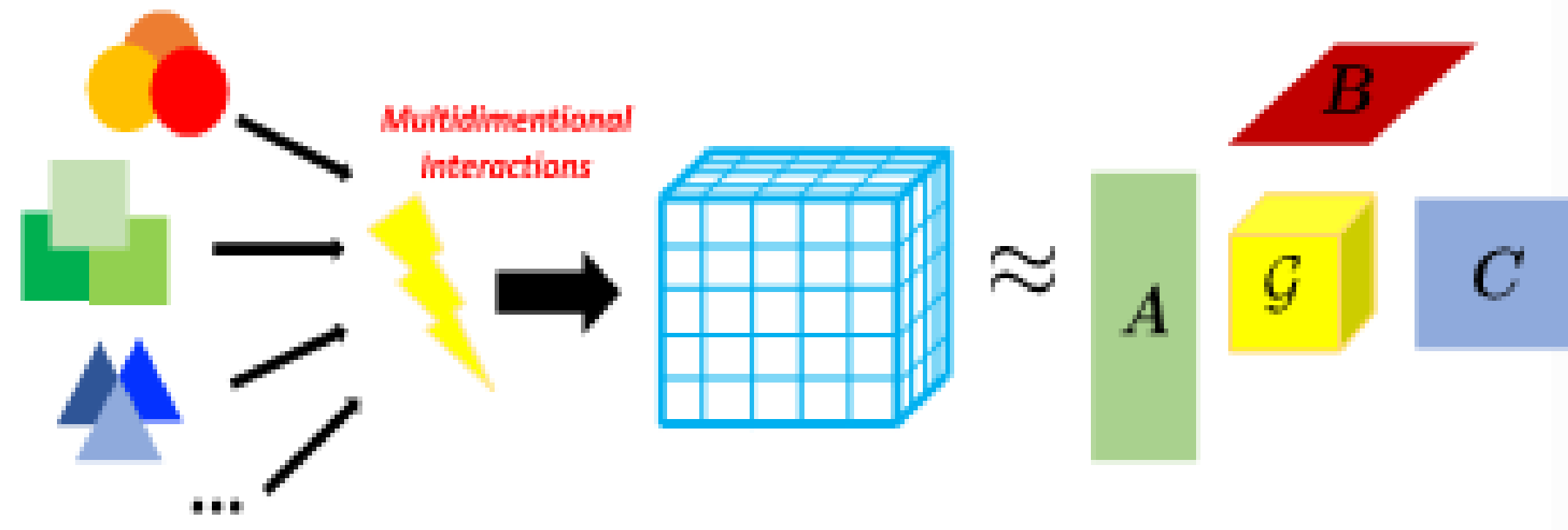


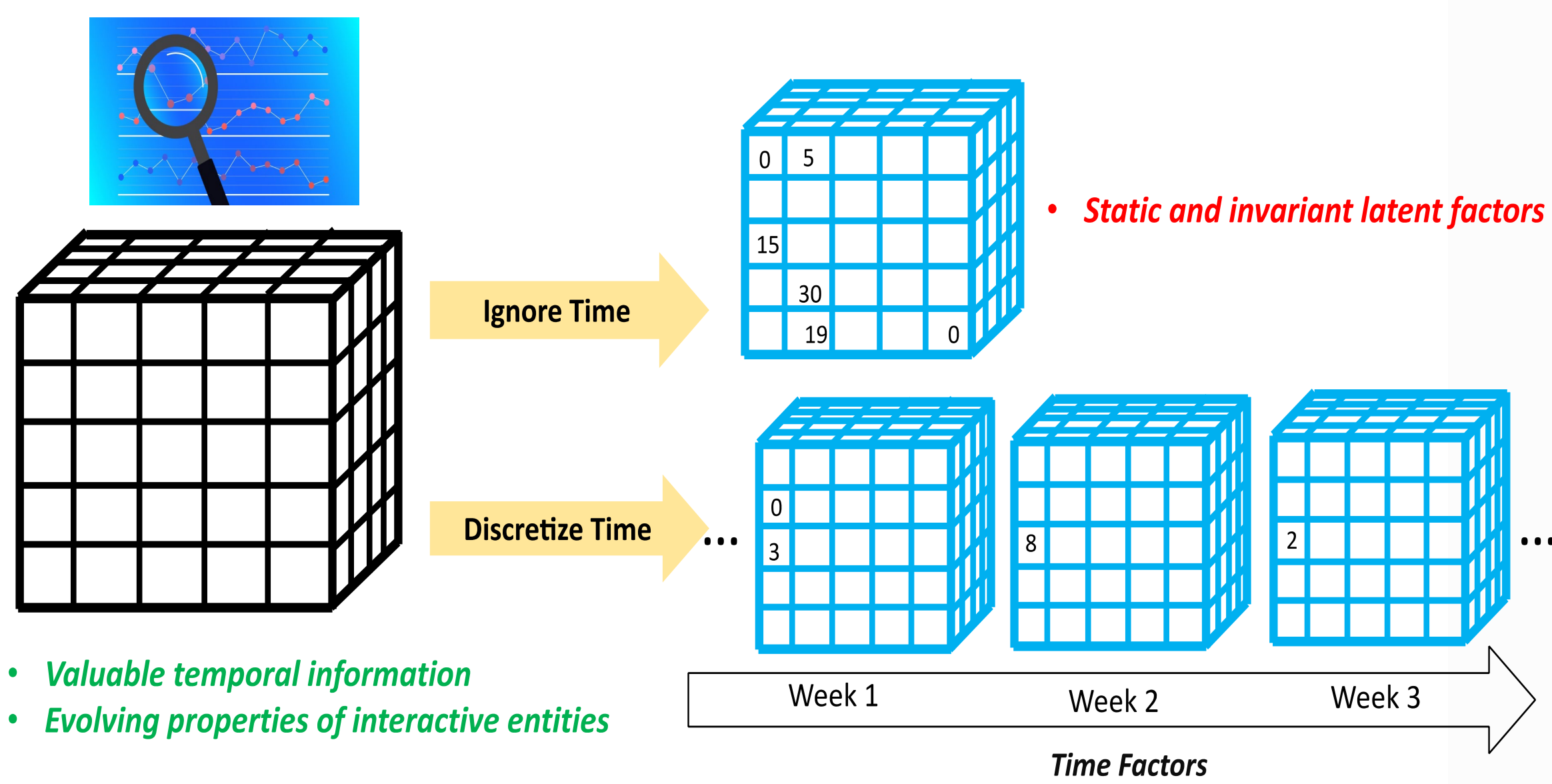
Introduction

Tensor Decomposition



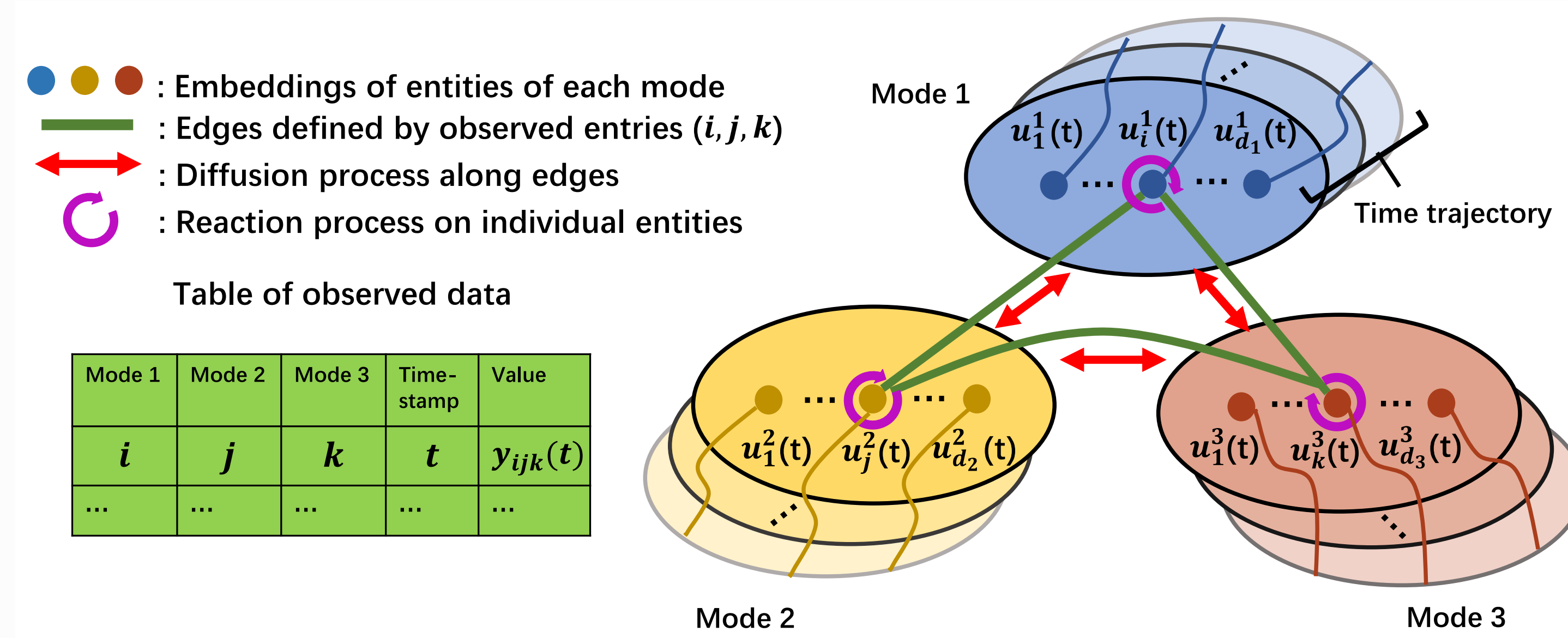
- Customer, Store, Product
 - Location, Age, Gender
 - Website, Location, Ads Type
 - Latitude, Longitude, Elevation
 - ...
- Online Store Transactions
 - Social Media User Behaviors
 - Advertisement Click Log Data
 - Global Climate Data
 - ...
- Tucker decomposition (Tucker, 1966)
 - CANDECOMP/PARAFAC (CP) decomposition (Harshman, 1970)
 - ...

Underexplored Temporal & Structural Information



- Valuable temporal information
 - Evolving properties of interactive entities
- Static and invariant latent factors cannot reflect evolving properties of entities, e.g. user preferences, commodity popularity and patient health status
 - Under utilized structural knowledge of the data

Dynamic Embedding Learning



Diffusion Process on Multi-Partite Graphs

- Capture correlations between related entities via diffusion process

$$\frac{d\mathcal{U}(t)}{dt} = (\mathcal{W} - \mathcal{A})\mathcal{U}(t)$$

$$\mathcal{W} = \begin{pmatrix} 0 & \mathbf{W}^{1,2} & \dots & \mathbf{W}^{1,K} \\ \mathbf{W}^{2,1} & 0 & \dots & \vdots \\ \vdots & \vdots & \ddots & \mathbf{W}^{K-1,K} \\ \mathbf{W}^{K,1} & \dots & \mathbf{W}^{K,K-1} & 0 \end{pmatrix}$$

$$\mathcal{A} = \text{diag} \left(\sum_{s \in \{1 \dots K\} \setminus 1} \mathbf{A}^{1,s}, \dots, \sum_{s \in \{1 \dots K\} \setminus K} \mathbf{A}^{K,s} \right)$$

Reaction Process of Individual Entities

- Formulate entity self-evolvement

$$\frac{\partial \mathcal{U}(t)}{\partial t} = (\mathcal{W} - \mathcal{A})\mathcal{U}(t) + \mathcal{F}(\mathcal{U}, t), \quad \mathcal{U}(0) = \mathcal{U}_0$$

Entry Value Generation

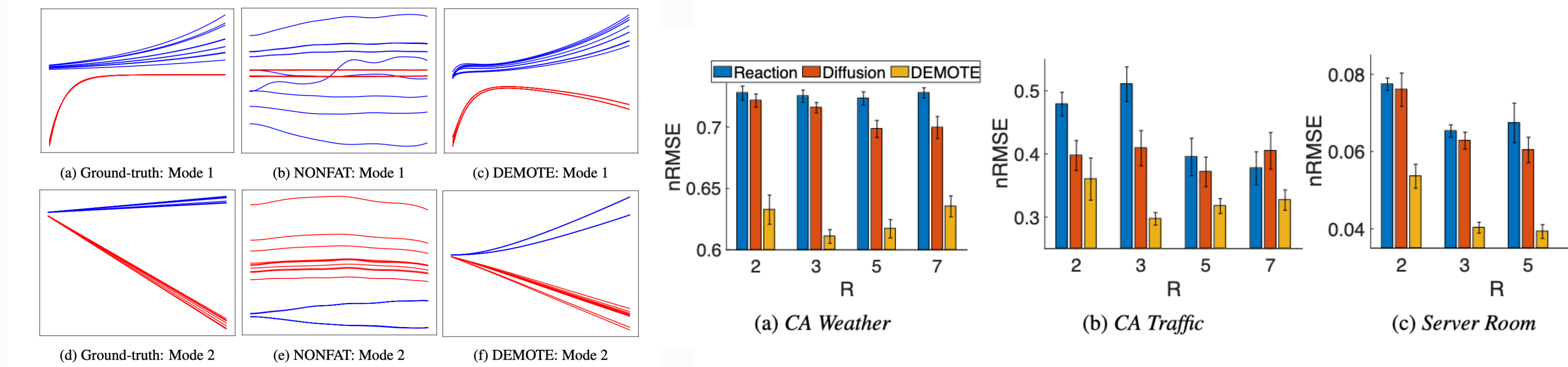
- Nonlinear tensor decomposition

$$m_{\ell}(t) = g(\mathbf{u}_{l_1}^1(t), \dots, \mathbf{u}_{l_K}^K(t))$$

Experimental Results

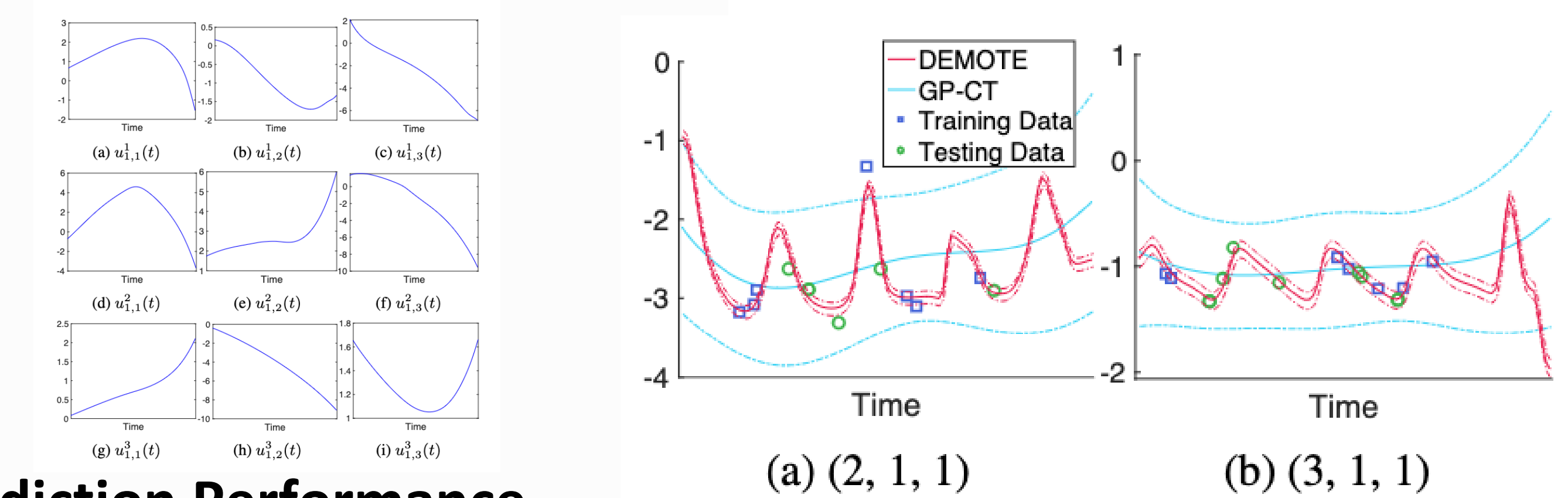
Simulation & Ablation Study

- To capture underlying dynamics accurately, both diffusion and reaction processes are essential



Trajectory Learning

- Enhanced prediction results with dynamic embeddings



Prediction Performance

- Improved performance

CA Weather: 7x6x30x30, 15K
CA Traffic: 7x6x20x20, 30K
Server Room: 34x3x3, 10K

	R=2	R=3	R=5	R=7
CA Weather	0.7140 ± 0.0035	0.7092 ± 0.0030	0.7080 ± 0.0031	0.7091 ± 0.0034
GP-DTL	0.7117 ± 0.0031	0.7114 ± 0.0036	0.7144 ± 0.0036	0.7149 ± 0.0039
NONFAT	0.7229 ± 0.0054	0.7116 ± 0.0035	0.7148 ± 0.0032	0.7260 ± 0.0044
CP-DTND	0.7148 ± 0.0031	0.7260 ± 0.0035	0.7273 ± 0.0037	0.7260 ± 0.0044
CP-DTSD	0.7209 ± 0.0034	0.7240 ± 0.0032	0.7148 ± 0.0032	0.7274 ± 0.0031
NONFATND	0.7113 ± 0.0045	0.6979 ± 0.0026	0.6609 ± 0.0022	0.6543 ± 0.0015
CP-CT	1.0000 ± 0.0006	0.9959 ± 0.0007	1.0000 ± 0.0007	1.0000 ± 0.0004
GP-CT	0.7143 ± 0.0038	0.7154 ± 0.0027	0.7209 ± 0.0034	0.7277 ± 0.0033
NONFAT	0.6907 ± 0.0014	0.6608 ± 0.0012	0.6503 ± 0.0014	0.6469 ± 0.0016
NONFATND	0.7144 ± 0.0042	0.7260 ± 0.0032	0.7345 ± 0.0031	0.7523 ± 0.0029
THIS-OIE	0.7111 ± 0.0032	0.7209 ± 0.0031	0.7144 ± 0.0034	0.7260 ± 0.0032
DEMOTTE	0.6327 ± 0.0119	0.6109 ± 0.0056	0.6172 ± 0.0075	0.6354 ± 0.0085

