FEMA: Flexible Evolutionary Multi-faceted Analysis for Dynamic Behavior Pattern Discovery

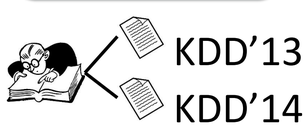
Meng Jiang[1], Peng Cui[1], Fei Wang[2], Xinran Xu[1], Wenwu Zhu[1], Shiqiang Yang[1]
[1] Department of Computer Science and Technology, Tsinghua University, Beijing, China
[2] IBM T. J. Watson Research Center, Yorktown Heights, NY, USA

Motivation and Goals

Modeling How to formulate human behavior?

Pattern discovery How to understand human behavior?

Prediction What is the missing human behavior?

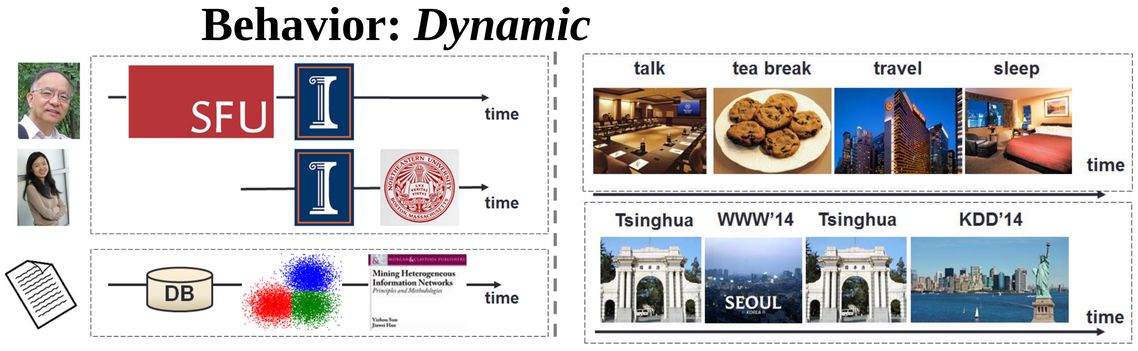


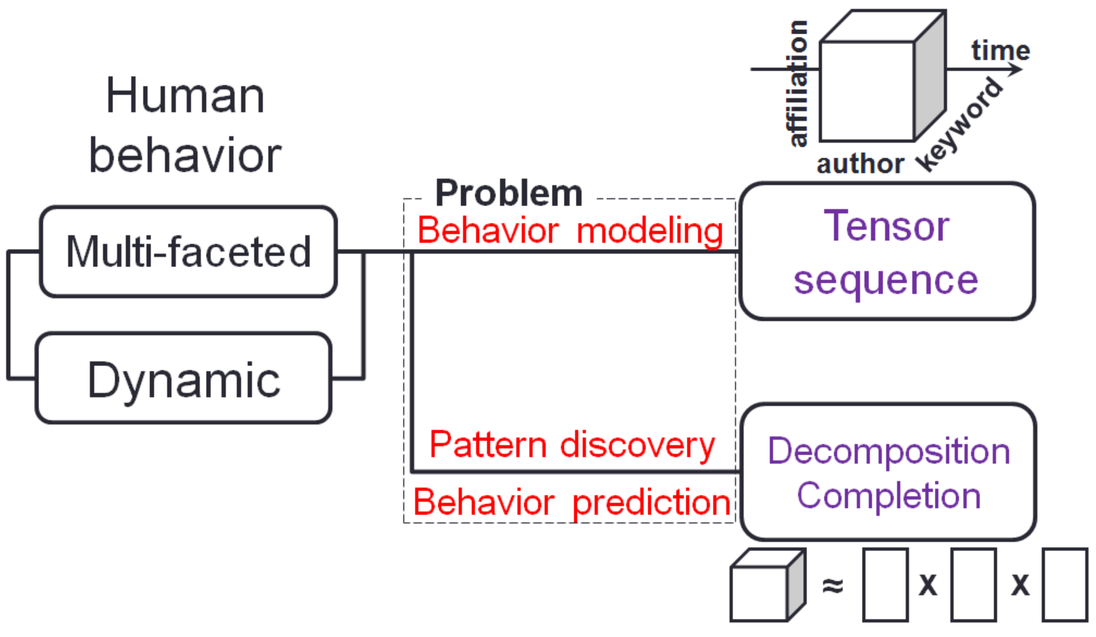
Given: Behavior data sequence
Find: A behavior analysis framework that fast and best discovers behavior patterns
Goals:
G1. Model the human behavior
G2. Understand the hidden patterns
G3. Predict the missing behavior

Human Behavior Modeling

Behavior: *Multi-faceted information*

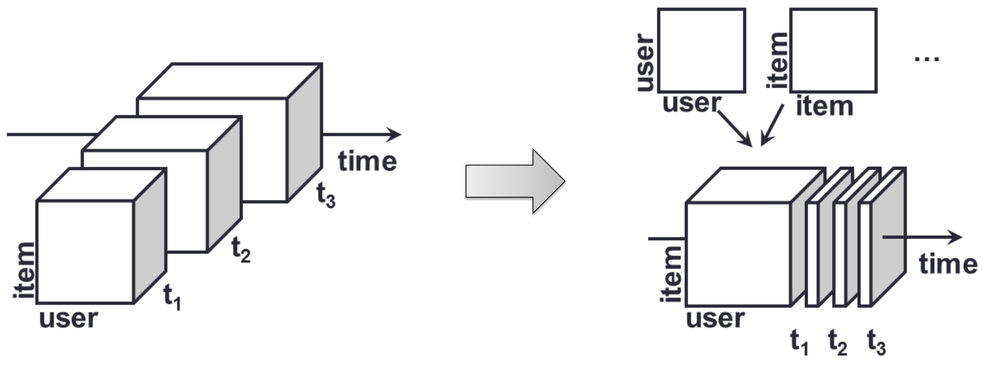
Behavior: *Dynamic*



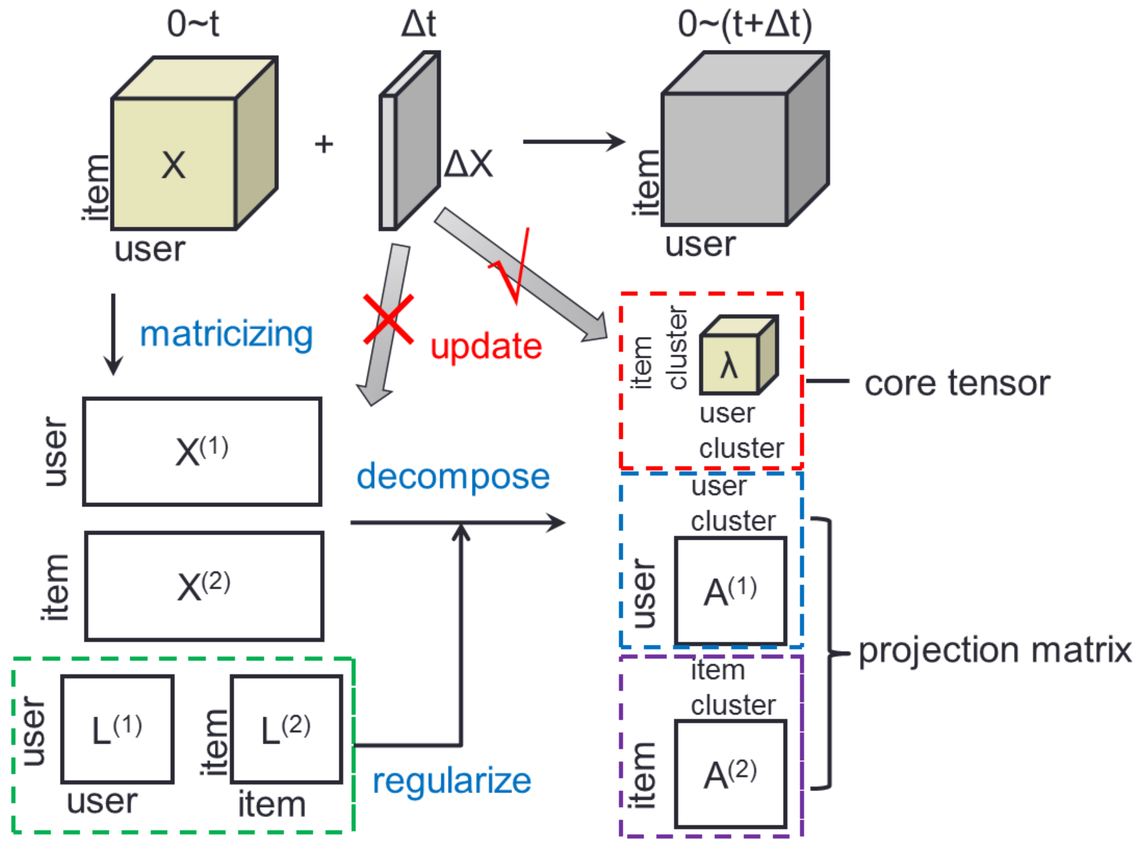


Challenges and Solutions

C1: High Sparsity - high-order tensors
S1: ***Auxiliary knowledge from regularizations***
C2: High Complexity - long sequence of tensors
S2: ***Update projection matrices with new coming data***



Framework and Algorithm



Tensor Perturbation Theory

$$[(\mathbf{X^{(m)}}+\Delta\mathbf{X^{(m)}})(\mathbf{X^{(m)}}+\Delta\mathbf{X^{(m)}})^\top+\mu^{(m)}\mathbf{L^{(m)}}]\cdot(\mathbf{a_i^{(m)}}+\Delta\mathbf{a_i^{(m)}})=(\lambda_i^{(m)}+\Delta\lambda_i^{(m)})(\mathbf{a_i^{(m)}}+\Delta\mathbf{a_i^{(m)}})$$

Approximation Algorithm

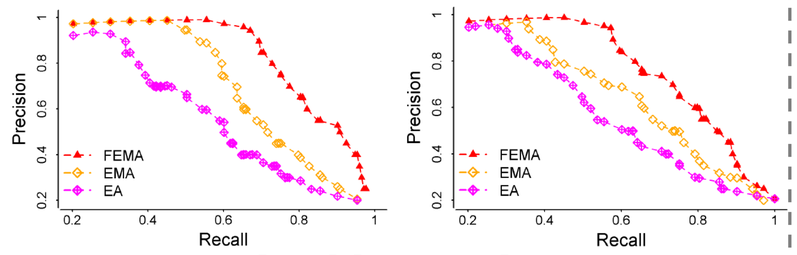
$$\Delta\lambda_i^{(m)}=\mathbf{a_i^{(m)\top}}(\mathbf{X^{(m)}}\Delta\mathbf{X^{(m)\top}}+\Delta\mathbf{X^{(m)}}\mathbf{X^{(m)\top}})\mathbf{a_i^{(m)}} \qquad \Delta\mathbf{a_i^{(m)}}=\sum_{j\neq i}\frac{\mathbf{a_j^{(m)\top}}(\mathbf{X^{(m)}}\Delta\mathbf{X^{(m)\top}}+\Delta\mathbf{X^{(m)}}\mathbf{X^{(m)\top}})\mathbf{a_i^{(m)}}}{\lambda_i^{(m)}-\lambda_j^{(m)}}\mathbf{a_j^{(m)}}$$

Bound Guarantee

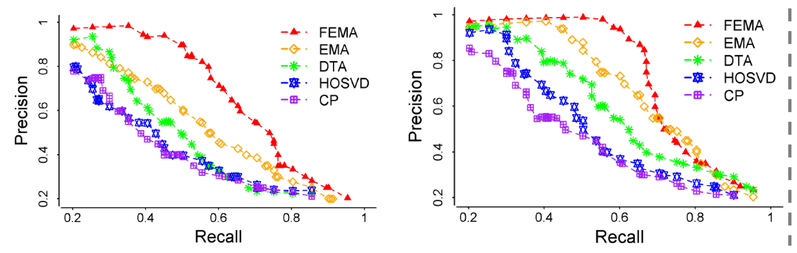
$$|\Delta\lambda_i^{(m)}|\leq 2(\lambda^{\max}_{\mathbf{X^{(m)\top}X^{(m)}}})^{\frac{1}{2}}\|\Delta\mathbf{X^{(m)}}\|_2 \qquad |\Delta\mathbf{a_i^{(m)}}|\leq 2\|\Delta\mathbf{X^{(m)}}\|_2\sum_{j\neq i}\frac{(\lambda^{\max}_{\mathbf{X^{(m)\top}X^{(m)}}})^{\frac{1}{2}}}{|\lambda_i^{(m)}-\lambda_j^{(m)}|}$$

Experiments

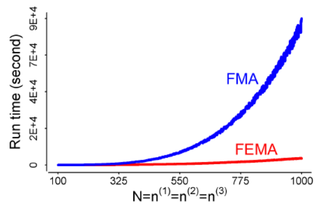
Leveraging Multi-faceted Info



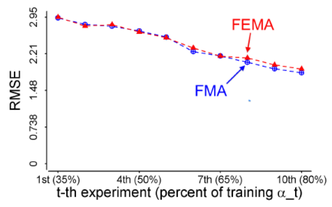
Leveraging Flexible Regularizations



Efficiency & Loss

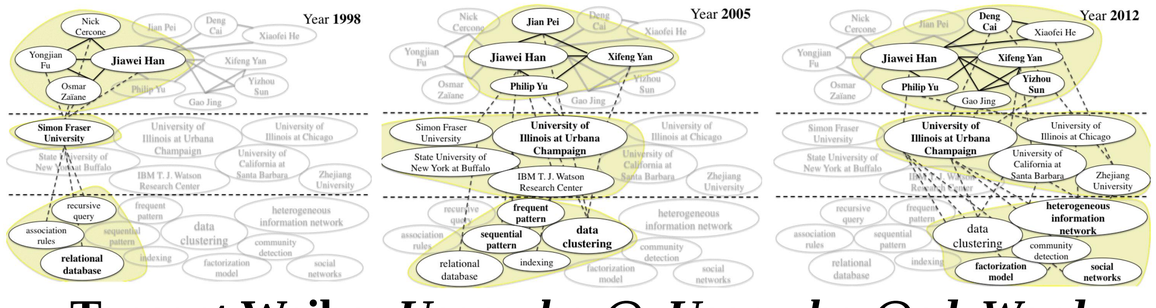


Time vs Num. objects N

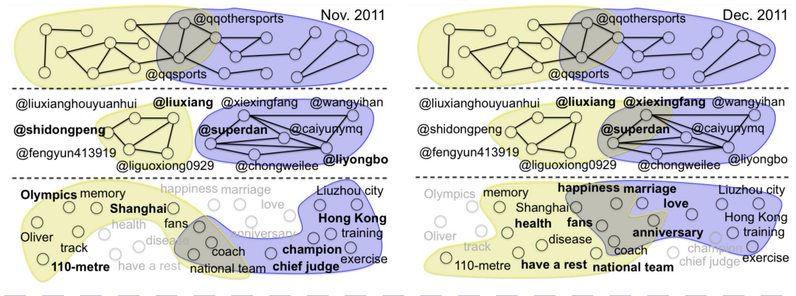


The loss is small.

Microsoft Academic Search: *Author, Affiliation, Keyword*



Tencent Weibo: *User-who-@, User-who-@ed, Word*



Acknowledgement

Contact: Meng Jiang
<jm06@mails.tsinghua.edu.cn>

清華大學 Tsinghua University