effective way.

And I will create a home folder to store the code for the deep learning model and sync back up my other files Project Management，create different sprints based on my learning.

4 Project Management

4.1 Activities

Here are the activities to accomplish each goal:

Object	Activities
A) completes the research, study, and research of the recommender system.	a) Conduct a systematic search of similar software b) Create a feature comparison table c) Complete a literature search d) Perform a literature review e) Conduct a user survey

B) completes the learning and research of deep learning.	a) learning online course of deep learning b) research of the model c) collection of the model implements d) learn the main theory and accomplish one by myself
C) collects appropriate data for analysis and evaluation.	a) find some articles about processing the data b) find the book dataset c) Analyze the data set, according to different characteristics d) Divide the dataset into training and testing sets
D) uses suitable deep learning models in combination with recommender systems.	a) create the Deep & Cross Network (DCN) model b) Use the training set for model training c) Test with the test set
E) implemented and tested.	a) Use the different dataset to test the whole system

Table 2: Activities

4.2 Schedule

That is my Gantt chart to show the activities and their deadlines.:

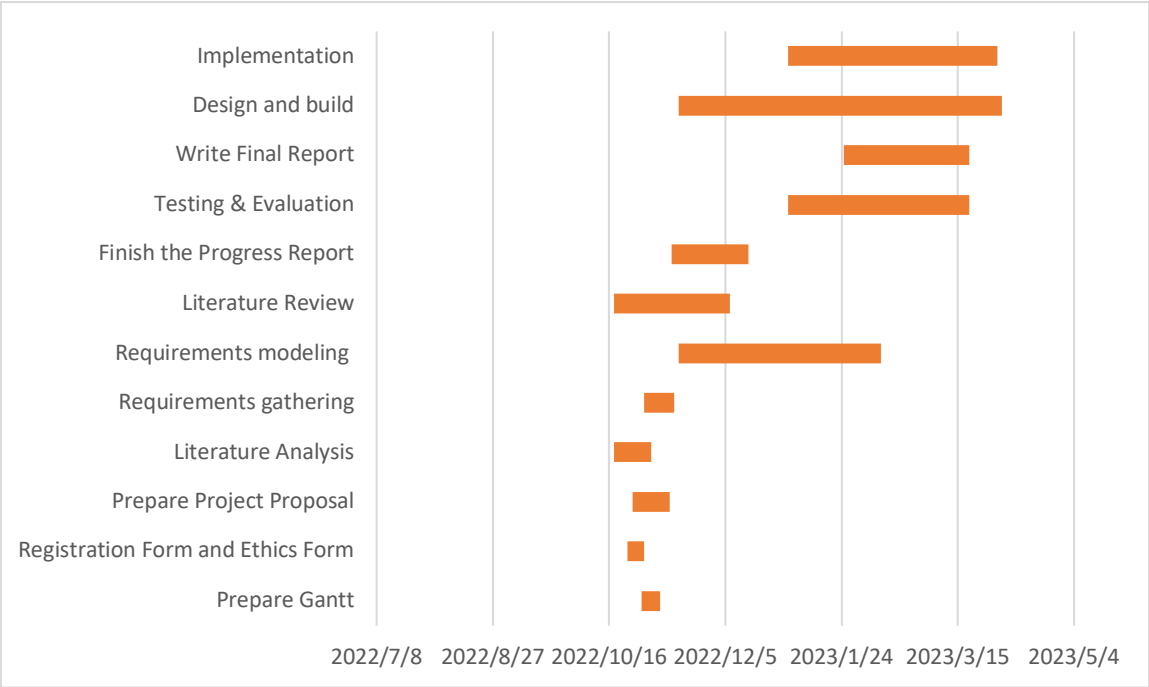

Figure 3: Gantt chart

4.3 Data management plan

I use both local storage and Google Cloud to manage my projects, and the papers and data are stored locally before being uploaded to a folder in the cloud and synced. Because I'm using CoLab, I'll automatically upload the code to Google Cloud after completing the code in the cloud, and then back it up to a local file for saving.

Figure4: Upload the folder to the google drive

4.4 Project Deliverables

All documents and resources that need to be submitted include: project proposal, progress report, final report, project code, dataset, testing data.

There are also some more detailed documents that are: weekly meeting logs, requirements or user stories, testing documentation, and ethics forms.

Figure5: local folder

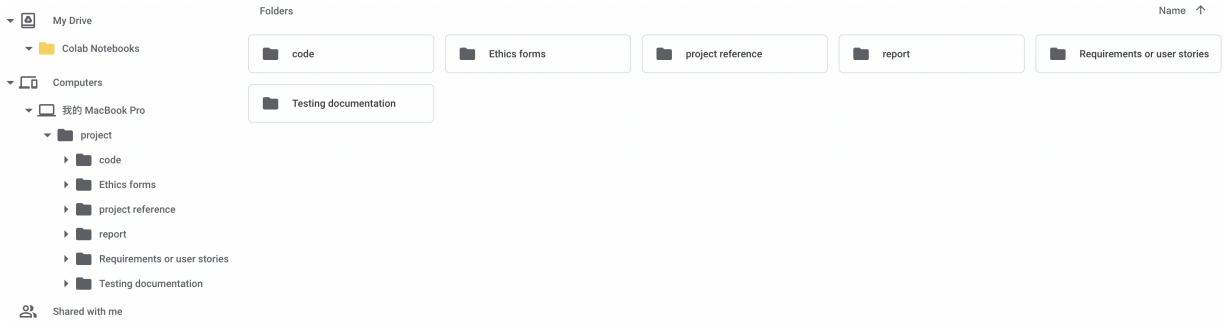

Figure6: Cloud disk folder

5 References

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