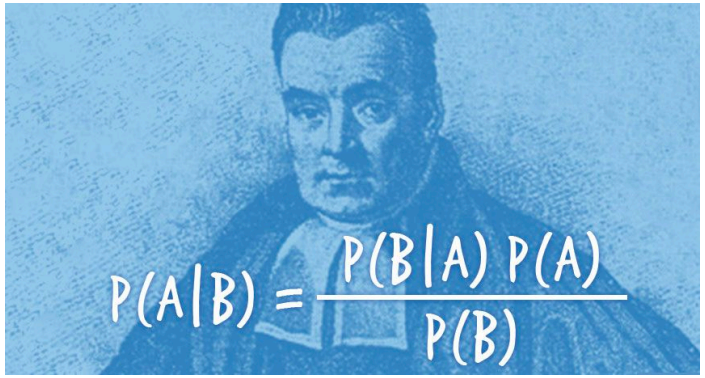

Shandian Zhe: Probabilistic Machine Learning

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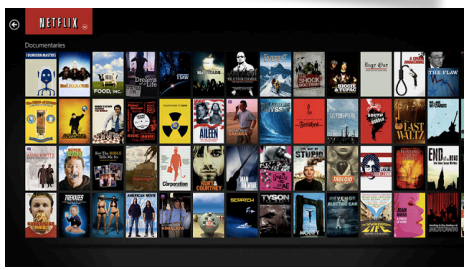
Research Topics:

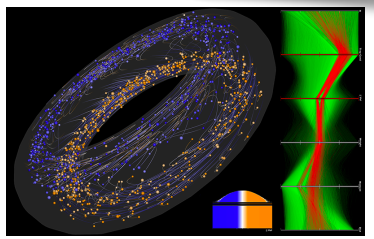
1. Bayesian Nonparametrics
2. Bayesian Deep Learning
3. Probabilistic Graphical Models
4. Large-Scale Learning System
5. Tensor/Matrix Factorization
6. Embedding Learning

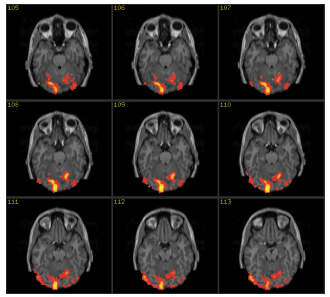
Applications:

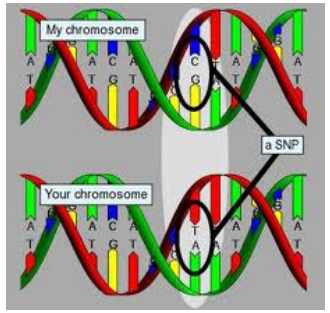
- Collaborative Filtering
- Online Advertising
- Physical Simulation
- Brain Imaging Data Analysis

....









Stochastic Nonparametric Event-Tensor Decomposition

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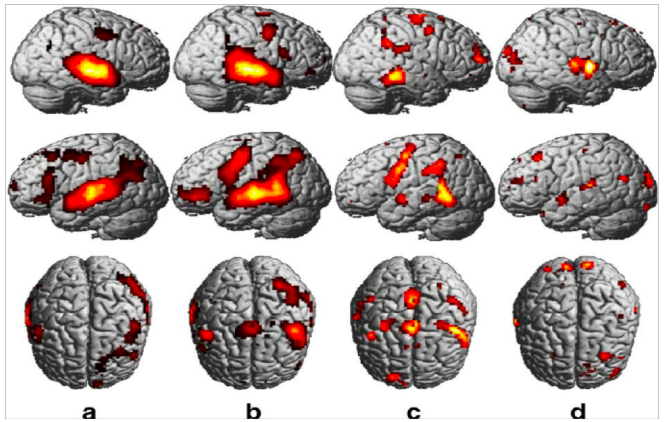
Tensor Data: Widely Used High-Order Data Structures to Represent Interactions of Multiple Objects/Entities

(user, movie, episode)

(user, advertisement, page-section)



(subject, voxel, electrode)

(user, item, online-store)

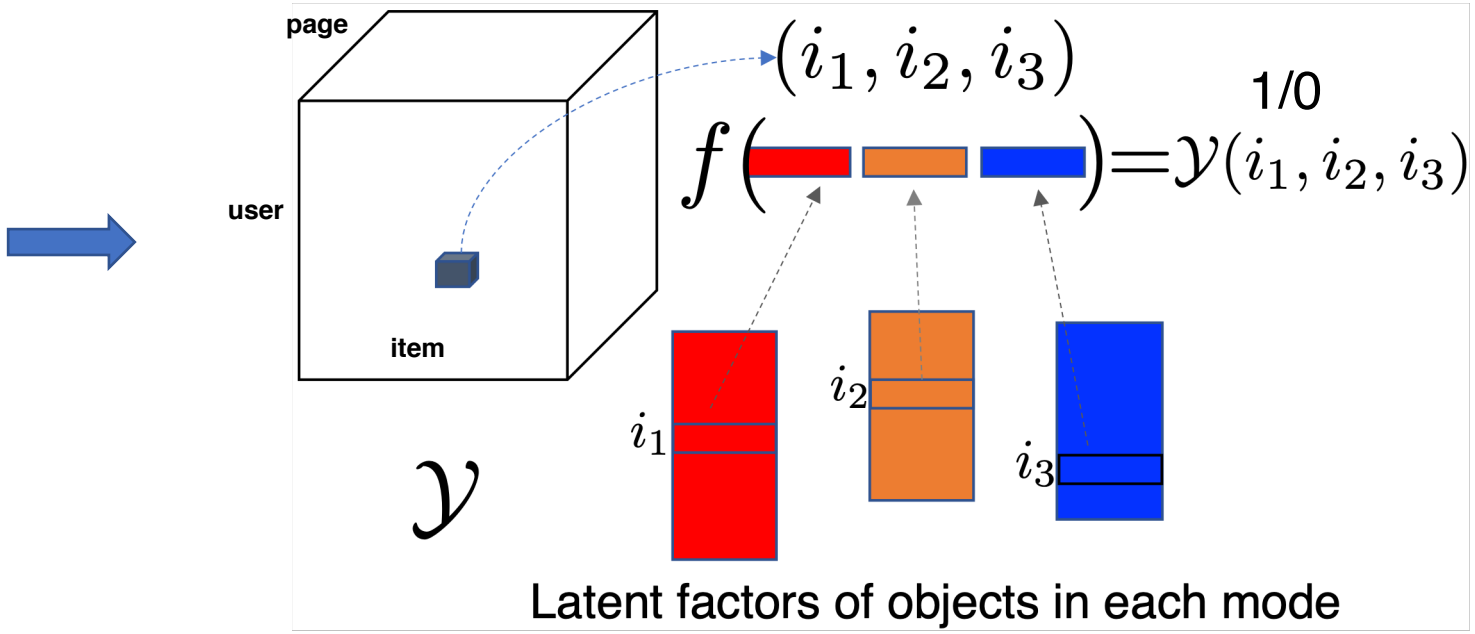
(user, user, location, message-type)

(patient, gene, condition)

Tensor Decomposition

Interaction Records

user	item	page	purchase
100	25	35	1
23	21	56	0
100	25	35	1
..	..		..
32	33	46	0



Traditional methods: **Multilinear assumptions**

$$\mathcal{Y}(i_1, i_2, i_3) = \sum_{j=1}^{r} \alpha_j \prod_{k} u^1_{i_1} u^2_{i_2} u^3_{i_3}$$ Tucker

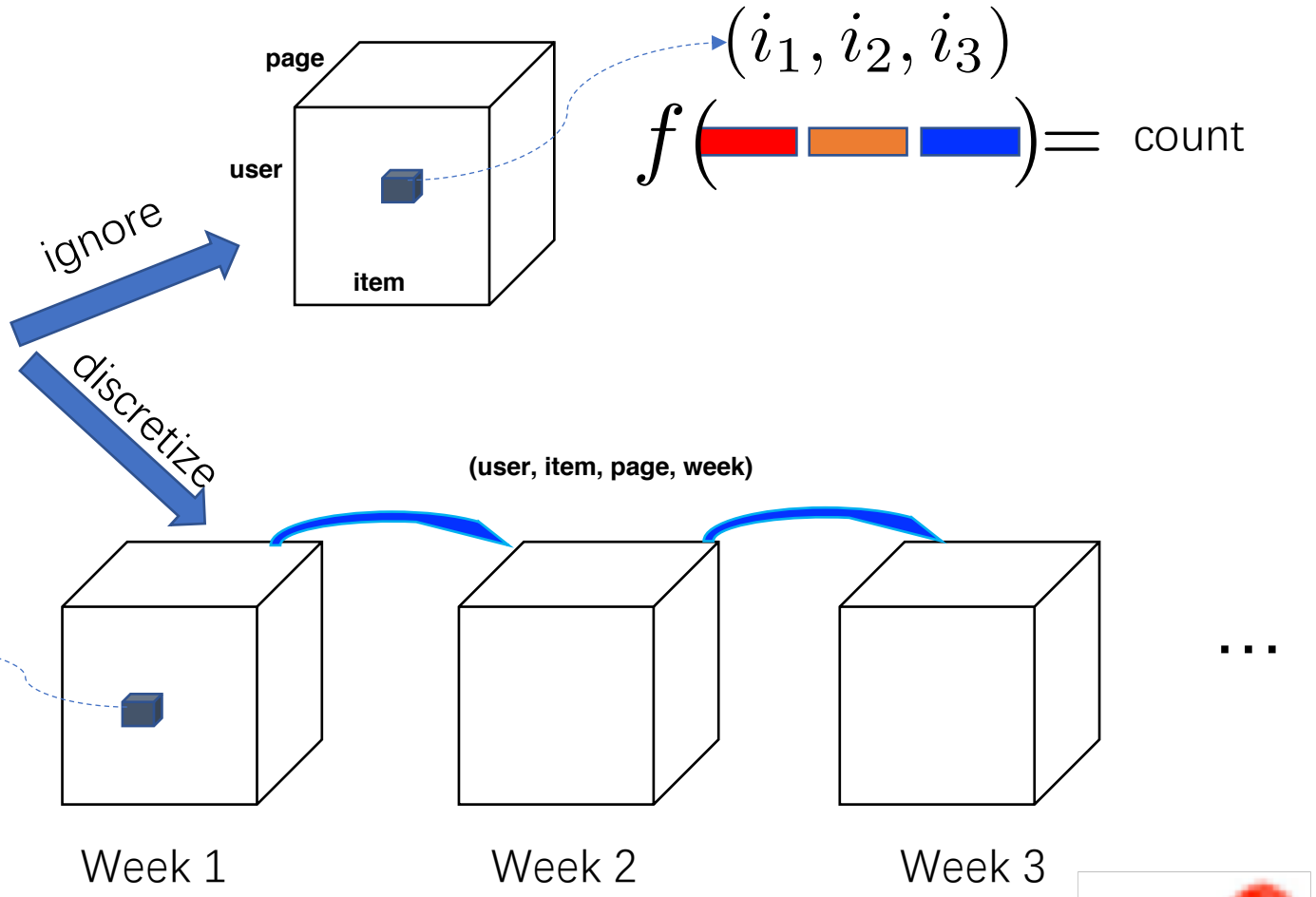
$$\mathcal{Y} = \mathcal{W} \times_1 \mathbf{U}_1 \times_2 \mathbf{U}_2 \times_3 \mathbf{U}_3$$ CP

Oversimplified

Tensor Decomposition with Time

Practical Interaction Records

user	item	page	purchase	time-stamp
100	25	35	1	23:00/05/06/2010
23	21	56	0	20:00/05/07/2010
100	25	35	1	22:10/05/08/2010
..	..		..	..
32	33	46	0	23:00/05/20/2010

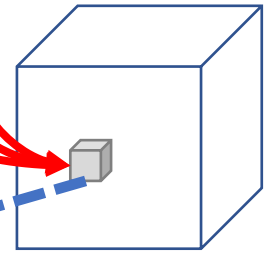


Ignore or over-simplify the temporal influences between entity interactions!

Stochastic Nonparametric Event-Tensor Decomposition

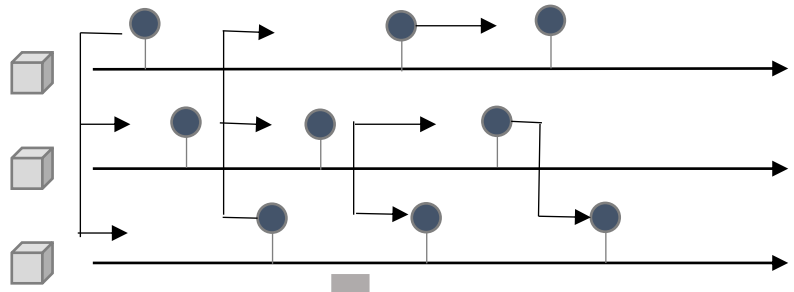
Step 1: Event-tensor formulation

user	item	page	time-stamp
100	25	35	23:00/05/06/2010
23	21	56	20:00/05/07/2010
100	25	35	22:10/05/08/2010
..	..		..
32	33	46	23:00/05/20/2010



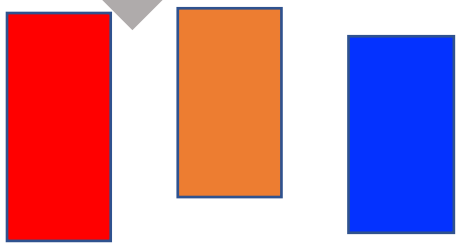
index	time-stamps
(100,25,35)	$\{s_1, s_2 \ldots s_n\}$

Step 2: Hybridize Gaussian processes and Hawkes processes for decomposition



temporal (triggering) relationships

static (nonlinear) relationships



Step 3: Doubly Stochastic variational EM

$$\mathcal{L} = \mathbb{E}_{p(k),p(l)}(\tilde{\mathcal{L}}_{k,l}) \quad \tilde{\mathcal{L}}_{k,l} = \mathbb{E}_{q(\mathbf{g})}\left(\log \frac{p(\mathbf{g})}{q(\mathbf{g})}\right) + \sum_{j \in N_k} \phi_{s_j,\bar{A}_{s_j}} \frac{N}{|N_k|} + \sum_{j \in N_k} \sum_{\mathbf{i} \in M_l} \psi_{s_j,\mathbf{i},\mathbf{i}_j} \frac{N}{|N_k|} \frac{M}{|M_l|}$$

Sparse GP + Super-position theorem

entries events

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