Beginning:

The paper addresses the cold-start problem in recommender systems, which is a challenge in providing recommendations for new users or items. The authors propose to solve this problem by utilizing the interactions of the cold-start users in the auxiliary source domain to help with recommendations in the target domain.

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自動產生的描述

The key issue in CDR, is how to transfer a user's preferences from the source domain to the target domain. Most existing methods model a common preference bridge to transfer preferences for all users. However, since preferences vary from user to user, the authors propose that the preference bridges of different users should be different.

The authors propose a framework named Personalized Transfer of User Preferences for Cross-domain Recommendation (PTUPCDR)，it learns a meta-network that takes users' characteristic embeddings as input and generates personalized bridge functions to achieve personalized transfer of preferences for each user .

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After training, user embeddings in the source domain are fed into the meta-generated personalized bridge functions to obtain the transformed user embeddings. These transformed user embeddings are utilized as the initial embeddings in the target domain, making the method effective for cold-start users who have no interactions in the target domain.

The authors also discuss the challenges in optimizing a high-level meta-network and propose a task-oriented optimization procedure to learn the meta-network stably. They conduct extensive experiments on three cross-domain tasks using Amazon review dataset to demonstrate the effectiveness and robustness of PTUPCDR for not only cold-start scenarios but also warm-start scenarios.

Chapter 2 of the paper discusses related work in the fields of Cross-domain Recommendation (CDR), Cold-start Recommendation, and Meta Learning.

\*\*Cross-domain Recommendation (CDR):\*\*. Inspired by transfer learning, CDR is a promising solution to alleviate data sparsity and the cold-start problem in the target domain with the help of the auxiliary (source) domain. The paper mentions various methods that have been proposed for CDR, including deep learning-based models that enhance knowledge transfer and methods that focus on bridging user preferences in different domains. However, most of these methods learn a shared bridge function for all users, which is not personalized.

\*\*Meta Learning:\*\* Also known as learning to learn, meta learning aims to improve novel tasks' performance by training on similar tasks. There are various meta learning methods, including metric-based methods, gradient-based methods, and parameter-generating based methods. The proposed PTUPCDR falls into the third group, which utilizes a meta learner to predict networks' parameters. However, most of these methods focus on single-domain recommendations, while PTUPCDR is designed for cross-domain recommendations.

Chapter 3 of the paper introduces the model for Personalized Transfer of User Preferences for Cross-domain Recommendation (PTUPCDR). Here's a summary:

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自動產生的描述

3.1 Problem Setting

we have a source domain and a target domain. Each domain has a user set U = {𝑢1, 𝑢2, ...}, an item set V = {𝑣1, 𝑣2, ...}，and a rating matrix R. 𝑟𝑖𝑗 ∈ R denotes the interaction between user 𝑢𝑖 and item 𝑣𝑗 . To distinguish these two domains, we denote the user, item sets, and the rating matrix of the source domain as U𝑠 , V𝑠 , R 𝑠 , while U𝑡 , V𝑡 , R 𝑡 for the target domain. We define the overlapping users between the two domains as U𝑜 = U𝑠 ∩ U𝑡 . In contrast, V𝑠 and V𝑡 are disjoint, which means there is no shared item between the two domains.

In this paper, {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msubsup><mi>u</mi><mi>i</mi><mi>d</mi></msubsup></mstyle><annotation 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and item {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><mstyle mathsize=\"16px\"><msup><msub><mi>v</mi><mi>j</mi></msub><mi>d</mi></msup></mstyle></math>"} , respectively, where 𝑘 denotes the dimensionality of embeddings and 𝑑 ∈ {𝑠, 𝑡 } represents the domain label.

3.2 Characteristic Encoder

cold-start users have no interacted item in the target domain. Thus, it is essential the to exploits the interacted items in the source domain. The attention mechanism is employed on item embeddings by performing a weighted sum, which allows different parts to contribute differently when compressing them to a single representation.

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where {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><mi>P</mi><msub><mi>u</mi><mi>i</mi></msub></mstyle><annotation encoding=\"application/json\">{\"x\":[[126,127,127,128,129,129,130,130,130,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131],[127,127,127,129,131,135,139,143,146,150,153,155,160,162,165,168,171,174,175,175,176,176,177,177,177,177,176,175,173,172,171,169,166,163,161,155,152,149,147,144,142,139,137,135,132,129,126,123,120,119,117,116,116,116,116,116],[189,189,188,188,188,187,187,187,187,187,187,187,187,187,187,188,189,190,191,192,193,195,197,199,200,203,204,205,207,209,211,214,215,216,217,218,218,218,219,219,219,219,218,217,217,216,215,215,215,215,215,214,214,214,214,214,214,214,214,214,214],[237,237,238,238,238,238,238,238,238,238,238,238,238,238,237,237],[242,242]],\"y\":[[98,98,100,103,108,114,120,126,134,142,150,157,164,169,176,181,188,195,200,205,210,212,215,216,217,218,219],[93,92,92,92,92,92,92,92,92,92,92,92,92,92,92,93,95,96,97,100,100,103,105,109,112,115,118,121,124,126,127,128,130,132,133,136,136,137,137,138,138,138,138,138,137,136,136,136,134,133,132,132,132,131,130,129],[185,186,186,187,188,189,192,194,196,198,200,200,202,203,204,204,205,205,206,206,207,207,208,208,208,207,205,204,202,200,197,196,193,192,191,190,189,188,187,186,185,184,184,186,188,189,192,193,195,196,200,200,202,204,205,207,208,210,212,212,214],[195,194,194,196,197,200,203,204,207,209,210,212,214,215,216,217],[188,187]],\"t\":[[0,56,64,71,79,87,96,103,111,119,127,136,143,151,160,168,176,184,193,201,209,218,226,234,243,251,259],[818,888,895,903,911,920,927,935,943,951,959,968,976,984,993,1001,1009,1018,1026,1034,1043,1051,1059,1068,1076,1084,1093,1101,1109,1118,1126,1134,1143,1151,1159,1168,1176,1184,1193,1201,1209,1218,1226,1234,1243,1251,1259,1268,1276,1288,1309,1320,1336,1344,1351,1359],[1776,1833,1839,1847,1855,1863,1871,1879,1887,1896,1903,1911,1935,1943,1951,1959,1968,1976,1984,1993,2001,2009,2018,2032,2039,2047,2055,2063,2071,2080,2087,2095,2103,2126,2134,2143,2151,2159,2168,2176,2208,2226,2297,2303,2311,2326,2335,2343,2351,2359,2368,2376,2384,2393,2401,2409,2418,2426,2434,2447,2487],[2937,2998,3005,3026,3034,3043,3051,3059,3068,3076,3084,3093,3101,3109,3126,3141],[3521,3534]],\"version\":\"2.0.0\"}</annotation></semantics></math>"} ∈ {"mathml":"<math xmlns=\"http://www.w3.org/1998/Math/MathML\" style=\"font-family:stix;font-size:16px;\"><semantics><msup><mi>R</mi><mi>k</mi></msup><annotation encoding=\"application/json\">{\"x\":[[102,102,103,104,107,107,108,108,110,110,110,110,110,110,109,108,107,105,104,103,103,103],[117,117,117,119,123,127,132,136,142,147,153,160,166,171,175,179,183,184,186,186,187,187,186,183,179,176,173,170,165,159,155,148,143,137,131,128,126,124,123,123,123,126,129,132,136,139,143,147,151,155,158,162,165,169,173,175,179,180,185,187,188,189],[218,217,216,215,215,215,215,215,215,215,215,215,215,215,215,217,217,217,217,217,217,217,217,217,217,217],[238,238,238,237,235,231,229,227,225,223,222,221,221,222,223,223,223,225,227,230,233,236,240,243,245,247,250,252,255,256]],\"y\":[[103,102,108,116,124,133,141,151,161,173,184,196,207,217,228,236,243,248,253,256,256,258],[100,99,98,98,98,98,98,98,100,100,100,102,103,105,107,109,111,112,115,117,121,127,132,142,147,149,152,154,155,156,157,158,160,161,163,164,164,165,166,167,168,169,171,173,176,181,186,190,196,202,209,218,225,231,237,242,247,248,254,256,259,260],[50,50,50,50,51,52,55,56,60,63,66,68,72,77,80,84,88,91,93,96,97,99,100,103,104,105],[61,60,60,60,60,60,61,62,63,64,64,65,66,66,67,68,68,68,70,72,74,76,80,81,83,84,84,85,87,87]],\"t\":[[0,63,86,93,101,109,118,126,135,143,151,160,168,176,185,193,201,210,218,226,235,243],[606,679,684,693,701,710,718,726,735,743,751,759,768,776,784,793,801,809,818,826,835,843,851,859,868,876,885,893,901,909,918,926,935,943,951,960,968,993,1093,1101,1110,1118,1126,1135,1143,1151,1160,1168,1176,1185,1193,1201,1209,1218,1226,1234,1243,1251,1260,1268,1276,1285],[1662,1668,1693,1710,1723,1731,1739,1747,1755,1763,1771,1779,1788,1795,1803,1811,1819,1827,1835,1843,1851,1859,1868,1876,1885,1925],[2220,2271,2283,2291,2299,2307,2315,2323,2331,2339,2347,2429,2452,2518,2526,2551,2559,2568,2576,2585,2593,2601,2610,2618,2626,2635,2643,2651,2659,2668]],\"version\":\"2.0.0\"}</annotation></semantics></math>"}denotes the transferable characteristic(user preference) embedding of user 𝑢𝑖 , and 𝑎𝑗 is the attention score for item 𝑣𝑗 , which can be interpreted as the importance of 𝑣𝑗 in predicting the personalized bridge function.we learn the attention score from the items’ embeddings by an attention network. Formally, the attention network is defined as:

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自動產生的描述

where ℎ(·) denotes the attention network, and 𝜃 denotes the parameters of ℎ(·). In this paper, ℎ(·) is a two-layer feed-forward network. Note that the normalized attention score 𝑎𝑗 is beneficial to find the useful interacted items for a specific user.

where the denominator Σ\_ exp({"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msubsup><mi>a</mi><mi>l</mi><mo>'</mo></msubsup></mstyle><annotation encoding=\"application/json\">{\"x\":[[262,263,263,263,263,263,263,262,260,260,259,258,257,255,254,252,251,250,249,248,247,245,243,241,239,237,236,234,232,231,228,227,226,224,223,222,220,219,219,218,218,218,218,218,219,221,222,224,226,228,230,233,236,239,242,245,248,251,255,259,261,263,266,269,270,271,272,273,273,274,274,274,274,274,274,274,273,272,271,271,270,269,268,267,267,267,267,267,267,267,267,267,268,268,268,268,269,269,269,270,270,271,271,271,271,272,273,275,275,276,277,278,279,279,279,280,281,282,283,283],[297,297,297,297,296,295,295,294,293,292,292,291],[285,284,283,283,284,285,287,288,290,292,294,295,298,300,305,307,310,312,314,317,319,319,321,322,323,323,323,323,323,323,323,323,323,323,323,323,323,323,323,322,321,319,319,319,318,317,317,316,315,315,314,313,312,312,312,312,312,312,312,312,312,311,311,311,311,311,311,311,311,311,311,311,311,311,311,311,311,311,311,312,312,312,312,313,314,314,315,315,315,315,316,317,318,318,319,320,322,323,324,325,327,328,330,331,332,334,336,337,339,339,340,341,341,342,343,343,344]],\"y\":[[186,186,185,184,184,183,182,180,180,178,178,177,176,176,175,174,174,174,173,173,173,173,173,173,175,176,176,177,179,180,182,184,186,189,193,195,198,200,204,208,212,215,218,221,223,224,226,227,228,228,229,229,229,229,229,229,229,228,225,222,218,214,210,203,200,198,196,194,192,190,189,188,187,185,184,183,182,182,182,182,182,182,182,182,183,184,185,188,189,192,194,196,198,200,206,209,212,216,218,222,224,228,230,231,232,234,235,238,240,242,244,244,244,246,246,247,248,248,248,248],[137,136,138,140,141,143,145,148,148,151,152,152],[300,299,298,297,297,296,296,294,292,291,289,288,287,284,280,277,275,272,268,264,259,254,251,248,245,243,240,237,236,232,230,228,224,221,218,216,214,212,208,205,203,202,200,199,198,196,196,196,195,194,194,194,194,195,196,198,199,201,203,204,206,208,210,214,216,217,220,220,223,224,226,228,228,230,233,235,236,240,242,244,246,248,249,251,253,256,258,259,261,263,264,266,268,270,272,273,275,276,277,279,281,283,285,286,288,289,291,292,292,293,294,294,295,295,296,296,296]],\"t\":[[0,7,38,45,54,61,70,94,115,123,132,140,148,157,165,173,182,190,198,206,215,223,248,256,265,273,282,290,298,306,315,323,332,340,348,356,365,373,381,390,398,406,415,423,431,440,448,456,465,473,481,490,498,507,515,523,532,540,548,557,565,573,581,590,598,606,615,623,631,640,648,657,665,703,734,783,790,815,823,850,873,886,1064,1090,1106,1115,1123,1131,1140,1148,1157,1165,1173,1181,1190,1198,1206,1215,1223,1231,1240,1248,1256,1265,1273,1282,1290,1301,1309,1318,1325,1333,1341,1349,1357,1390,1406,1422,1431,1440],[1898,1983,2007,2015,2023,2032,2040,2048,2056,2065,2073,2081],[52915,52930,52939,52947,52959,52967,52989,52997,53014,53022,53030,53039,53047,53055,53064,53072,53080,53089,53097,53105,53114,53122,53130,53139,53147,53155,53164,53172,53180,53189,53197,53206,53214,53222,53231,53239,53247,53255,53264,53272,53280,53289,53303,53312,53331,53356,53381,53389,53399,53407,53544,53551,53559,53580,53589,53597,53605,53614,53622,53631,53639,53647,53655,53664,53672,53680,53689,53697,53705,53720,53727,53735,53743,53751,53772,53780,53789,53797,53806,53814,53822,53831,53839,53847,53855,53864,53872,53880,53889,53897,53905,53914,53922,53930,53939,53947,53955,53964,53972,53980,53989,53997,54006,54014,54022,54030,54039,54047,54055,54064,54072,54080,54089,54097,54105,54131,54177]],\"version\":\"2.0.0\"}</annotation></semantics></math>"}) is the sum of the exponentiated attention scores over all items.

3.3 Meta Network

學習如何去學習，比如說機器學習是學習如何去optimize gradient，學習如何去找出weight個bias，而meta learning嘗試找出最佳的學習的方法（function），例如net的 architecture、initialized embedding（MAML）、learning gradient algorithm

這些learnable component統稱𝜙

元学习（Meta-Learning）的过程主要包括以下步骤：

任务生成（Task Generation）：元学习首先需要一个任务集，这些任务需要有一定的相关性，但每个任务都有各自的特点。例如，在图像分类的场景下，每个任务可以是一个不同类别的图像分类问题。

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自動產生的描述

元训练（Meta-Training）：在元训练阶段，模型会在任务集中的每个任务上进行学习，并且尝试找到一个好的初始参数或学习策略，使得当接到新任务时，可以在少量的训练样本上进行快速适应。

元测试（Meta-Testing）：在元测试阶段，模型会面临新的任务，这些任务是在元训练阶段未见过的。模型需要在这些新任务上进行快速适应，然后测试其在新任务上的性能。把training task中的testset拿出来测试performance 再计算误差，

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自動產生的描述

在機器學習裡，是用trainset去计算loss，然后再根据这个loss进行gradient descend，而在meta learning中是用testset去計算loss。

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自動產生的描述

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自動產生的描述

用training task裡面不同的task的trainset來train model，然後用testset來optimize model，找出best parameter 𝜙 with learning algorithm,然後再把testing task的trainset用這個algorithm train，再把testset放進去得出結果。

只需要testing task的trainset的很小樣本就可以train出來

與ML的差別

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自動產生的描述

Paper：

there exists a certain connection between the preference relationship and the user’s characteristics.

The model then uses a meta network, which takes the user's transferable characteristics {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><mi>P</mi><msub><mi>u</mi><mi>i</mi></msub></mstyle><annotation encoding=\"application/json\">{\"x\":[[126,127,127,128,129,129,130,130,130,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131,131],[127,127,127,129,131,135,139,143,146,150,153,155,160,162,165,168,171,174,175,175,176,176,177,177,177,177,176,175,173,172,171,169,166,163,161,155,152,149,147,144,142,139,137,135,132,129,126,123,120,119,117,116,116,116,116,116],[189,189,188,188,188,187,187,187,187,187,187,187,187,187,187,188,189,190,191,192,193,195,197,199,200,203,204,205,207,209,211,214,215,216,217,218,218,218,219,219,219,219,218,217,217,216,215,215,215,215,215,214,214,214,214,214,214,214,214,214,214],[237,237,238,238,238,238,238,238,238,238,238,238,238,238,237,237],[242,242]],\"y\":[[98,98,100,103,108,114,120,126,134,142,150,157,164,169,176,181,188,195,200,205,210,212,215,216,217,218,219],[93,92,92,92,92,92,92,92,92,92,92,92,92,92,92,93,95,96,97,100,100,103,105,109,112,115,118,121,124,126,127,128,130,132,133,136,136,137,137,138,138,138,138,138,137,136,136,136,134,133,132,132,132,131,130,129],[185,186,186,187,188,189,192,194,196,198,200,200,202,203,204,204,205,205,206,206,207,207,208,208,208,207,205,204,202,200,197,196,193,192,191,190,189,188,187,186,185,184,184,186,188,189,192,193,195,196,200,200,202,204,205,207,208,210,212,212,214],[195,194,194,196,197,200,203,204,207,209,210,212,214,215,216,217],[188,187]],\"t\":[[0,56,64,71,79,87,96,103,111,119,127,136,143,151,160,168,176,184,193,201,209,218,226,234,243,251,259],[818,888,895,903,911,920,927,935,943,951,959,968,976,984,993,1001,1009,1018,1026,1034,1043,1051,1059,1068,1076,1084,1093,1101,1109,1118,1126,1134,1143,1151,1159,1168,1176,1184,1193,1201,1209,1218,1226,1234,1243,1251,1259,1268,1276,1288,1309,1320,1336,1344,1351,1359],[1776,1833,1839,1847,1855,1863,1871,1879,1887,1896,1903,1911,1935,1943,1951,1959,1968,1976,1984,1993,2001,2009,2018,2032,2039,2047,2055,2063,2071,2080,2087,2095,2103,2126,2134,2143,2151,2159,2168,2176,2208,2226,2297,2303,2311,2326,2335,2343,2351,2359,2368,2376,2384,2393,2401,2409,2418,2426,2434,2447,2487],[2937,2998,3005,3026,3034,3043,3051,3059,3068,3076,3084,3093,3101,3109,3126,3141],[3521,3534]],\"version\":\"2.0.0\"}</annotation></semantics></math>"} as input and generates a personalized bridge function between the user's embeddings in the source and target domains. The proposed meta network is formulated as:



where 𝑔(·) is the meta network, which is parameterized by 𝜙. In this paper, the meta network is a two-layer feed-forward network. The 𝒘𝑢𝑖 is a vector whose size depends on the structure of the bridge function. The personalized bridge function is formulated as:



, to fit the size of bridge’s parameters, we reshape the vector 𝒘𝑢𝑖 ∈ {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msup><mi>R</mi><msup><mi>k</mi><mn>2</mn></msup></msup></mstyle><annotation 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into a matrix 𝒘𝑢𝑖 ∈ {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msup><mi>R</mi><mrow><mi>k</mi><mo>&#xD7;</mo><mi>k</mi></mrow></msup></mstyle><annotation 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where {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msubsup><mi>u</mi><mi>i</mi><mi>s</mi></msubsup></mstyle><annotation 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denotes the embedding of user 𝑢𝑖 in the source domain, and {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msubsup><mover><mi>u</mi><mo>^</mo></mover><mi>i</mi><mi>t</mi></msubsup></mstyle><annotation 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represents the transformed embedding. Finally, we can utilize the transformed embedding {"mathml":"<math style=\"font-family:stix;font-size:16px;\" xmlns=\"http://www.w3.org/1998/Math/MathML\"><semantics><mstyle mathsize=\"16px\"><msubsup><mover><mi>u</mi><mo>^</mo></mover><mi>i</mi><mi>t</mi></msubsup></mstyle><annotation encoding=\"application/json\">{\"x\":[[118,119,119,119,119,119,119,119,119,118,118,117,117,117,116,116,116,115,115,115,115,115,115,115,116,117,118,118,119,120,120,122,123,123,127,129,131,134,136,137,139,142,144,146,147,147,148,149,150,151,151,152,152,153,153,154,154,155,155,155,155,155,156,156,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,157,156,156,156,155,155,155,155,155,155,155,155,155,155,155,155,155,155,155,155,155,155,156,156,156,157,157,158,159,159,159,160,160,161,162,163],[121,123,123,124,126,127,128,130,132,135,135,137,139,139,140,140,141,142,142,143,143,143,143,143,143,143,144,145,146,147,147,147,147,147,148,149,150,151,151,151,152,154,155,155,156,157,158,159,159,159,160,160,161,161,162,162,162,163,163],[196,199,203,205,212,215,217,218,219],[214,213,212,211,211,211,211,210,210,209,209,209,208,208,208,208,208,208,208,208,208,208,208,208,208,208,208,208,208,209,210,210,211,212,213,214,215,215,217,218,219,220,221,223,223,224,225,226,227,227,228,229,229,230,230,230,230,229,229,228,227],[215,217,218,218,219,219,219,219,219,219,219,219,219,219,219,220,220,221,221,221,222,222,222,222],[219,219,218,218,217,217,216]],\"y\":[[179,179,180,181,183,185,188,192,194,197,200,204,206,209,212,216,216,219,222,224,227,228,230,232,233,236,237,238,239,240,240,240,240,240,240,240,240,239,237,236,233,231,228,227,225,223,221,220,218,216,215,215,213,212,211,208,208,205,204,200,199,198,196,194,193,192,191,190,189,188,188,186,185,184,184,183,182,184,186,189,192,195,196,199,201,203,206,208,210,212,214,215,216,218,219,220,223,224,225,227,228,228,230,231,232,233,235,236,237,239,240,240,241,242,242,243,244,244,244,244,244,244],[164,164,163,163,162,161,160,160,158,156,154,152,151,149,148,146,146,144,144,144,143,142,140,140,140,138,137,137,137,138,139,140,141,142,144,146,148,149,152,153,156,157,159,160,162,164,165,168,170,172,173,175,176,176,178,180,180,181,182],[115,115,115,115,115,115,115,115,115],[101,100,100,100,101,103,104,106,108,110,111,113,116,117,120,123,125,128,130,131,132,133,134,135,136,137,138,140,140,141,141,142,142,143,143,143,144,144,144,144,144,143,142,141,141,140,140,140,138,137,136,135,134,134,133,132,132,132,131,130,130],[245,245,245,246,247,248,249,251,253,255,257,260,260,263,264,265,266,267,268,269,271,272,274,276],[230,229,228,228,227,225,224]],\"t\":[[0,86,103,112,120,128,137,145,153,162,170,178,187,195,203,212,220,228,237,245,253,262,270,278,287,295,303,315,337,347,355,363,371,379,403,411,420,428,437,445,453,462,470,478,486,495,503,512,520,528,537,545,553,562,570,578,587,595,603,611,620,628,653,668,675,683,691,699,707,715,737,747,770,778,787,795,811,949,955,963,971,979,987,995,1005,1011,1020,1028,1037,1045,1053,1062,1070,1078,1087,1095,1103,1112,1120,1131,1139,1153,1162,1170,1178,1187,1196,1203,1212,1220,1228,1237,1245,1253,1267,1275,1324,1345,1353,1380,1404,1469],[2423,2495,2503,2512,2520,2528,2537,2545,2553,2562,2570,2578,2587,2595,2603,2612,2627,2635,2643,2653,2662,2670,2683,2691,2699,2707,2728,2887,2899,2907,2915,2923,2945,2953,2962,2970,2978,2987,2995,3003,3011,3020,3028,3036,3045,3053,3062,3070,3078,3087,3095,3103,3112,3123,3147,3155,3178,3187,3317],[23381,23451,23457,23465,23489,23497,23505,23513,23536],[23939,23995,24003,24011,24025,24033,24041,24049,24057,24065,24073,24081,24094,24103,24111,24120,24128,24137,24144,24153,24161,24169,24178,24186,24194,24211,24225,24233,24241,24249,24269,24278,24286,24295,24303,24311,24320,24328,24336,24345,24353,24361,24369,24378,24386,24401,24409,24428,24441,24449,24457,24465,24486,24497,24505,24528,24537,24545,24569,24609,24637],[25354,25403,25411,25425,25433,25441,25449,25457,25465,25473,25481,25489,25497,25505,25513,25538,25545,25553,25561,25569,25578,25586,25594,25603],[26082,26128,26136,26145,26153,26161,26169]],\"version\":\"2.0.0\"}</annotation></semantics></math>"} for prediction.

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自動產生的描述

3.4 Optimization problem

since some users only have limited interactions, the user’s embedding 𝒖 𝑡 𝑖 may be not reasonable and accurate enough. Learning towards the relatively unreasonable embeddings would lead to negative impact on the model.so instead of using mapping-oriented optimization,The model is trained using a task-oriented optimization procedure , 1.which alleviates the effects of unreasonable embeddings. It directly uses the rating data, which is ground truth rather than approximate intermediate results. 2.This procedure has more training samples, which can avoid overfitting.

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自動產生的描述

where 𝑟𝑖𝑗 denotes the rating of user 𝑖 on item 𝑗, 𝒖𝑖 is the user embedding, 𝒗𝑗 is the item embedding, and |R| is the total number of ratings. The goal of this loss function is to minimize the difference between the actual rating 𝑟𝑖𝑗 and the predicted rating 𝒖𝑖𝒗𝑗.

3.5 Overall Procedure

The overall training procedure can be divided into three steps: pre-training, meta, and initialization stages.

Pre-training stage: This step is to learn latent spaces for each domain,The loss function is formulated as:

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自動產生的描述(8)

where |R| denotes the number of ratings. After the pre-training step, we can obtain the pre-trained embeddings 𝒖 𝑠 , 𝒖 𝑡 , 𝒗 𝑠 , 𝒗 𝑡 .

Meta stage: The existing methods directly train a common bridge function, while PTUPCDR trains the characteristic encoder and the meta network. The characteristic encoder and the meta network are optimized with Equation (7).

Initialization stage: When a new user comes (CDR assumes the new user has some interactions in the source domain), we use the transformed embedding to initialize the new user’s embedding in the target domain. Test stage: For the extreme cold-start users who have no interactions in the target domain, directly utilize the initial embedding 𝒖ˆ 𝑡 𝑖 = 𝑓𝑢𝑖 (𝒖 𝑠 𝑖 ;𝒘𝑢𝑖 ) for prediction. For the warm-start users who have some interaction in the target domain, it is convenient to fine-tune the initial embeddings with new interactions, and utilize the fine-tuned embeddings for prediction

Code 架構：

entry.py for configuration set up 裡面會再call data preprocessing

run.py的main 首先會call get\_model，

直接用torch.nn.Embedding的方法獲得ui和vj from source domain 的embedding （data\_src）call from get\_data—》read\_log\_data（self.src\_path（train\_src.csv），self.batchsize\_src）

then optimize the embeddings by using task oriented loss function

然後再加入attention 機制 來做summation ，算出指定的user 他對商品的preference。p

DATA preprocessing

在entry.py中，ataPreprocessingMid會進行三次，分別是對Books', 'CDs\_and\_Vinyl', 'Movies\_and\_TV中的uid iid y過濾出來，然後存到csv裡

for ratio in [[0.8, 0.2], [0.5, 0.5], [0.2, 0.8]]:

for task in ['1', '2', '3']:

DataPreprocessingReady(config['root'], config['src\_tgt\_pairs'], task, ratio).main()

把不同task與ratio的組合丟進去做處理，

Task 1：**src:**"Movies\_and\_TV"，**tgt:**"CDs\_and\_Vinyl"

Task2 **src:**"Books"，**tgt:**"Movies\_and\_TV"

Task3 **src:**"Books"，**tgt:**"CDs\_and\_Vinyl"

有9種組合

[0.8, 0.2]後面的是test rate，用來做test

每種組合的DATA

train\_src = src直接用來做一開始的embedding

train\_tgt（除去test user的target domain user）

src和tgt裡面有uid和idd和y（rating

pos\_seq\_dic（從每個co user中選出rating》3的src的data），用每個co user from src來做key ，大過3的idd做valve

｛1:［101，103］｝

Train\_meta :

train\_meta的data是target domain的，而pos\_seq\_dict的data用的是source domain的 train\_meta里面的iid和pos\_seq里面的不能重复，因为他们的iid是来自不同domain的

這樣train meta裡面既包含了target domain的uid（co-user）和iid，又包含了該user在src中rating大於3的idd list，所以train meta会包含cross domain的information  
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自動產生的描述

test選自test\_user（randomly selected user from co-user）,然後再從target domain中抽取test user的data，然後再把pos\_seq\_dic加入去，

get\_data

data\_src from train\_src

data\_tgt from train\_tgt

data\_meta , from train\_meta

後面的positive sequence與前面的uid iid合在一起，不滿20的就用0來填補

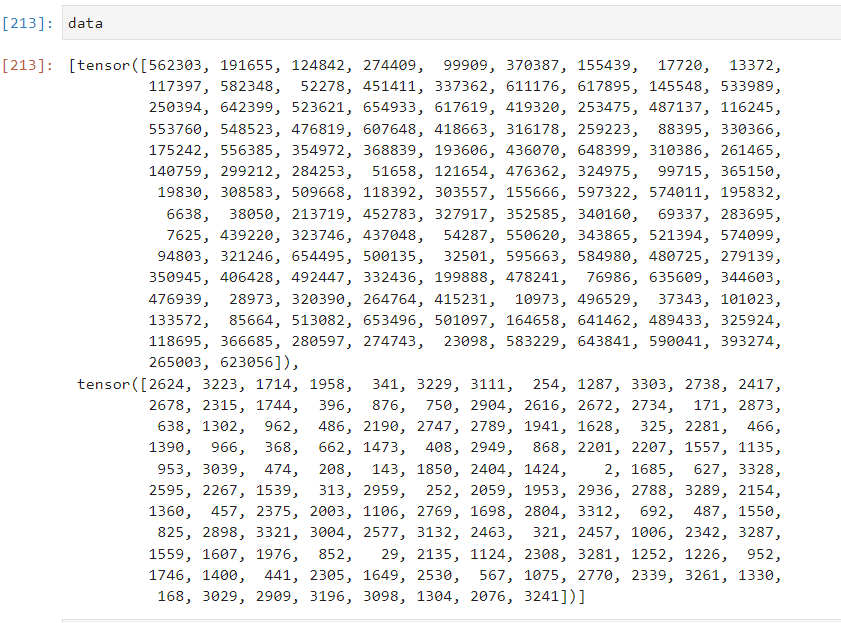
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自動產生的描述

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自動產生的描述

1. **data\_map**: This data might be used to map or align entities or features between the source and target domains. For example, it might indicate which users or items in the source domain correspond to which users or items in the target domain.



Target domain 的unique uid，每个uid对应特定的index

1. **data\_aug**: This is the augmented data. Data augmentation is a technique used to increase the amount of training data by creating modified versions of the existing data. This can help improve the model's performance, especially when the original dataset is small.

**把src 和tgt concat在一起**

data\_test

4.2 Cold-start Experiments (RQ1)

(1) TGT is a single-domain model that only uses data from the target domain, and its performance is unsatisfying. Compared with TGT, all other cross-domain methods could exploit data from the source domain, thus achieving better results.

Method:CDR EMCDR PTUPCDR

Model base:MF GMF DNN