One Person, One Model, One World: Learning Continual User Representation without Forgetting

SIGIR2021

Data&Code: https://github.com/fajieyuan/SIGIR2021_Conure

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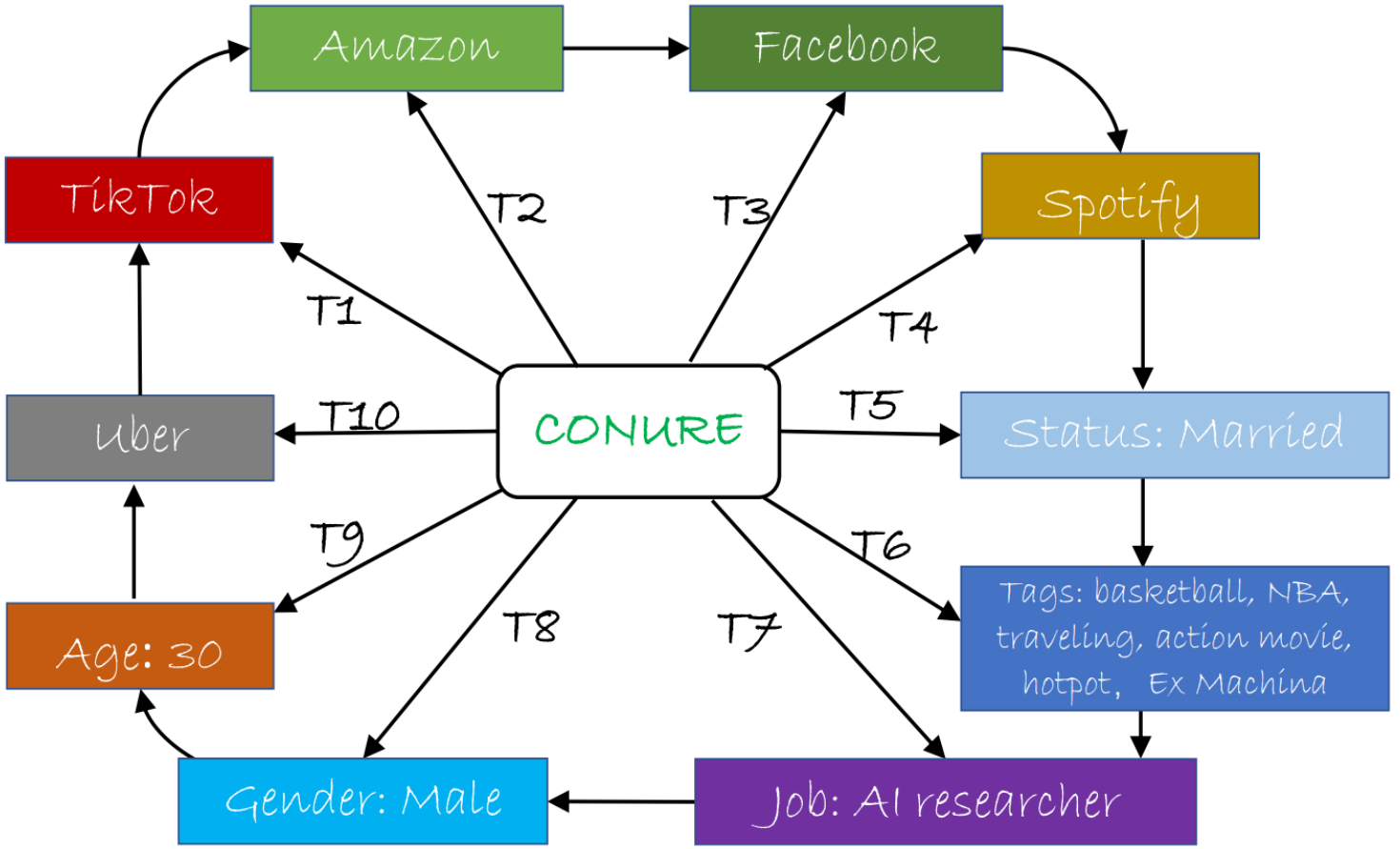
Outline

- Motivation
- Related Work
- Conure
- Experiments

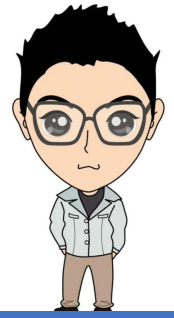
Our Motivation

A person has different roles to play in life!
But all these roles may have some commonalities, such as personalization, habits, preference.

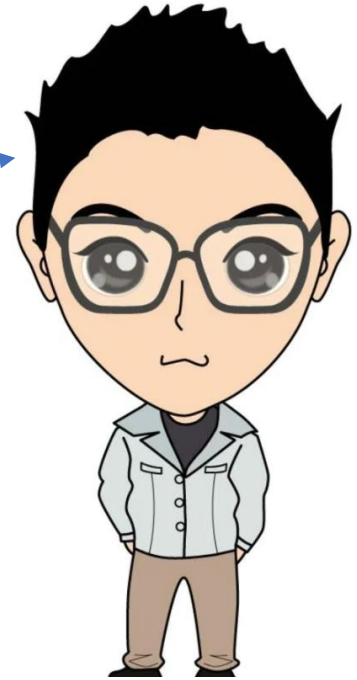


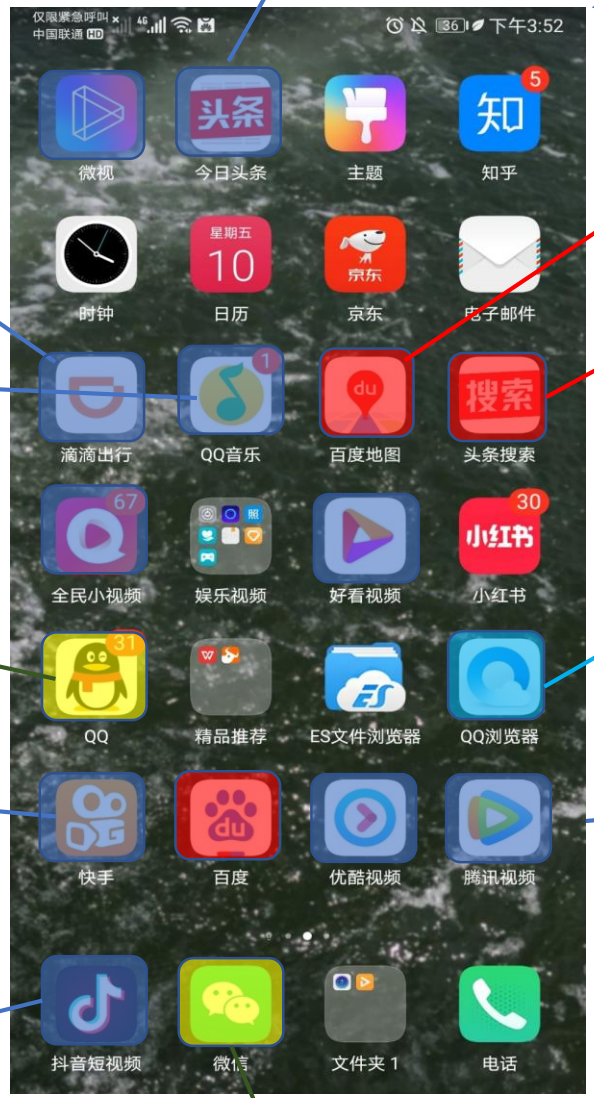
Our Focus:
Whether we can build a user representation model that could keep learning throughout all sequential tasks without forgetting

One Person, One Model, One World



A person has different roles to play in life! But all these roles may have some commonalities, such as personalization, habits, preference.





News Rec

Video Rec

Car Rec

Music Rec

Social APP

Video Rec

Video Rec

Social APP

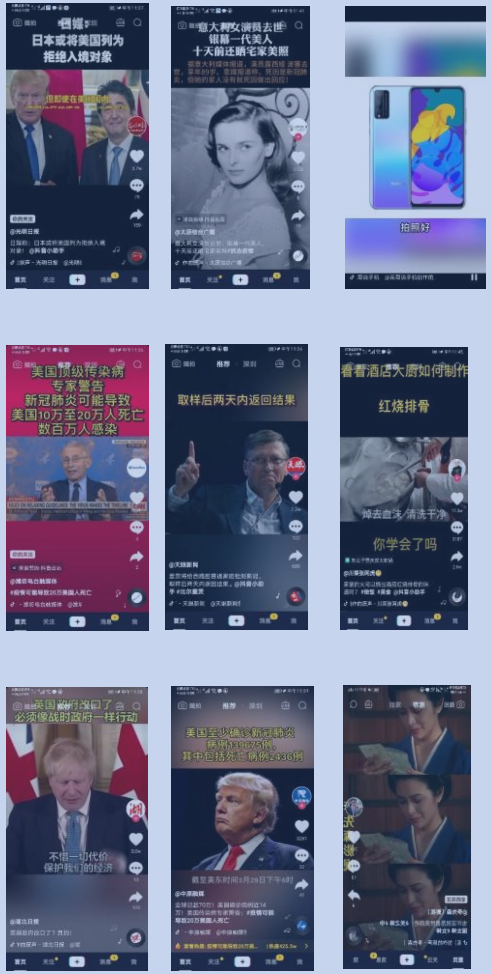
Map APP

Search Engine

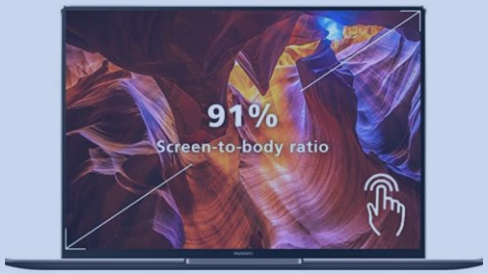
Browser

Video Rec

Clicking logs



TikTok -- warm user



13.9" LTPS DISPLAY | 4.4mm ULTRA-THIN BEZEL | 91% SCREEN-TO-BODY RATIO | 178° VIEWING ANGL

Amazon —cold users

No interaction

Ads --- new users

Using Lifelong learning techniques to solve recommendation tasks

Keypoints

- Necessity and possibility why lifelong learning for UR learning?
- Lifelong learning paradigm throughout all tasks.
- Performance gain for tasks have certain correlations.

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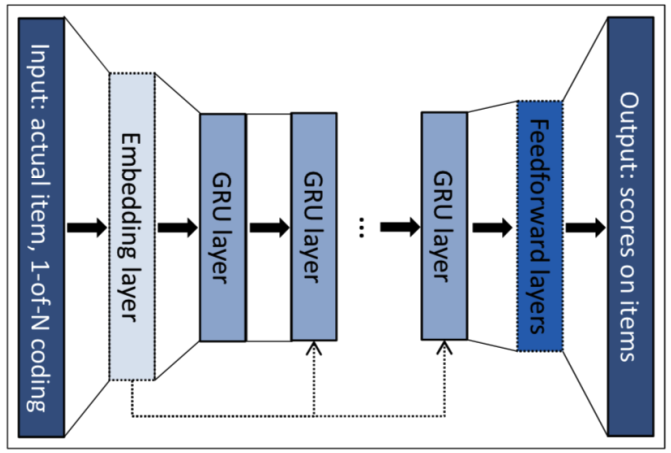
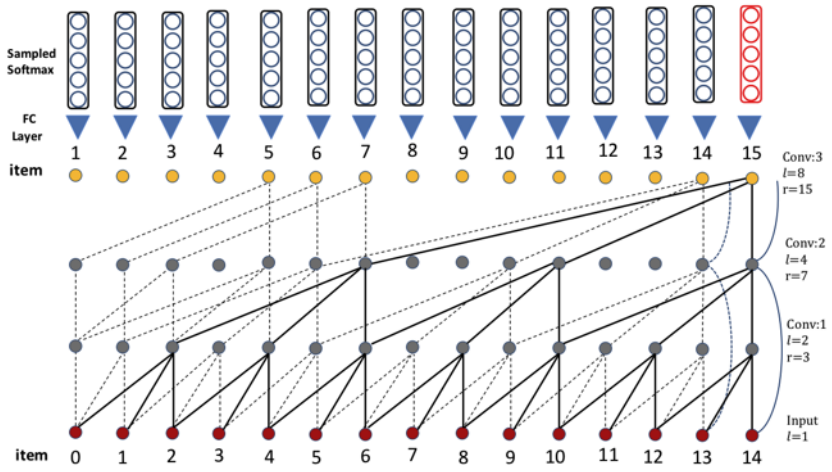
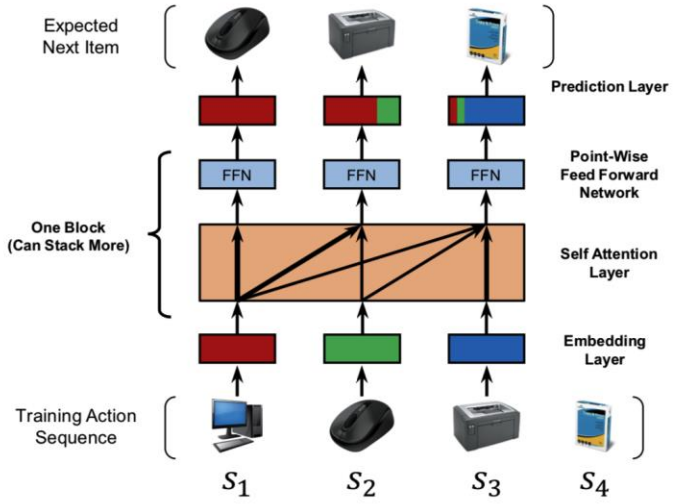
- **Classical UR models** (works well but is specific to only one task)



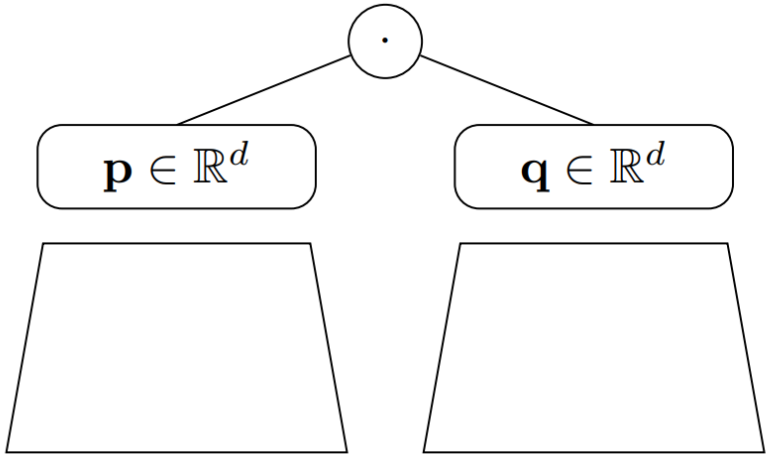
GRU4Rec (Hidasi et al ICLR2016)



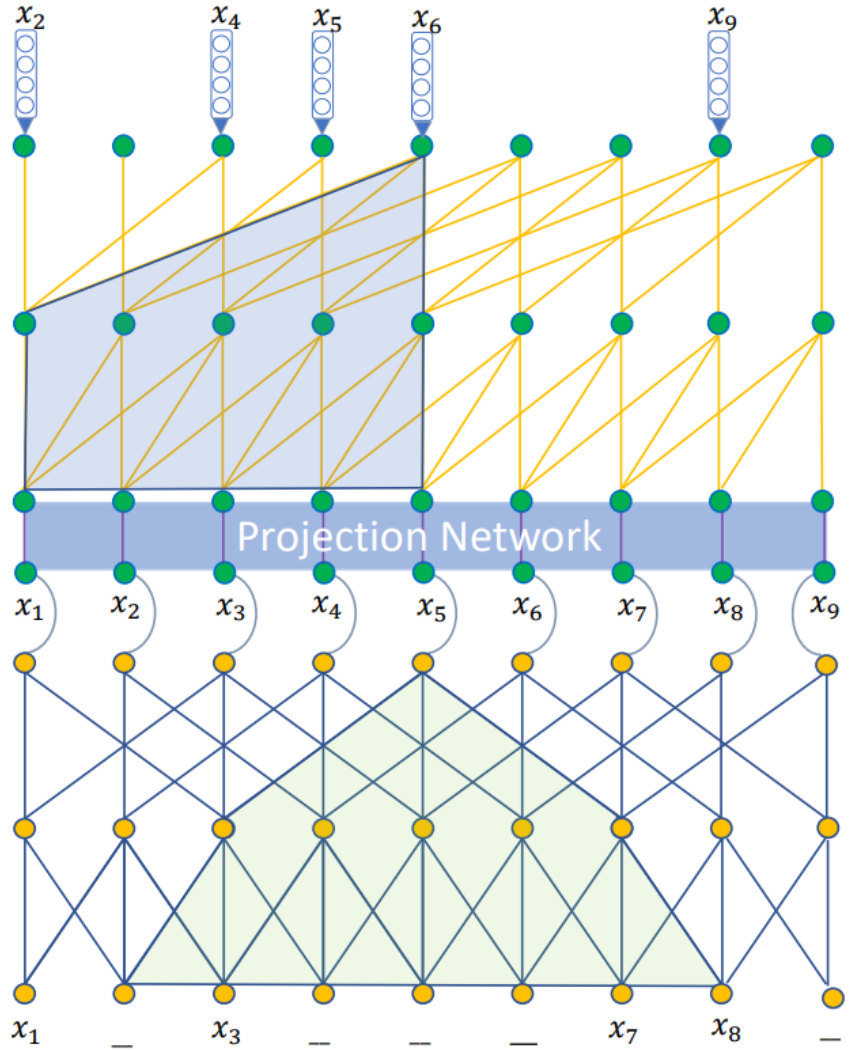
NextItNet (Yuan et al WSDM2019)



SASRec(Kang et al ICDM2018)



DSSM(Huang et al CIKM2013)



Grec (Yuan et al WWW2020)

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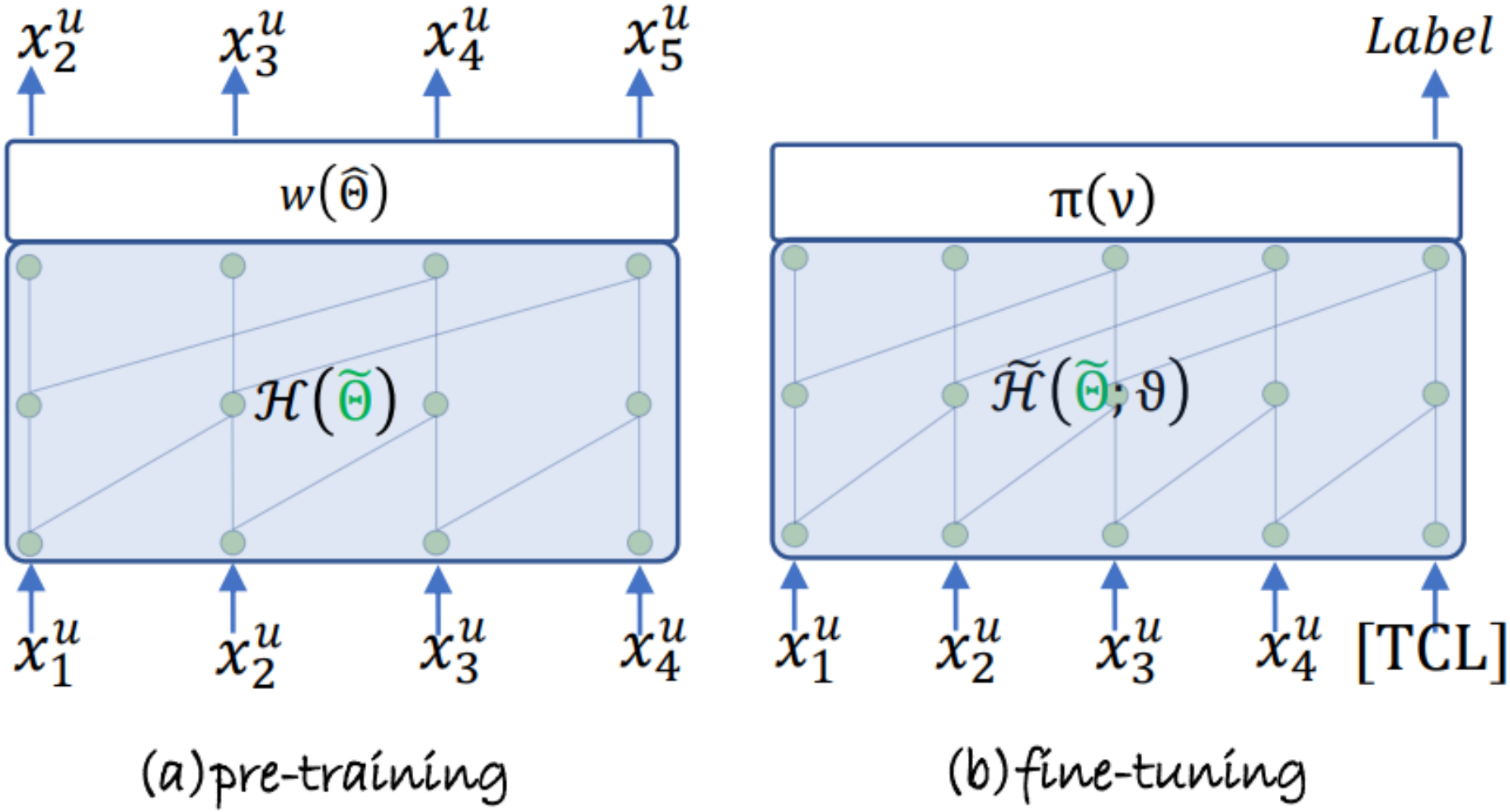
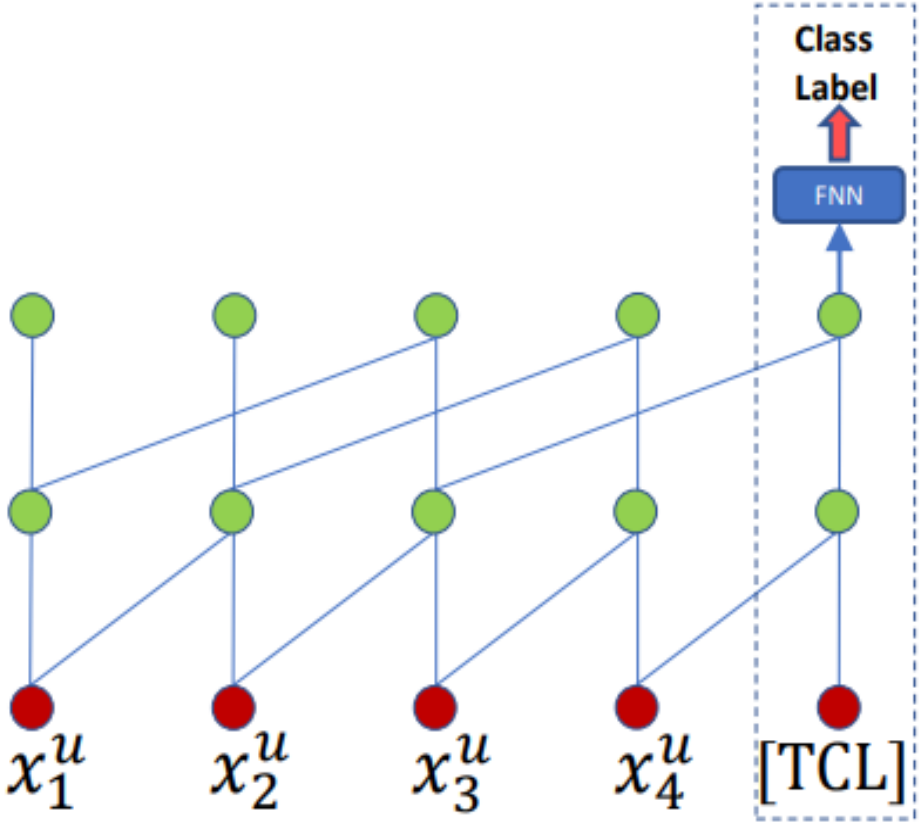
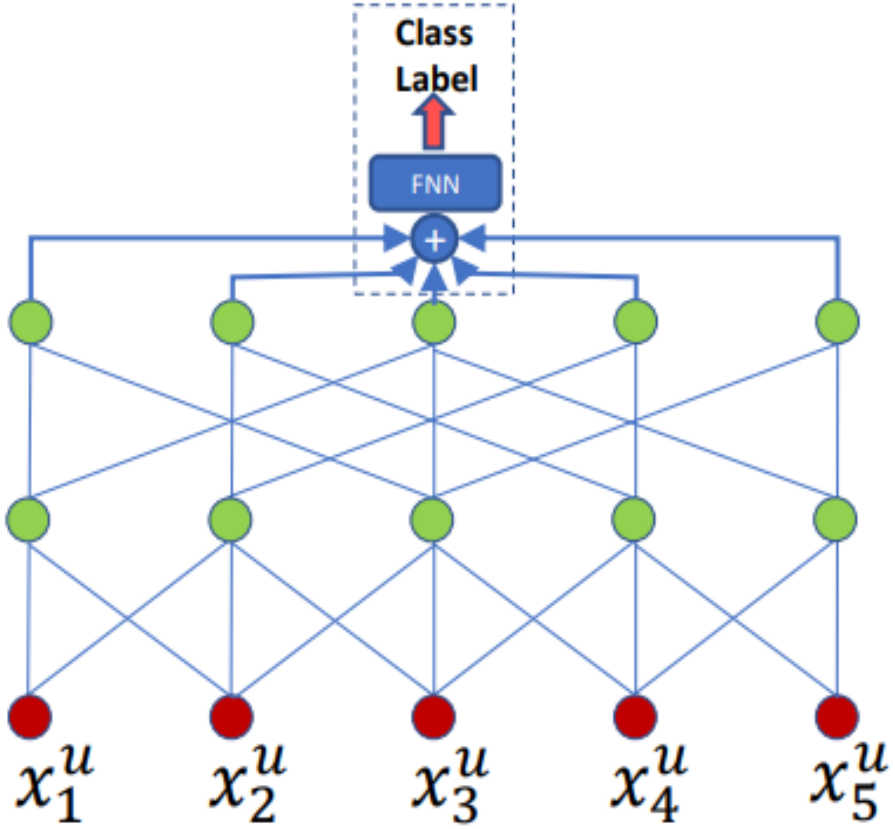
- PeterRec (Two-stage Transfer Learning):



- PeterRec (Finetuning):

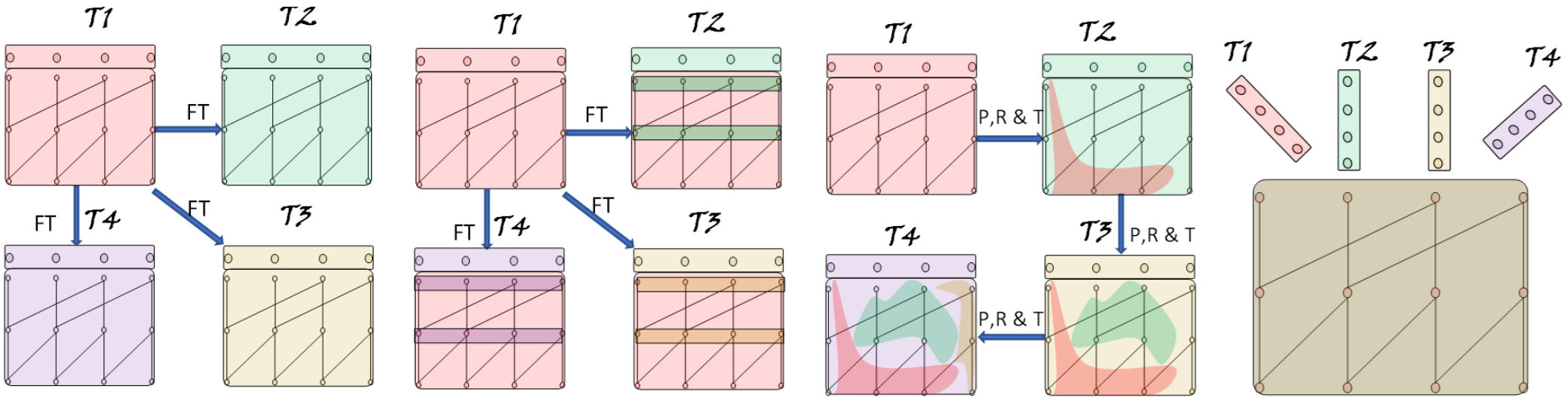




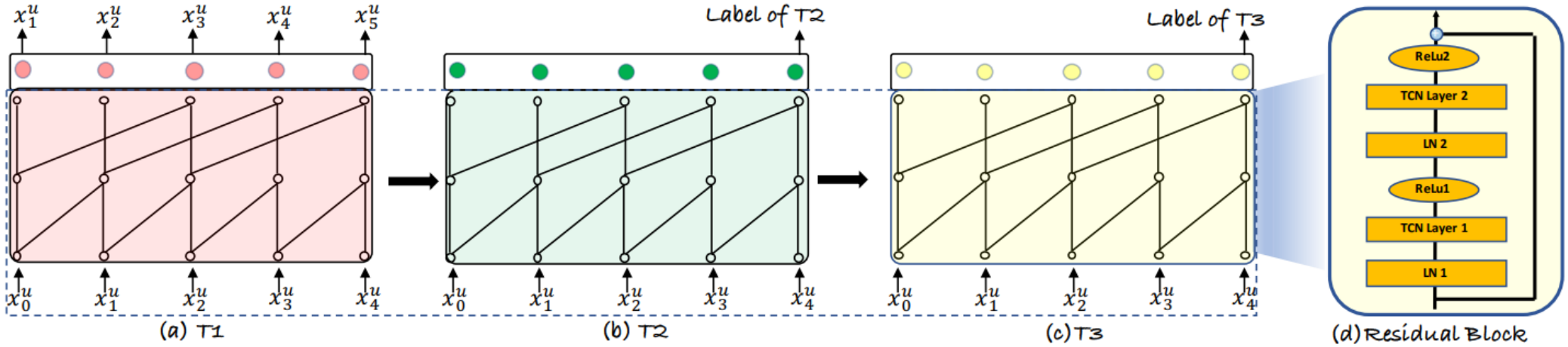
$$p(\mathbf{x}^u;\Theta) = \prod_{i=1}^{n} p(x_i^u | x_1^u, .., x_{i-1}^u;\Theta)$$

$$p(\mathbf{x}_\triangle^u;\Theta) = \prod_{i=1}^{m} p(x_{\triangle_i}^u | \tilde{\mathbf{x}}^u;\Theta)$$

- Transfer Learning Paradigm Comparisons:

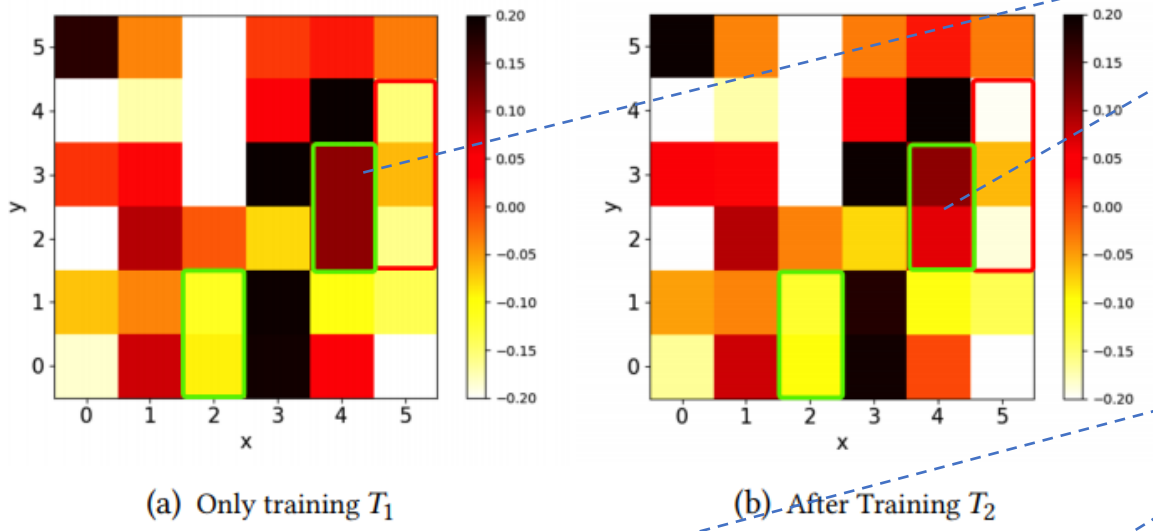


(a) Standard TF (b) PeterRec (b) Conure (b) MTL



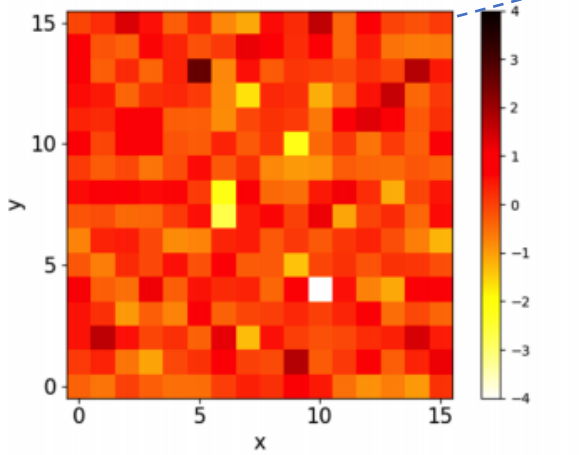
Lifelong learning without parameter preserving

- Catastrophic Forgetting :

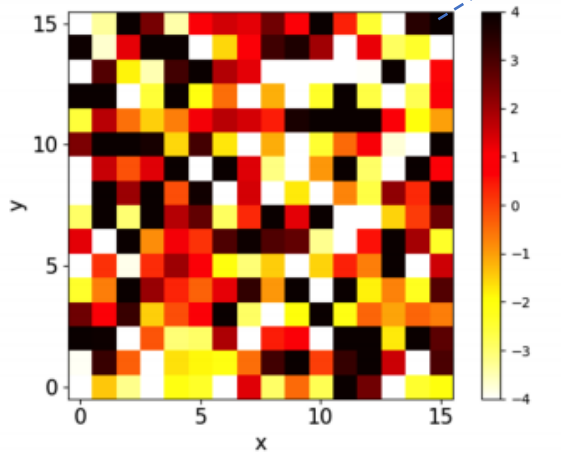


(a) Only training T_1

(b) After Training T_2



(c) Only training T_1

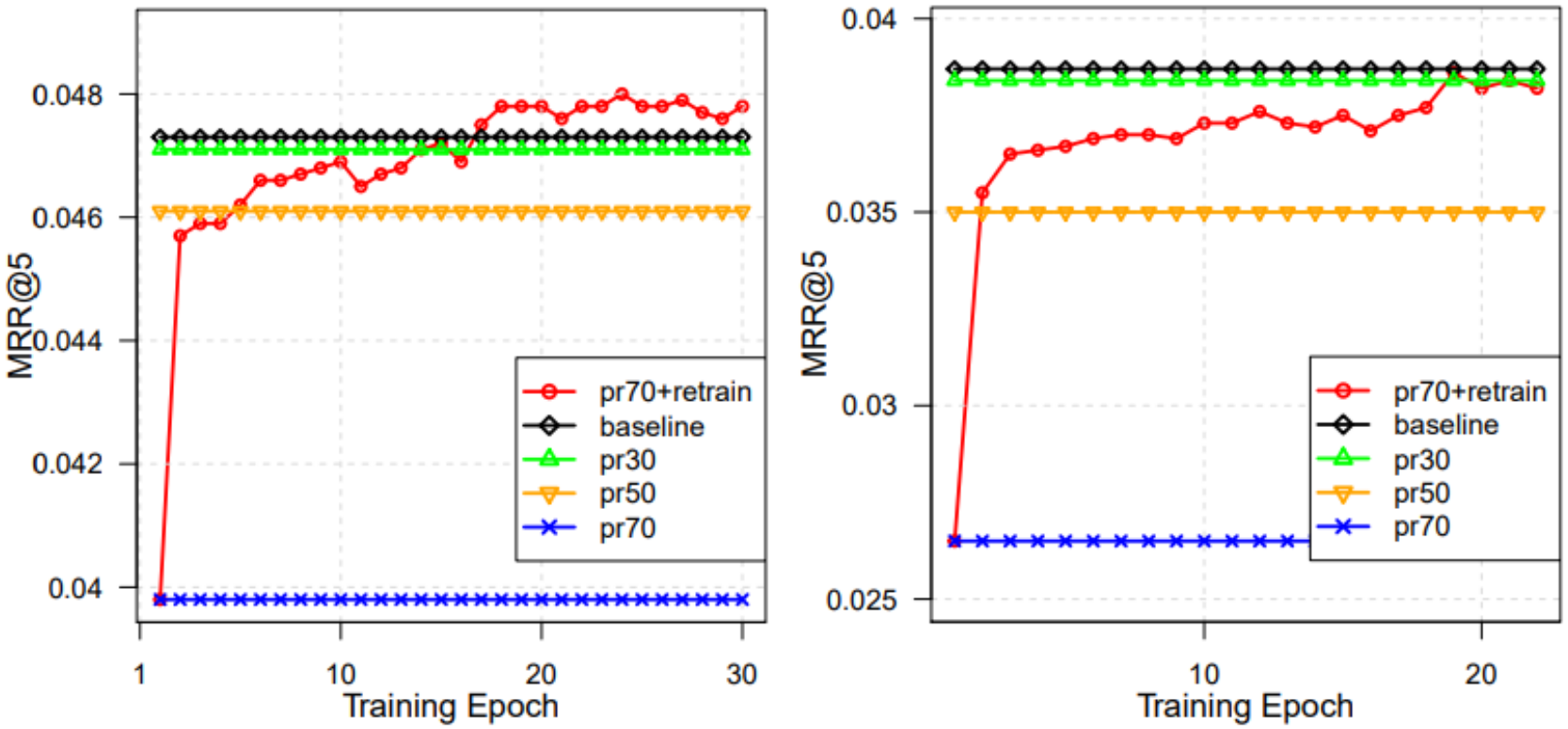


(d) After training T_2

Parameter Changes

Last hidden Vector Changes

- Over-parameterization:



(a) $f = 256$ with 16 CNN layers

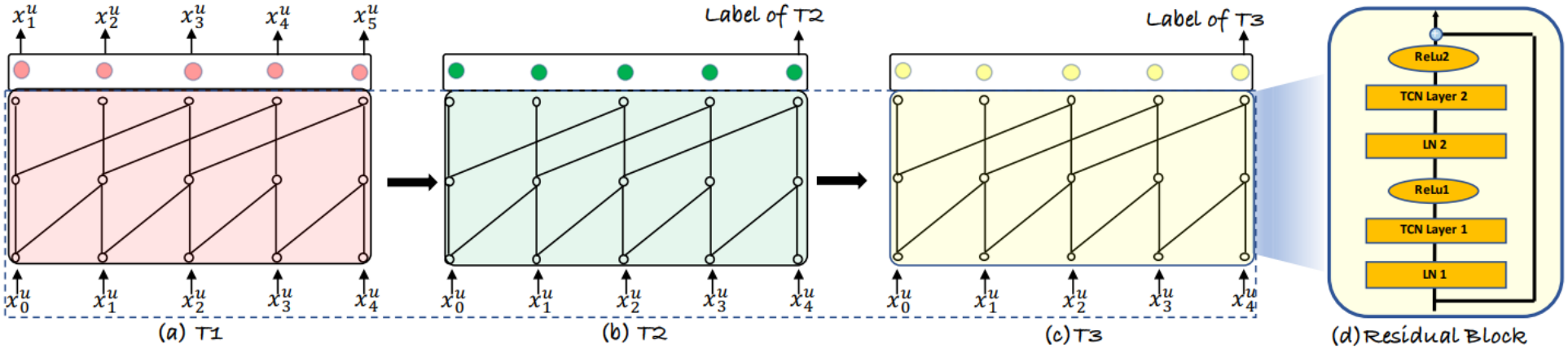
(b) $f = 64$ with 8 CNN layers

— (1) the more parameters are pruned, the worse it performs

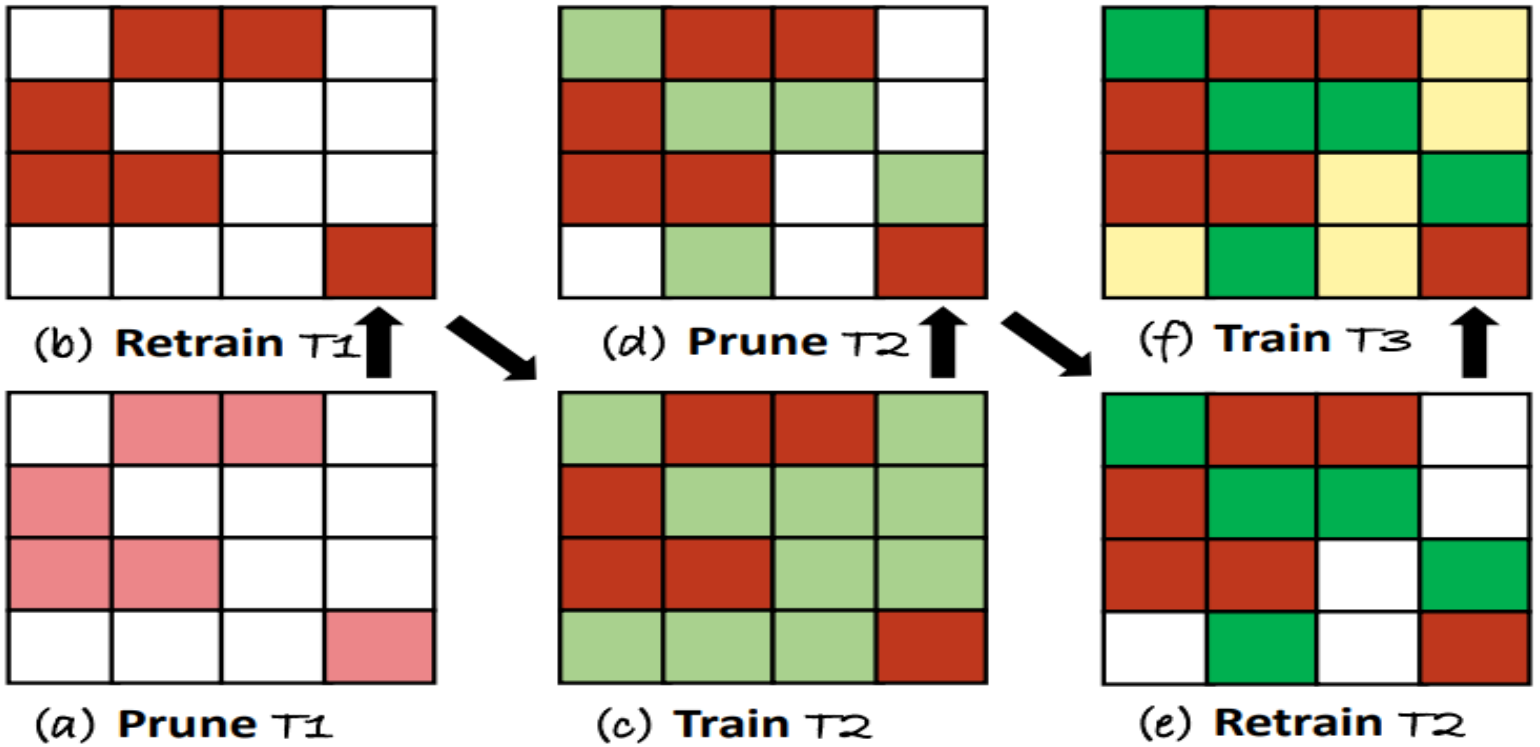
— (2) performing retraining on the pruned network (i.e., "pr70+retrain") regains its original accuracy quickly

— (3) smaller models (i.e., (b)) are also highly over-parameterized

- Conure architecture and learning process.



(d) Residual Block



Conure is conceptually very simple, easy to implement, and applicable to various sequential encoder networks.

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- Datasets:

TTL: https://drive.google.com/file/d/1imhHUsivh6oMEtEW-RwVc4OsDqn-xOaP/view
ML: https://drive.google.com/file/d/1-_KmnZFaOdH11keLYVcgkf-kW_BaM266/view

Table 1: Number of instances. The number of distinct items $|\mathcal{X}|$ in T_1 for TTL and ML is $646K$ and $54K$ ($K = 1000$), respectively. The number of labels $|\mathcal{Y}|$ is $18K$, $8K$, 8, 2, 6, respectively from T_2 to T_6 in TTL, and $26K$, $16K$, respectively from T_2 to T_3 in ML. $M = 1000K$.

Data	T_1	T_2	T_3	T_4	T_5	T_6
TTL	$1.47M$	$2.70M$	$0.27M$	$1.47M$	$1.47M$	$1.02M$
ML	$0.74M$	$3.06M$	$0.82M$	-	-	-

- Results:

Table 2: Accuracy comparison. #B is the number of backbone networks. The left and right of '||' represent TTL and ML, respectively. *Conure-* denotes *Conure* that has not experienced the pruning operation after training on the current task. The worse and best results are marked by '▽' and '△', respectively.

Model	T_1	T_2	T_3	T_4	T_5	T_6	#B	T_1	T_2	T_3	#B
DNN	0.0104	0.0154	0.0231	0.7131	0.8908	0.6003	**6**	0.0276	0.0175	0.0313	**3**
SinMo	0.0473	0.0144	0.0161	0.7068	0.8998	$0.5805^{\triangledown}$	**6**	0.0637	0.0160	$0.0259^{\triangledown}$	**3**
SinMoAll	$0.0009^{\triangledown}$	$0.0079^{\triangledown}$	$0.0124^{\triangledown}$	$0.5640^{\triangledown}$	$0.7314^{\triangledown}$	0.6160	**1**	$0.0038^{\triangledown}$	$0.0145^{\triangledown}$	0.0310	**1**
FineSmax	0.0473	0.0160	0.0262	0.6798	0.8997	0.6070	**1**	0.0637	0.0150	0.0262	**1**
FineAll	0.0473	0.0172	0.0271	$0.7160^{\triangle}$	0.9053	0.6132	**6**	0.0637	0.0189	0.0325	**3**
PeterRec	0.0473	0.0173	0.0275	0.7137	0.9053	0.6156	**1**	0.0637	0.0182	0.0308	**1**
MTL	-	0.0151	0.0172	0.7094	0.8979	0.6027	**1**	-	0.0167	0.0276	**1**
Conure-	0.0473	0.0174	0.0286	0.7139	0.9051	0.6180	-	0.0637	0.0183	0.0347	-
Conure	$0.0480^{\triangle}$	$0.0177^{\triangle}$	$0.0287^{\triangle}$	0.7146	$0.9068^{\triangle}$	$0.6185^{\triangle}$	**1**	$0.0656^{\triangle}$	$0.0197^{\triangle}$	$0.0353^{\triangle}$	**1**

— (1) Conure largely outperforms other models on T3 because of the positive transfer from T1 and T2
— (2) Conure, PeterRec and FineAll largely outperforms SimMo because of of the positive transfer from T1
— (3) SinMoAll performs much worse on most tasks (except the last one) because of catastrophic forgetting

- Ablation study- T2 for T3:

Table 3: Impact of T_2 on T_3. *Conure_noT_2* denotes training *Conure* on T_3 after T_1. *Conure_noT_2* and *Conure* both are the *Conure-* versions. TTL20% and ML20% denote the 20/80 train/test split.

	TTL	TTL20%	ML	ML20%
Conure_noT_2	0.0277	0.0245	0.0334	0.0295
Conure	0.0286	0.0261	0.0347	0.0309
Impro.	3.2%	6.5%	3.9%	4.7%

— (1) Without training T2, Conure shows worse results, e.g., -6.5% on TTL20%

- Ablation study- Task order:

Table 4: Impact of task orders. Order1 is the original order as mentioned in Section 5.1. KC, KT and Life denotes the clicking dataset, the thumbs-up dataset and the life status dataset of *Kandian*, respectively. Results on T_1 are omitted due to the same accuracy. The left and right of '||' are results of *Conure*- and *Conure*, respectively.

Orders	KC	KT	Life	KC	KT	Life
Order1	0.0174	0.0286	0.6180	0.0177	0.0287	0.6185
Order2	0.0174	0.0289	0.6154	0.0177	0.0290	0.6152
Order3	0.0174	0.0289	0.6145	0.0177	0.0287	0.6149

— (1) Conure is not sensitive to the task order.

- Ablation study:

Table 5: Pruning and retraining both the embedding & convolutional layers. The left & right of '||' are tasks on TTL & ML.

Models	T_1	T_2	T_3	T_1	T_2	T_3
Conure-	0.0473	0.0175	0.0290	0.0637	0.0191	0.0341
Conure	0.0474	0.0177	0.0295	0.0645	0.0196	0.0347

— (1) pruning also works for the embedding layer

Table 6: Results by specifying *Conure* with Transformer as the backbone network. The left and right of '||' represent tasks on TTL and ML, respectively. 'Mo' , 'FA', 'C-', 'C', denotes Models, FineAll, Conure- and Conure, respectively.

Mo	T_1	T_2	T_3	#B	T_1	T_2	T_3	#B
FA	0.0510	0.0161	0.0243	**3**	0.0654	0.0193	0.0321	**3**
C-	0.0510	0.0177	0.0288	-	0.0654	0.0198	0.0345	-
C	0.0513	0.0179	0.0289	**1**	0.0662	0.0200	0.0357	**1**

— (1) Conure is not restricted to specialized sequential encoder.

— (2) Conure with the Transformer backbone works a bit better than it with NextItNet.

Contributions:

- (1) providing the first lifelong learning paradigm for user representations.
- (2) providing insights for forgetting and redundancy issues in user representation models
- (3) designing Conure, the first lifelong learning algorithm - smple and easy to implement
- (4) instantiazing Conure with NextItNet and Transformer backbones
- (5) Extensive experiments with SOTA performance with many new discoveries and insights

Q&A

Case study:

user behavior on T1

新用户推荐效果： 左侧是A场景用户行为
右侧是B场景下预测出来的用户行为。A B为不同的推荐引擎。 该用户在B场景下均为新用户或者只有少量的点击被仅用作评测。

new user on T2, behavior predicted by Conure

宋晓峰一家五口生活照曝光，e3[illegible]
原来全家都是高颜值，5omi27v[illegible]
就属宋晓峰最丑！:e3072yxnw30，c306491vo1o
2014-04-17我为喜剧狂:5omi27[illegible]1tmwo
文松打出“一张4”，d08[illegible]
宋晓峰直接出“大王”，i[illegible]/c
文松顿时一脸懵圈:c3[illegible]36h0n0
宋晓峰：我媳妇为什么不让握手？就凭这一句话，m[illegible]18leoyh
台下观众们都被逗乐！:t0[illegible]6p9hx
宋小宝被谢楠质问：你什么玩意！吴京也忍不住笑了:d[illegible]

赵本山上台领奖太搞笑：硬把颁奖现场弄成相声大会，逗乐全场大[illegible]
峰哥就是屌，澡堂吹牛不打草稿，吓得壮汉赶紧跑：[illegible]
https://v.qq.com/x/page/6945f50a928674ah.html:69
https://v.qq.com/x/[illegible]
1997年，卓琳代小平同志参加香港回归盛典，现场响起经久不[illegible]
赵四谢广坤又同台演小品了，笑料百出，观众尖叫不停:95[illegible]
https://v.qq.com/x/page/2935f9fd88c009ah.html:29
江疏影，独一无二的嘟嘴，这是被谁气到啦？:0[illegible]
皮蓬生涯最“妖”一球，乔丹都愣了！这到底是打球还是耍猴？:92
CBA总决赛经典冲突1：广东男篮掌击门，杜锋头顶外援被打晕:1035fb
天龙八部：乔峰的演技有多好？看看这段你就明白了，多少人
王大拿说不差钱，结果刘大脑袋2亿拿下金店，王大拿当场傻[illegible]
副省长太嚣张，谁料军区处长一句话让他秒怂，真是太解气了
超级大山炮之夺宝奇兵：静静的看完这一段，不笑算我输。:0
https://v.qq.com/x/[illegible]487ah.html
https://v.qq.com/x/page/7855fb[illegible]480ah.html
赵四最硬气的两场打架
也是场面最大的两次
百看不厌:3855fb73d6d435ah:8054
https://v.qq.com/x/page/80[illegible]ah.html
郭德纲占于谦便宜被反杀，相声皇后真不简单！:5505f6f7d
颁奖礼与郭德纲同台的女星，范冰冰被套路，柳岩被逗得没法
赵本山颁奖晚会现场：硬把获奖感言说成了小品，把台下大腕
武警突击检查酒店，不料打开包厢，里面坐的竟是自己老婆！
媳妇去公司找丈夫，见丈夫有这么漂亮的秘书，瞬间不淡定了
https://v.qq.com/x/page/893[illegible]ah.html
https://v.qq.com/x/page/9865fb[illegible]ah.html
说实话，你是不是来砸场子的！:1[illegible]
https://v.qq.com/x/page/2865fbf52e4536ah.html
影视：朱德被污蔑，周总理直接请示伟大领袖危机顿时解除，
岳云鹏大型吹牛现场，那叫一个一本正经，就连郭德纲都被整
https://v.qq.com/x/page/86[illegible]ah.html
刘华强霸气上场：给我拼命，你有这个实力？太爷们了:7455
小伙要特别服务，没想到这个服务和想象中好像有点区别呀:5
美就算了，但是又很拽，就很过分啦！:85[illegible]
就知道谭维维不简单！连《刀剑如梦》也能翻唱超越，开嗓飒
https://v.qq.com/[illegible]html
https://v.qq.c[illegible]aw.html
小伙被老板看上，本想着干一番大事业，没想到却是保洁工作
普京大帝的伊尔96-300，可在空中发动核战争，接机场面太[illegible]
史上最嚣张的绝杀！大将军转身提前庆祝 阿里纳斯五大绝杀:
https://v.qq.com/x/[illegible]
元帅俘虏一屋子军官，进屋之后与其挨个握手，胸怀真是让人
宋晓峰被列为编外人员，这大红裤衩子把兄弟们逗笑了！:81
倚天屠龙记：不愧是明教总部的，张无忌打的都费劲，武功太
https://v.qq.com/x/page/4415fb39521640bk.html

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