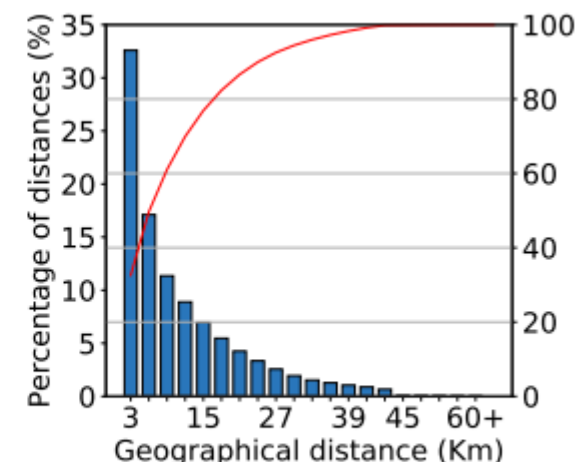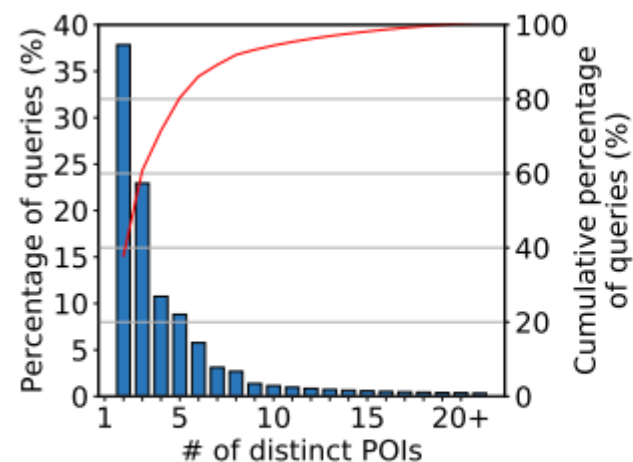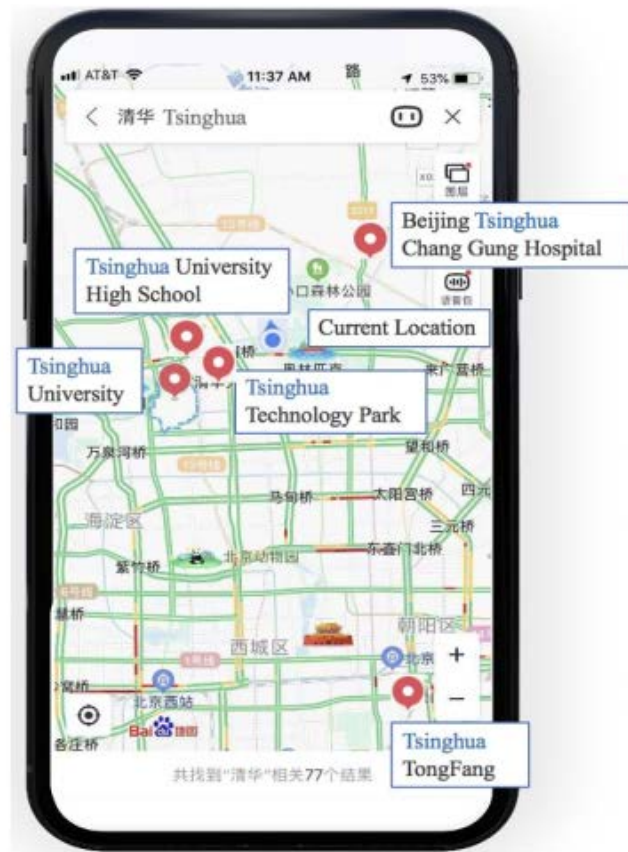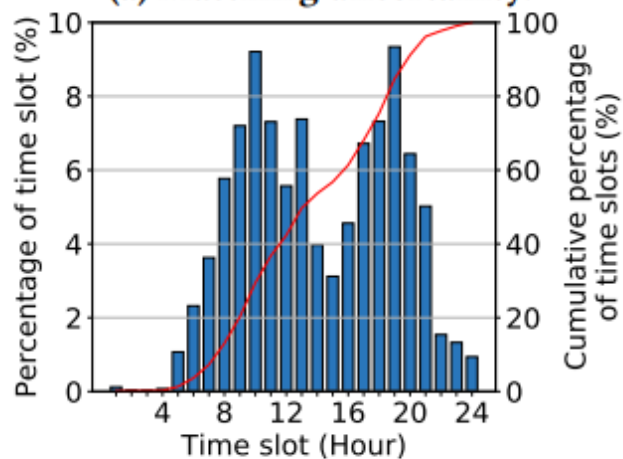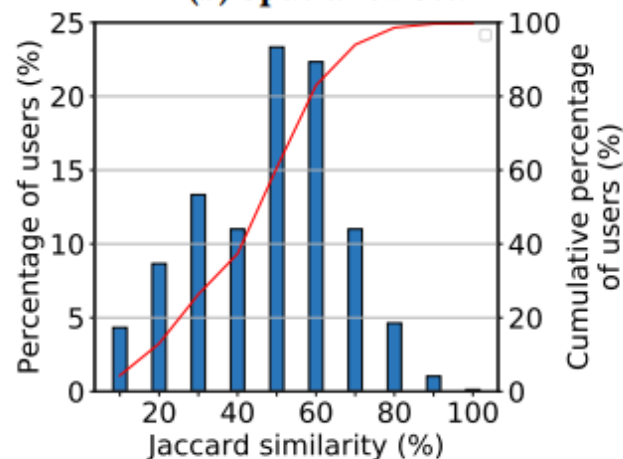**Matching**

POI: Point Of Interest

(a) Matching uncertainty.

(b) Spatial effect.

(c) Temporal effect.

(d) Jaccard similarity.

Definition 1. *Map query event.* A map query event is dened as a 4-tuple $mq = \{u, \tau, q, p\}$,

u user τ time slot q query p

DEFINITION 2. **Generic query-POI graph** is defined as $G^g = (V, E)$, where g is the generic symbol, $V = Q \cup P$ and E is a set of edges, indicating all query-POI interactions. Formally, we define $e_{ij} \in E$ as

$$e_{ij} = \begin{cases} 1, & v_i \in Q, v_j \in P, freq(v_i, v_j) \geq \delta \\ 0, & otherwise \end{cases},$$
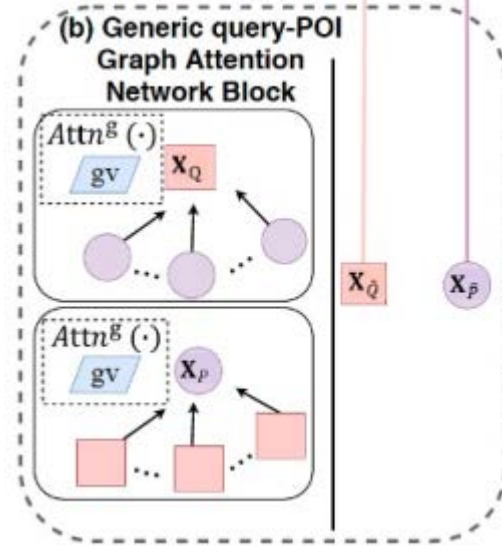
DEFINITION 3. **User-specific query-POI graph** is defined as $G^s_{u,t} = (V, E)$, where s is the user-specific symbol, E is a set of edges

$$\phi'_i = w_{i-1}\phi_{i-1} + w_i\phi_i + w_{i+1}\phi_{i+1},$$
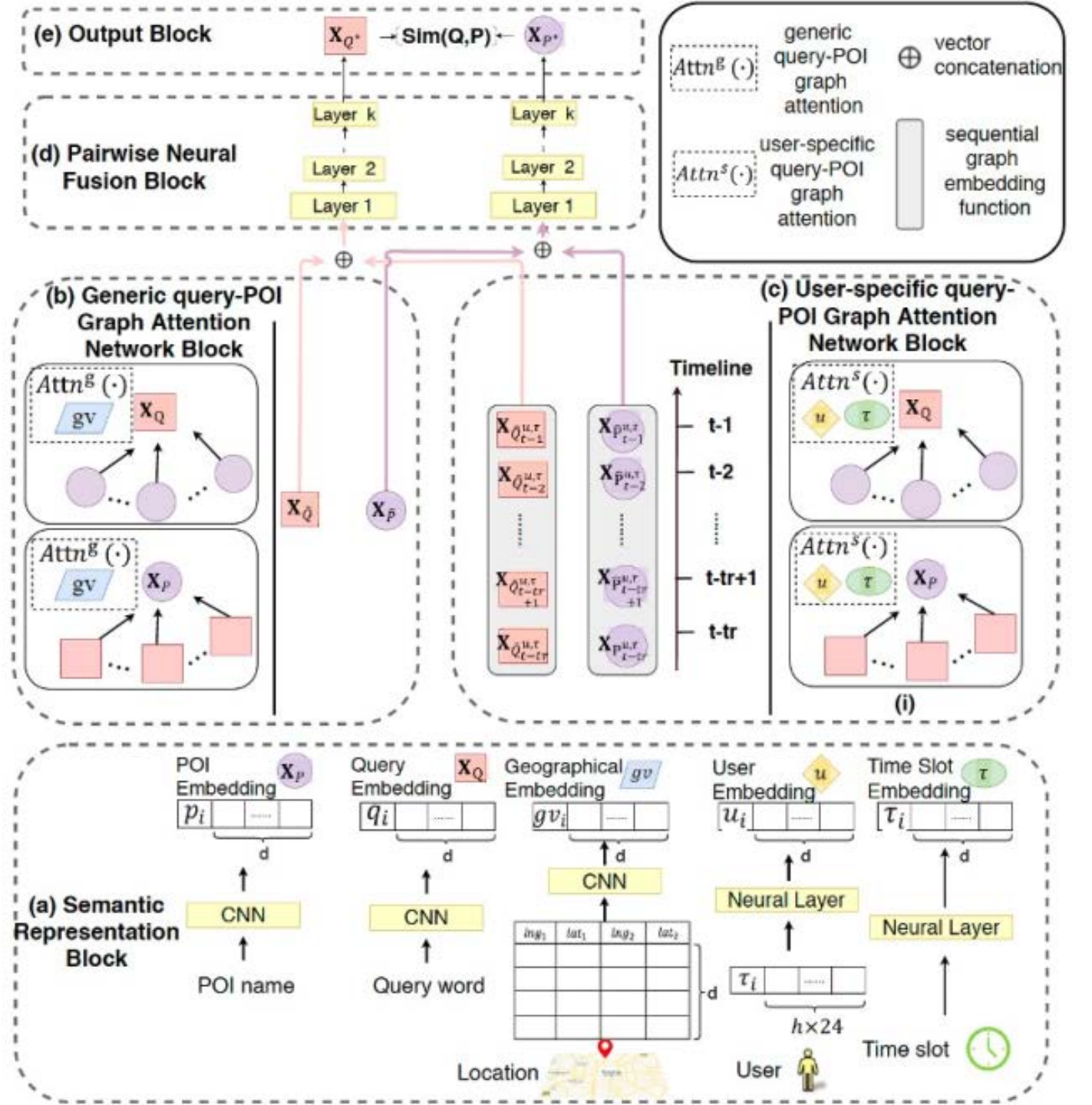
Generic query-POI graph attention

(b) Generic query-POI Graph Attention Network Block

$$X_{\tilde{Q}} = \sigma(A^Q(G^g)W^Q X_P + b),$$

$$X_{\tilde{P}} = \sigma(A^P(G^g)W^P X_Q + b),$$

Attention weights are determined by both static semantic similarities and geographical correlations.

User-specific query-POI graph attention

(c) User-specific query-POI Graph Attention Network Block
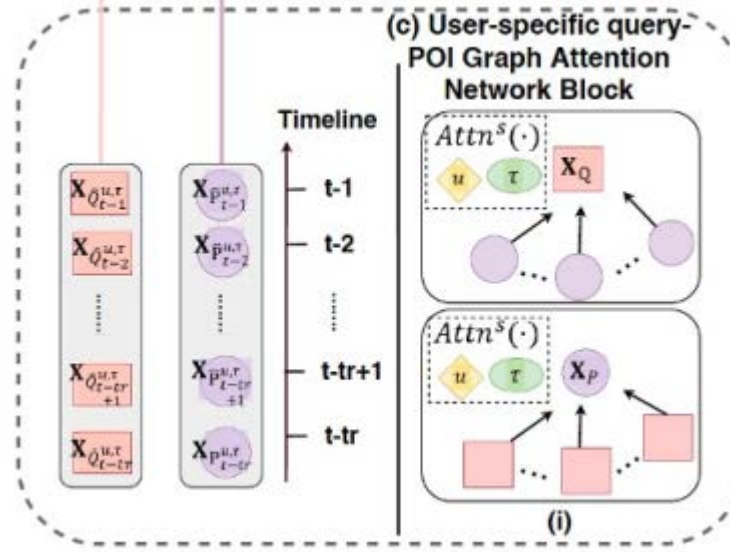
ARMA

$$X_{\hat{P}_t^{u,\tau}} = \sum_{i=1}^{t_1} X_{\hat{P}_{t-i}^{u,\tau}} Z_i + \sum_{i=1}^{t_2} \varepsilon_{t-i}^{u,\tau} Z_i',$$

$$X_{\hat{Q}_t^{u,\tau}} = \sum_{i=1}^{t_1} X_{\hat{Q}_{t-i}^{u,\tau}} Z_i + \sum_{i=1}^{t_2} \varepsilon_{t-i}^{u,\tau} Z_i',$$

Generic query-POI graph attention

$$X_{\tilde{Q}} = \sigma(A^Q(G^g)W^Q X_P + b),$$

$$X_{\tilde{P}} = \sigma(A^P(G^g)W^P X_Q + b),$$

Attention weights are determined by both static semantic similarities and geographical correlations.
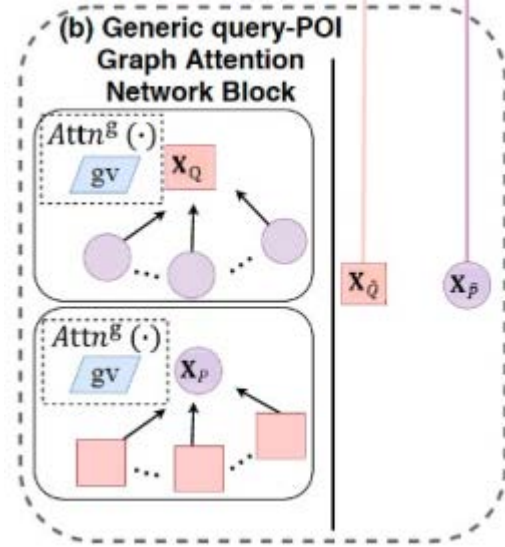
User-specific query-POI graph attention
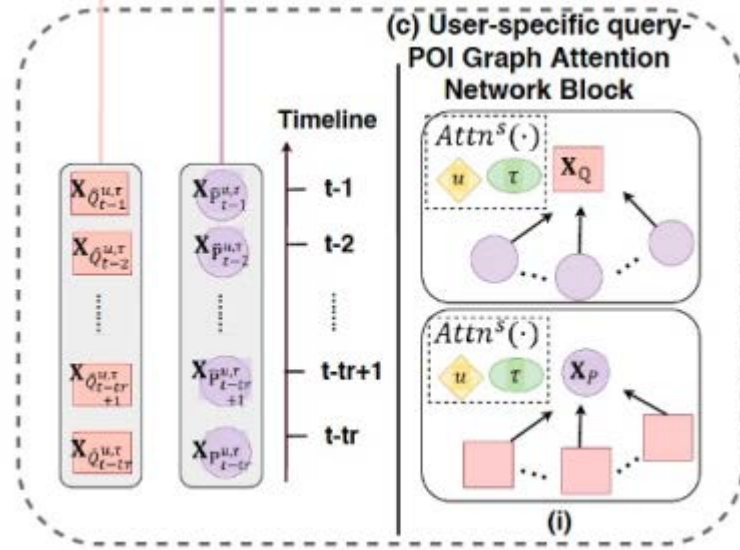
$$Y_{t+1}^{u,\tau} = \sum_{k=0}^{K_1-1} \psi_k(A_t)Y_t^{u,\tau}W_k + X_{\hat{p}_t^{u,\tau}}Z_0$$

$$X_{\hat{p}_{t+1}^{u,\tau}} = Y_{t+1}^{u,\tau} + \sum_{k=1}^{K_2-1} \psi_k(A_t)X_{\hat{p}_t^{u,\tau}}Z_k$$

$$X_{\hat{p}^{u,\tau}} = Conv(X_{\hat{p}_{t-tr}^{u,\tau}}, X_{\hat{p}_{t-tr+1}^{u,\tau}}, \ldots, X_{\hat{p}_{t-1}^{u,\tau}}),$$

$$\psi_k(A_t) = A_t^k \text{ records the k-path reachable nodes}$$

Fusion Block
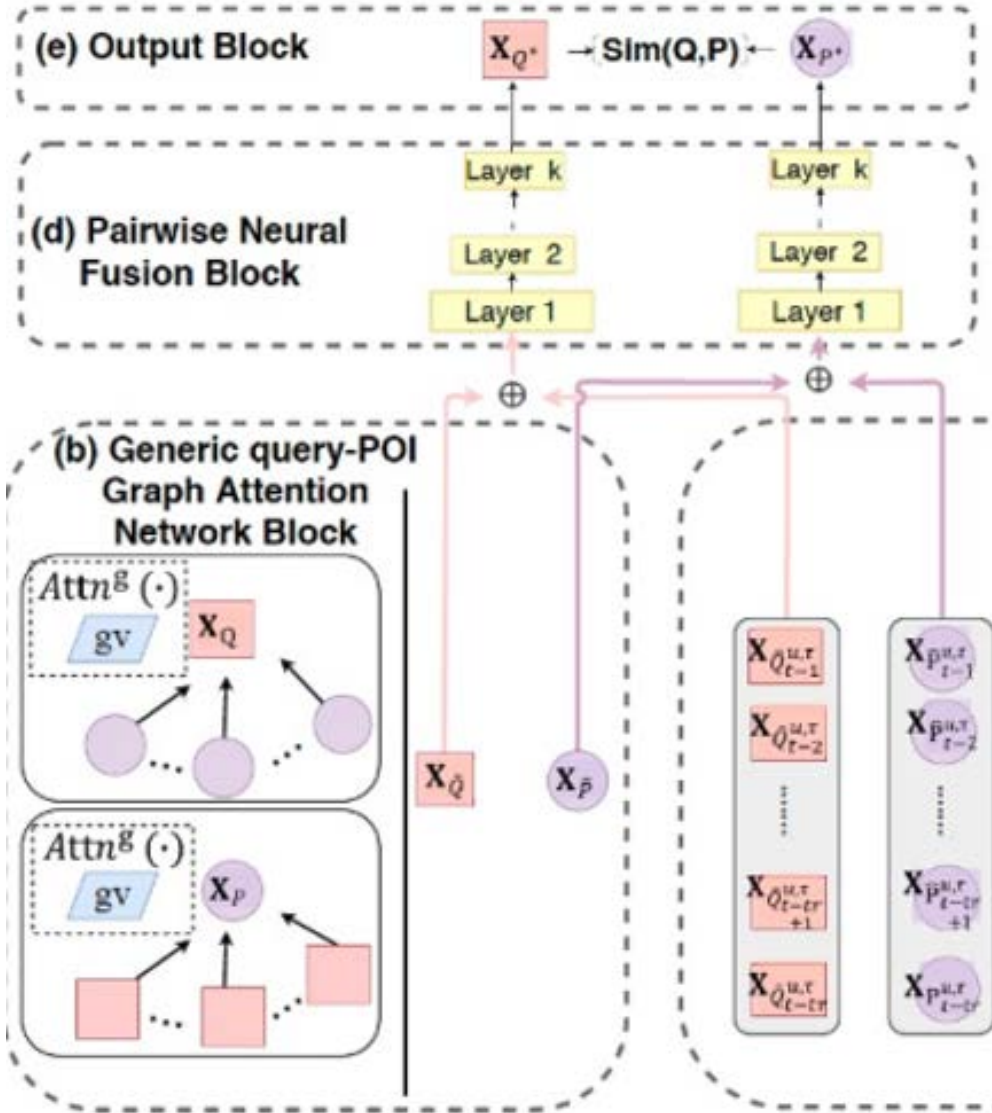
$$X_{P*} = \phi_S^P(\dots \phi_2^P(\phi_1^P(X_{\hat{p}u,\tau} \| X_{\tilde{P}}))),$$

$$X_{Q*} = \phi_S^Q(\dots \phi_2^Q(\phi_1^Q(X_{\hat{Q}u,\tau} \| X_{\tilde{Q}}))),$$

$$\phi_s^P(x) = \sigma(W_s^P x + b_s^P), s \in [1, S],$$

$$\phi_s^Q(x) = \sigma(W_s^Q x + b_s^Q), s \in [1, S],$$

$$S(Q, P) = cos(X_{Q*}, X_{P*}) = \frac{X_{Q*} X_{P*}}{\| X_{Q*} \| \| X_{P*} \|}$$

Evaluation Matrics

$$Hits@k = \frac{P_{u,q} \cap R_{u,q}(k)}{k},$$

$$NDCG@k = \frac{1}{IDCG} \sum_{i=1}^{M} \frac{2^{rel_i} - 1}{log(1 + i)},$$

Overall performance.

Algorithm	Beijing							Shanghai						
	Hits@3	Hits@5	Hits@10	NDCG@3	NDCG@5	NDCG@10	p-value	Hits@3	Hits@5	Hits@10	NDCG@3	NDCG@5	NDCG@10	p-value
Frequency-based search	0.2938	0.4593	0.5809	0.2685	0.3893	0.4749	5.76e-18	0.2863	0.4474	0.5796	0.2732	0.4145	0.5193	6.19e-17
Distance-based search	0.2492	0.3670	0.4399	0.2283	0.3115	0.3669	1.76e-18	0.2294	0.2974	0.3659	0.2122	0.2658	0.3148	3.26e-20
DSSM	0.6016	0.6889	0.7337	0.5982	0.6687	0.7024	6.77e-8	0.6217	0.7039	0.7475	0.6169	0.6851	0.6928	9.43e-7
C-DSSM	0.6243	0.6910	0.7647	0.6134	0.6705	0.7293	4.02e-5	0.6384	0.7292	0.7789	0.6255	0.7090	0.7535	6.57e-7
LSTM-DSSM	0.6441	0.7311	0.7860	0.6317	0.7025	0.7436	3.23e-9	0.6145	0.7371	0.7883	0.6236	0.7114	0.7562	1.92e-8
PALM	0.6743	0.7382	0.8251	0.6685	0.7022	0.7653	5.57e-4	0.6588	0.7531	0.8046	0.6327	0.7295	0.7689	1.55e-9
STDGAT-B	0.5973	0.6691	0.7231	0.5772	0.6219	0.6689	8.62e-13	0.6153	0.6970	0.7332	0.5939	0.6668	0.6921	4.05e-12
STDGAT-St	0.6377	0.7186	0.7795	0.6211	0.6729	0.7157	4.61e-6	0.6422	0.7690	0.7709	0.6313	0.7249	0.7467	1.58e-6
STDGAT-Dy	0.6573	0.7524	0.8026	0.6397	0.7244	0.7590	2.76e-7	0.6854	0.7792	0.8125	0.6672	0.7482	0.7643	7.54e-5
STDGAT	**0.7229**	**0.8038**	**0.8646**	**0.7034**	**0.7733**	**0.8042**	–	**0.7343**	**0.8161**	**0.8537**	**0.7266**	**0.7635**	**0.7971**	–