Smooth-AUC: Smoothing the Path Towards Rank-based CTR Prediction

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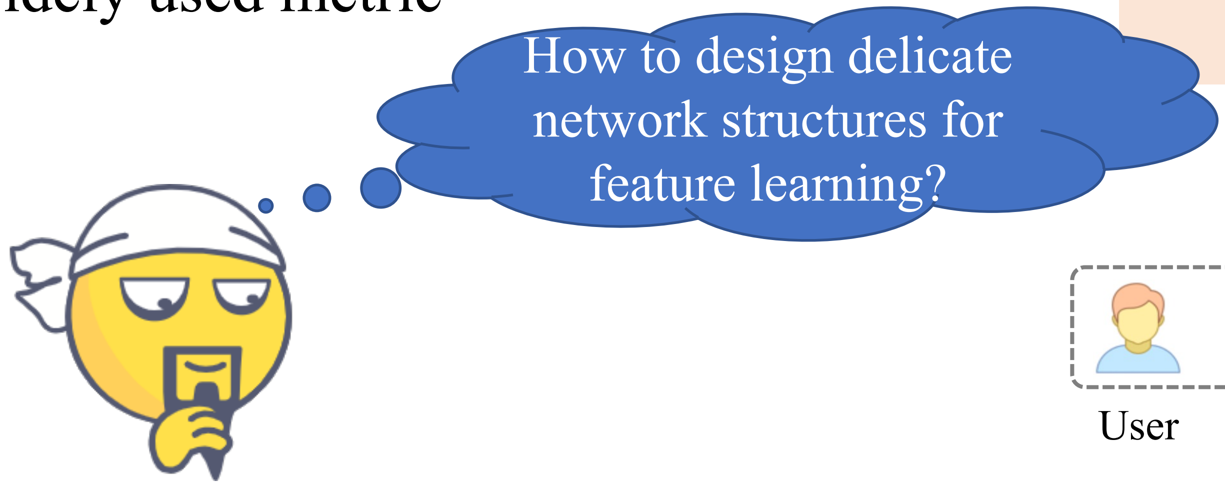
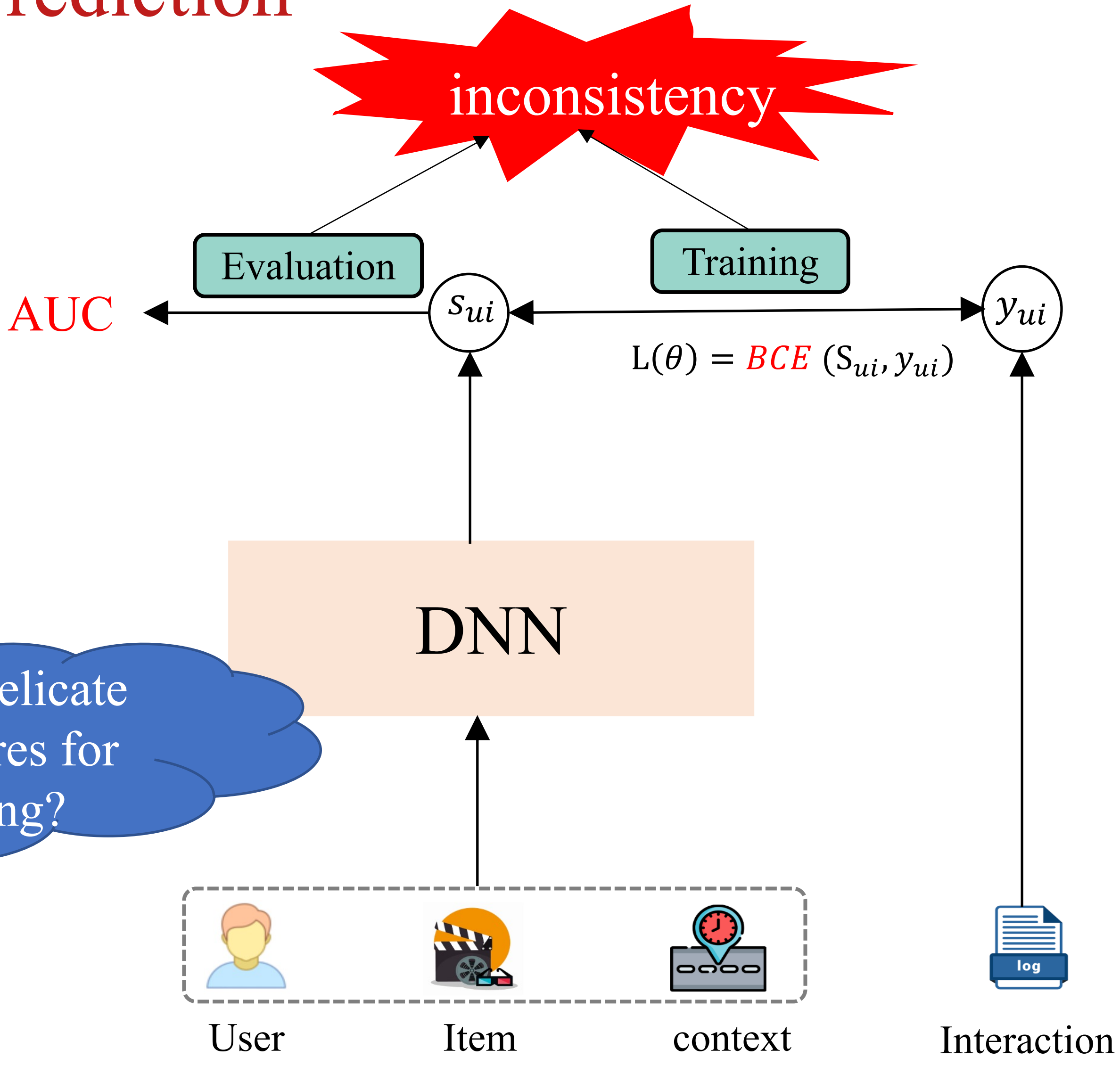
Click-Through Rate Prediction

- Click-through rate (CTR) prediction is a crucial task in many recommendation applications.
- For most existing DNNs-based CTR models, BCE is the common learning objective and AUC is the widely used metric





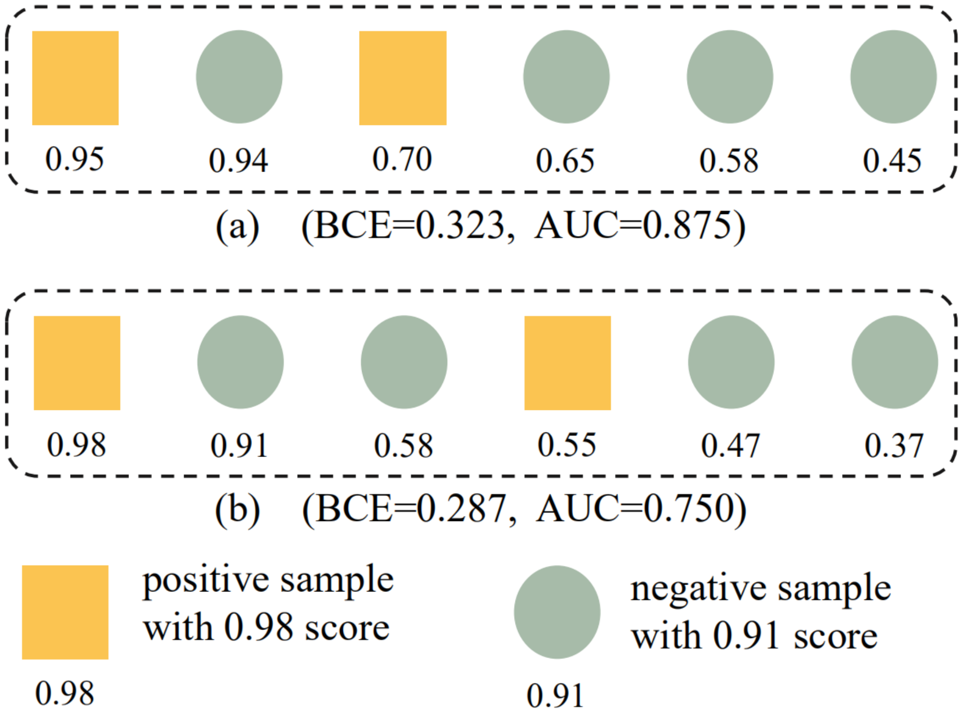
Measuring CTR Estimation Performance

- The is an inconsistency between BCE loss and AUC

- Our Goal – Optimize a smoothed version of the AUC Metric

$$L_{BCE}(u) = \sum_{i} s_{ui} log(y_{ui}) - (1 - s_{ui}) log(1 - y_{ui})$$

$$AUC(u) = \frac{\sum_{i\in P_u} \sum_{j\in N_u} \mathbb{I}(s_{ui} > s_{uj})}{|Pu| \times |N_u|}$$



(a) (BCE=0.323, AUC=0.875)

(b) (BCE=0.287, AUC=0.750)

s_{ui} and y_{ui}: the preference score and ground truth by user u on item i. P_u and N_u: the positive and negative items.

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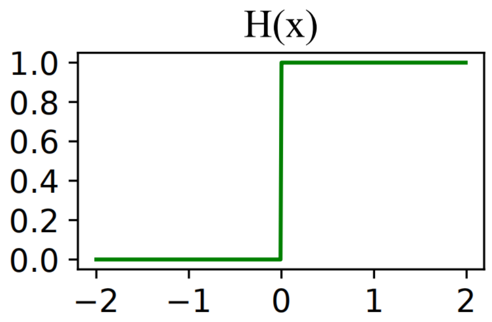
Smoothing the Area Under the ROC Curve

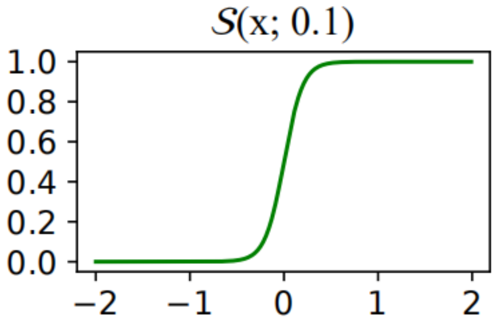
- AUC loss includes a non-differentiable Heaviside function

$$\mathcal{L}_{AUC} \propto H(x) = \begin{cases} 0 & \text{if } x < 0 \\ 1 & \text{if } x \geq 0 \end{cases}$$



- We replace the Heaviside function $H(x)$ by a sigmoid function $\mathcal{S}(x;\tau)$

$$\mathcal{L}_{SAUC} \propto \mathcal{S}(x;\tau) = \frac{1}{1 + e^{-\frac{x}{\tau}}}$$



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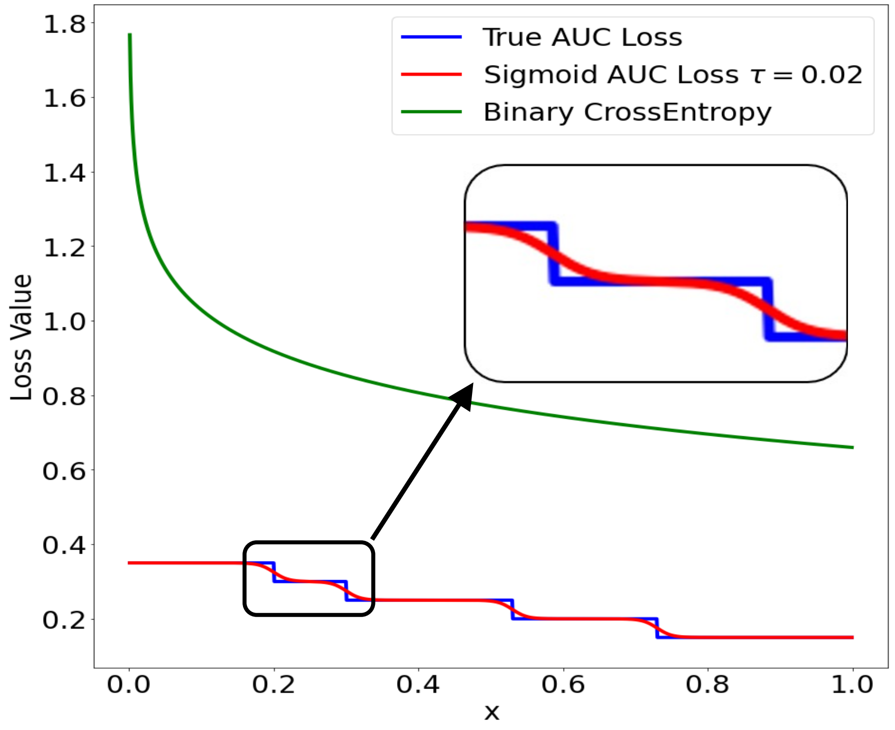
Smooth-AUC

- Smooth-AUC optimizes a ranking metric

$$L_{SAUC} = -\frac{1}{|U|}\sum_{u=1}^{|U|}\left[\frac{1}{|Pu|\times|Nu|}\sum_{i=1}^{|Pu|}\sum_{j=1}^{|Nu|}\mathcal{S}(D_{uij};\tau)\right]$$

- Compared with BCE loss, Smooth-AUC loss is closer to the true AUC loss

- Smooth-AUC is a plug-and-play objective that can be utilized by any DNNs-based CTR model



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Experiments

➢ Datasets

- CiteULike-a[1] —— papers management domain
- YiDian[2] —— news recommendation domain

	#Users	#Items	# Interactions	Density
CiteUlike-a	5,139	16,980	200,866	0.23%
YiDian	1,029,717	347,466	81,721,133	0.02%

➢ Backbone models

- DeepFM[1]
- FiBiNET[2]
- ONN[3]

➢ Metrics

- AUC
- MRR
- Precision

1: https://citeulike.org/
2: https://tech.yidianzixun.com/competition/#/

[1]: DeepFM: A Factorization-Machine based Neural Network for CTR Prediction. In IJCAI 2017.
[2]: FiBiNET: combining feature importance and bilinear feature interaction for click-through rate prediction. RecSys 2019.
[3]: Operation-aware Neural Networks for user response prediction. Neural Networks 2020.

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Experiments

	CiteULike-a			YiDian		
	AUC	MRR	P@10	AUC	MRR	P@10
DeepFM	0.861(+3.60%)	0.248(+36.69%)	0.539(+27.83%)	0.600(+6.17%)	0.076(+42.11%)	0.166 (+14.46%)
DeepFM-BPROPT	0.887(+0.56%)	0.304(+11.51%)	0.623(+10.59%)	0.626(+1.76%)	0.089(+21.35%)	0.177(+7.34%)
* DeepFM-SAUC	**0.892**	**0.339**	**0.689**	**0.637**	**0.108**	**0.190**
FiBiNET	0.875(+1.60%)	0.262(+32.44%)	0.585(+18.12%)	0.621(+2.58%)	0.087(+12.64%)	0.183(+4.92%)
FiBiNET-BPROPT	0.880(+1.02%)	0.316(+9.81%)	0.625(+10.56%)	0.631(+0.95%)	0.093(+5.38%)	0.187(+2.67%)
* FiBiNET-SAUC	**0.889**	**0.347**	**0.691**	**0.637**	**0.098**	**0.192**
ONN	0.877(+1.60%)	0.264(+32.95%)	0.583(+18.35%)	0.621(+2.25%)	0.091(+13.19%)	0.188(+5.85%)
ONN-BPROPT	0.886(+0.56%)	0.334(+5.09%)	0.645(+6.98%)	0.632(+0.47%)	0.095(+8.42%)	0.195(+2.05%)
* ONN-SAUC	**0.891**	**0.351**	**0.690**	**0.635**	**0.103**	**0.199**

* our method

- BPROPT & SAUC> BCE: attributed to the benefit of considering relative order between positive items and negative items.

- SAUC > BPROPT: SAUC not only considers the relative order of item pairs, but also optimizes the metric used for evaluation.

Thank you!

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