

Higher-order Link Prediction via Time-aware Dynamic Embedding Learning

Yujie YANG, Shuai CAO, Yuxin TANG, Dong LIU, Marcus KAISER

Frontiers of Computer Science, DOI: [10.1007/s11704-025-50638-z](https://doi.org/10.1007/s11704-025-50638-z)

Problems & Ideas

- Problems of conventional high-order link prediction approaches:
 - Most methods rely on static topology and ignore temporal evolution.
 - Failing to capture dynamic higher-order interactions is crucial for accurate prediction.
- Ideas: A time-aware dynamic embedding framework that integrates temporal structure walks and time series embeddings for robust higher-order link prediction.

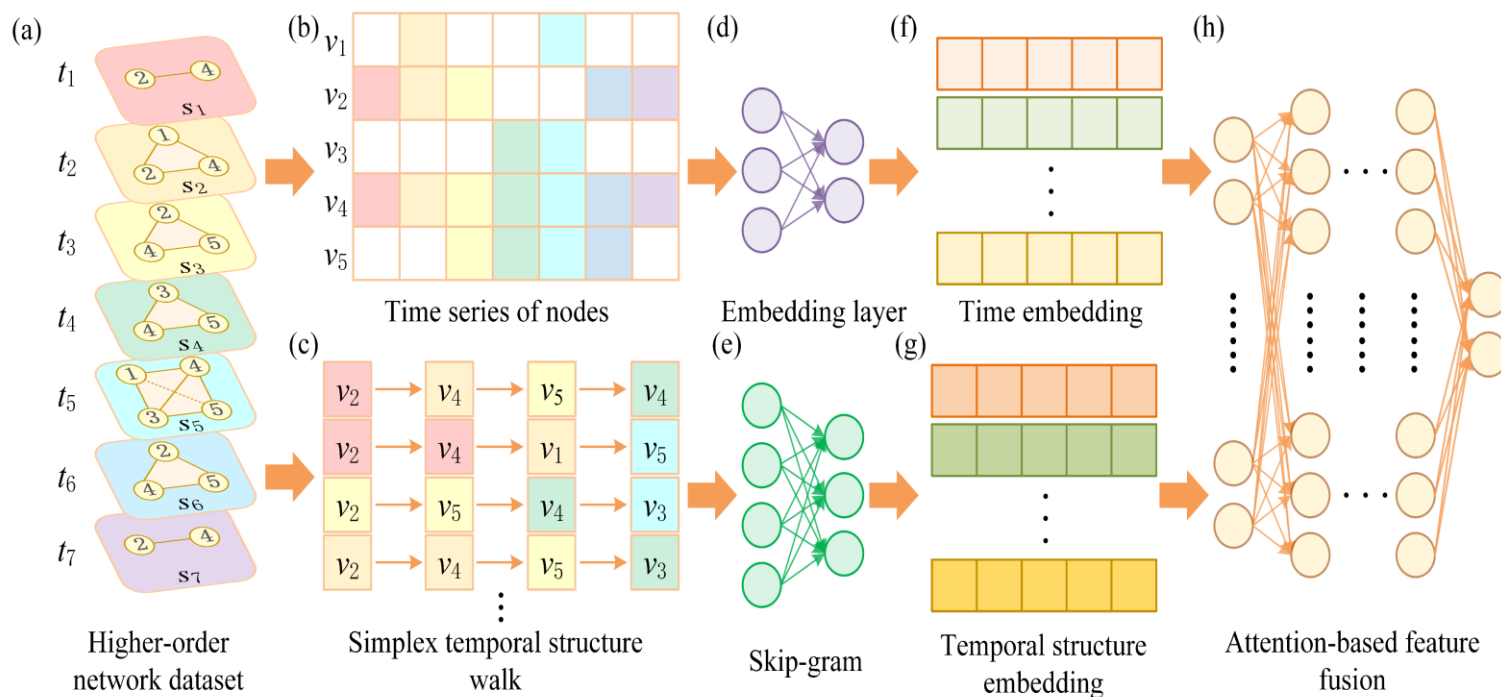


Figure 1. The framework of TDE.

Main Contributions

- Contributions:
 - A time-aware simplex walk strategy is introduced to capture local and global temporal dependencies across evolving simplices;
 - An adaptive fusion mechanism is designed to integrate structural and temporal embeddings into unified dynamic node representations;
 - Experimental results demonstrate that TDE achieves superior performance in terms of adaptability and prediction accuracy.

Orders	Datasets	Deepwalk	MM	HTGN	Transformer	HNE	RWTA	TDE
$k = 3$	Congress-bills	0.9094	0.8994	0.7049	0.9300	0.9324	<u>0.9312</u>	0.9118
	Contact-high-school	0.5127	0.6685	<u>0.9309</u>	0.5030	0.2476	0.5721	0.9797
	Contact-primary-school	0.5473	0.6968	<u>0.8286</u>	0.5215	0.2513	0.4656	0.9991
	Email-Enron	0.7501	0.6246	<u>0.7572</u>	0.7047	0.7543	0.7142	0.8570
	Email-Eu	0.7109	0.5114	0.9260	<u>0.9979</u>	0.4238	0.6268	0.9998
	NDC-substances	<u>0.9930</u>	0.8968	0.9853	0.9712	0.9811	0.9902	0.9939
	Tags-ask-ubuntu	<u>0.7752</u>	<u>0.8130</u>	0.8367	0.5116	0.5608	0.6805	0.5780
	Tags-math-sx	<u>0.8237</u>	0.7542	0.9532	0.5282	0.5145	0.4913	0.5207
	Threads-ask-ubuntu	0.9294	0.6465	0.9293	0.9316	<u>0.9321</u>	0.9009	0.9342
$k = 4$	Congress-bills	0.4437	0.8114	<u>0.6632</u>	0.6460	0.5955	0.5709	0.5123
	Contact-high-school	0.4736	0.6759	<u>0.7235</u>	0.6439	0.0099	0.6766	0.7424
	Contact-primary-school	0.5703	<u>0.7519</u>	0.6583	0.5332	0.0099	0.6121	0.9782
	Email-Enron	0.5272	<u>0.7946</u>	<u>0.8384</u>	0.4862	0.0267	0.6340	0.8603
	Email-Eu	0.7128	0.5995	0.9223	<u>0.9803</u>	0.1042	0.7304	0.9867
	NDC-substances	<u>0.9460</u>	0.9390	0.9356	0.8820	0.9299	0.8941	0.9520
	Tags-ask-ubuntu	0.6216	0.8524	0.9468	<u>0.9782</u>	0.0138	0.4340	0.9927
	Tags-math-sx	0.8065	0.7374	<u>0.9466</u>	0.4667	0.0084	0.5844	0.9971
	Threads-ask-ubuntu	0.5135	0.6532	<u>0.7587</u>	0.7083	0.2942	0.6930	0.7979

Table 1 The AP performance of seven algorithms in nine datasets. The optimal results are shown in bold, and the suboptimal values are underlined. k denotes the order of simplices to be predicted.