

# Deep Recommender System: Fundamentals and Advances

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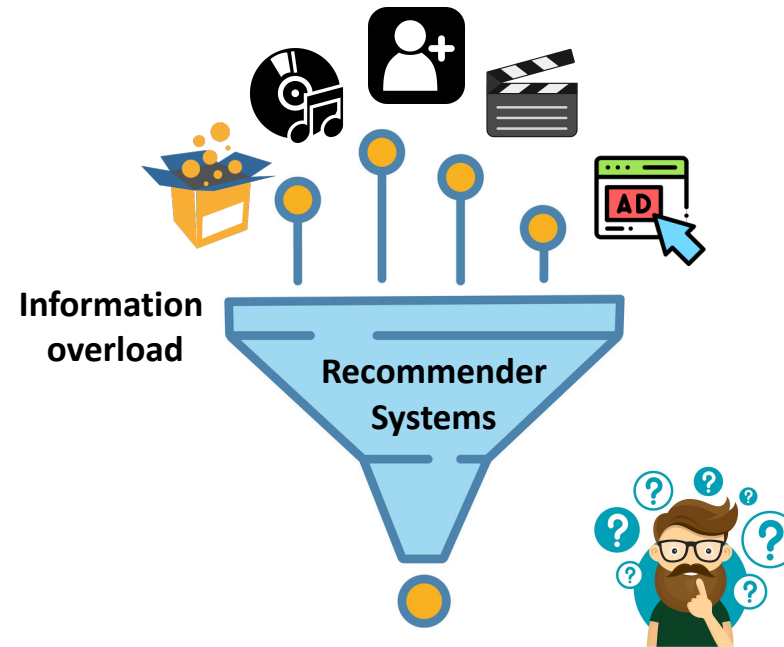
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Tutorial website: <https://deeprs-tutorial.github.io>



# Recommender Systems

## Age of Information Explosion



Recommend item X to user

**Items** can be: Products, News, Movies, Videos, Friends, etc.

# Recommender Systems

Recommendation has been widely applied in online services:

- E-commerce, Content Sharing, Social Networking ...



## Product Recommendation

Frequently bought together



Total price: \$208.9

Add all three to Cart

Add all three to List

# Recommender Systems



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## News/Video/Image Recommendation

For you

Recommended based on your interests

More For you

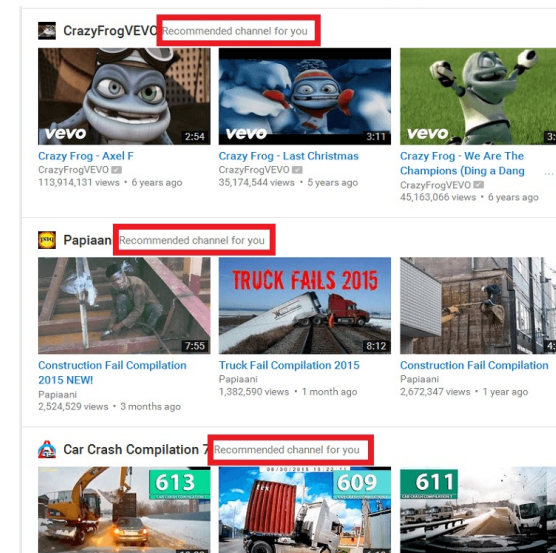
This Research Paper From Google Research Proposes A 'Message Passing Graph Neural Network' That Explicitly Models Spatio-Temporal Relations

MarkTechPost · 2 days ago



Tested: Brydge MacBook Vertical Dock, completing my MacBook Pro desktop

9to5Mac · 21 hours ago



# Recommender Systems



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- E-commerce, Content Sharing, Social Networking ...

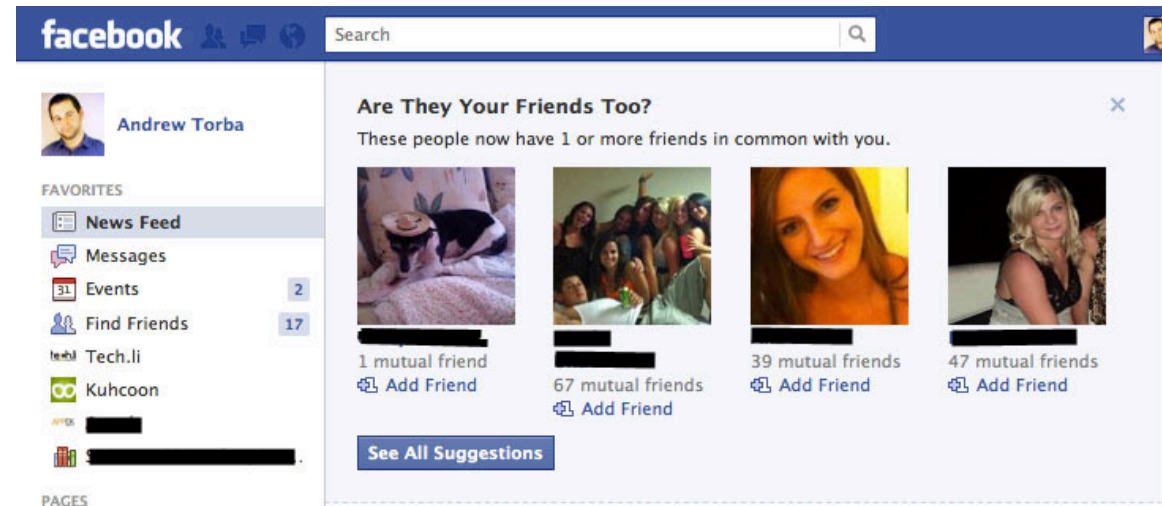
facebook



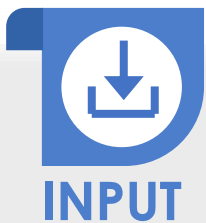
LinkedIn



## Friend Recommendation



# Problem Formulation

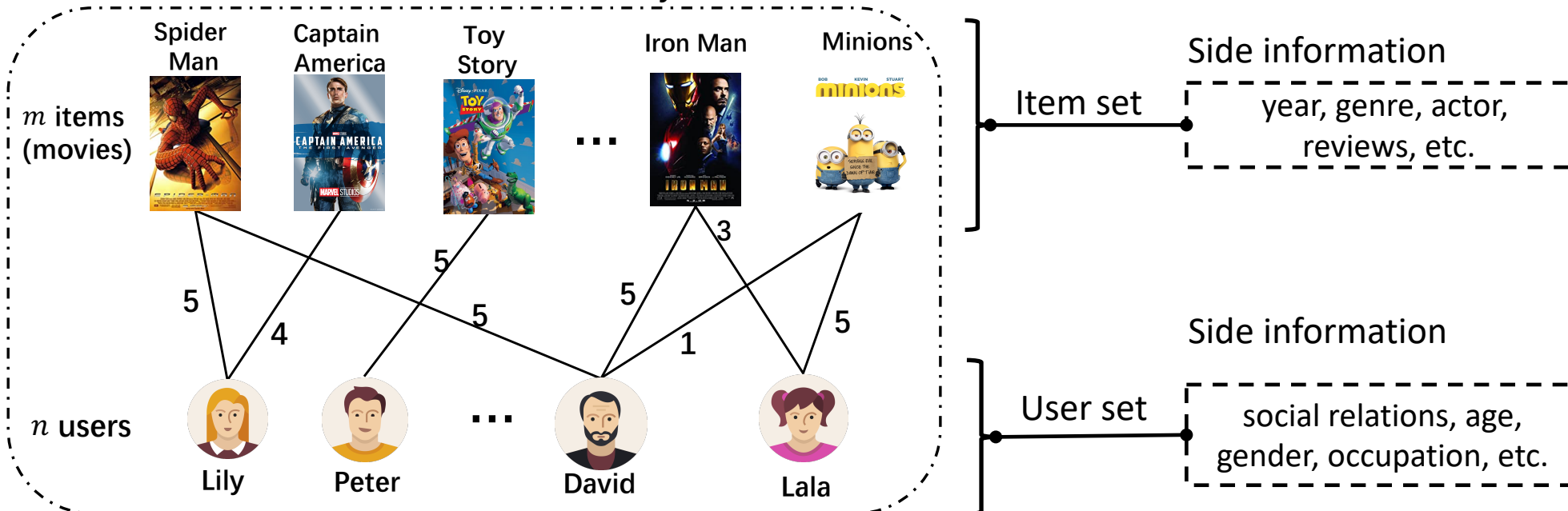


Historical user-item interactions or additional side information (e.g., social relations, item's knowledge, etc.)



Predict how likely a user would interact with a target Item (e.g., click, view, or purchase)

User-item Interaction History



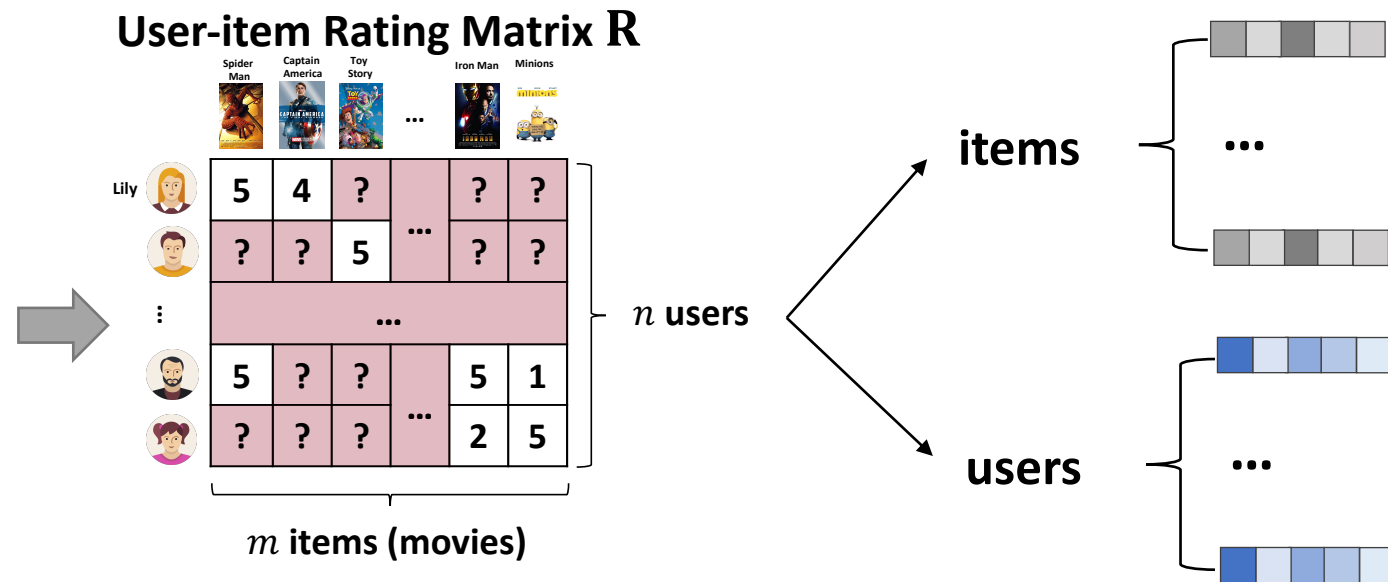
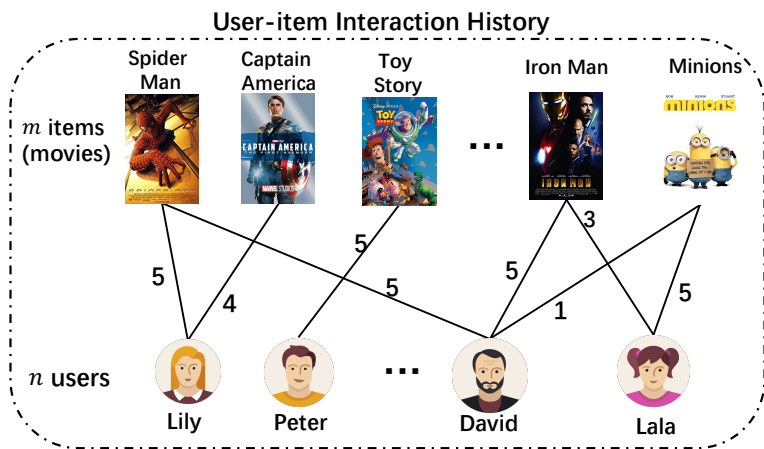


# Recommender Systems

## Collaborative Filtering (CF) is the most well-known technique for recommendation.

- Similar users (with respect to their historical interactions) have similar preferences.
- Modelling users' preference on items based on their past interactions (e.g., ratings and clicks).

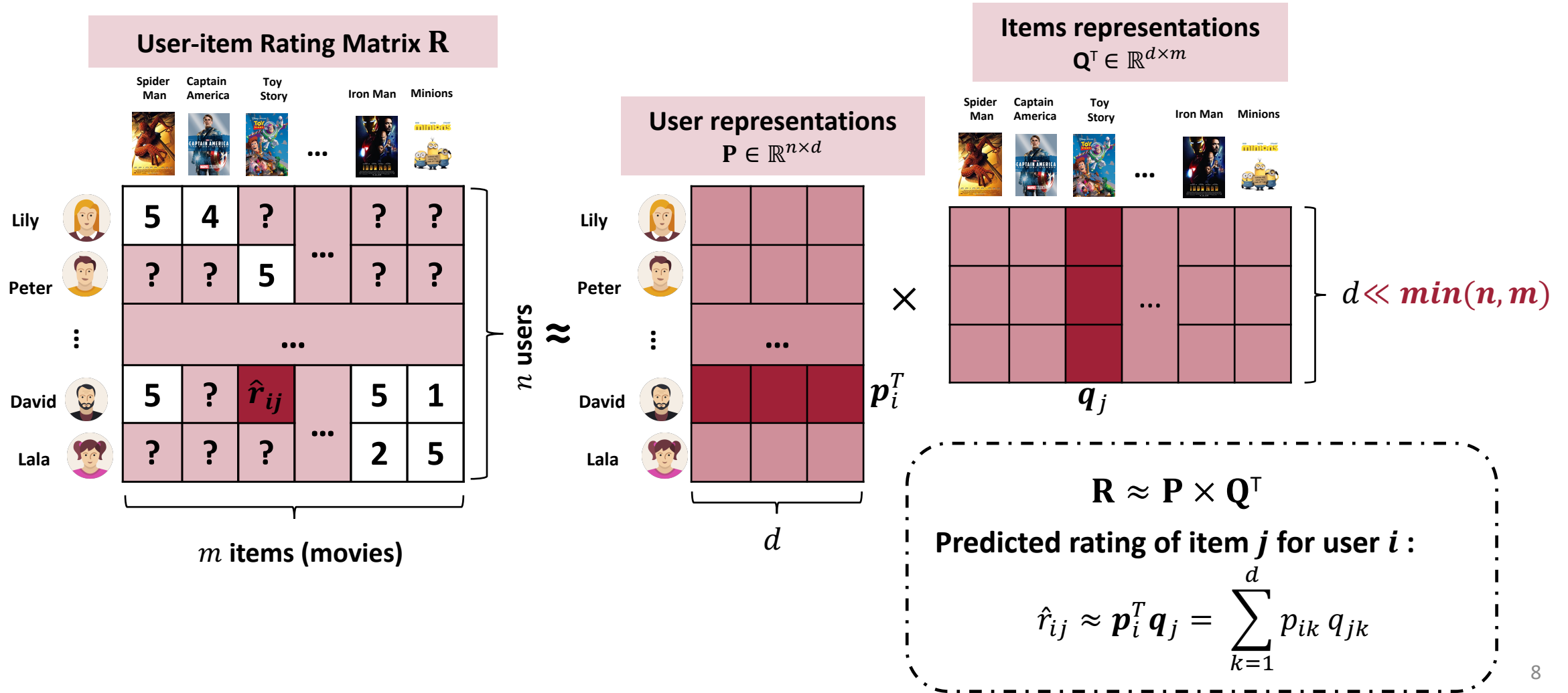
## Learning representations of users and items is the key of CF.



**Task: predicting missing movie ratings in Netflix.**

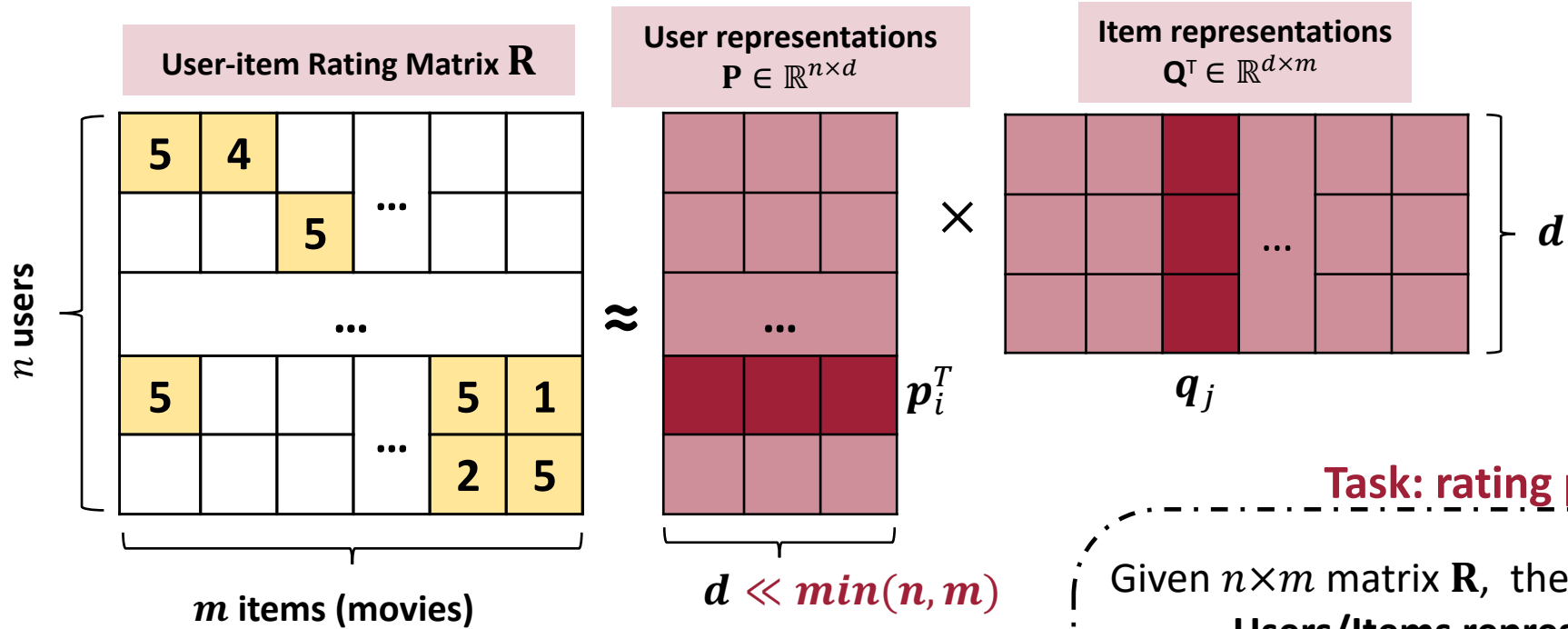
# Matrix Factorization

- Learn **representations** to describe users and items based on user-item rating matrix **R**.





# Matrix Factorization



 Observed user-item interactions (known):  $\mathcal{S}$

## Task: rating prediction in Netflix

Given  $n \times m$  matrix  $\mathbf{R}$ , the goal is to learn:  
**Users/Items representations:  $\mathbf{P} \in \mathbb{R}^{n \times d}, \mathbf{Q} \in \mathbb{R}^{m \times d}$**

Objective with rating reconstruction error:

$$\min_{\mathbf{P}, \mathbf{Q}} \sum_{i,j \in \mathcal{S}} (r_{ij} - \hat{r}_{ij})^2 = \sum_{i,j \in \mathcal{S}} (r_{ij} - \mathbf{p}_i^T \mathbf{q}_j)^2$$

 **observed rating score**

 **predicted rating score**

# Deep Learning is Changing Our Lives

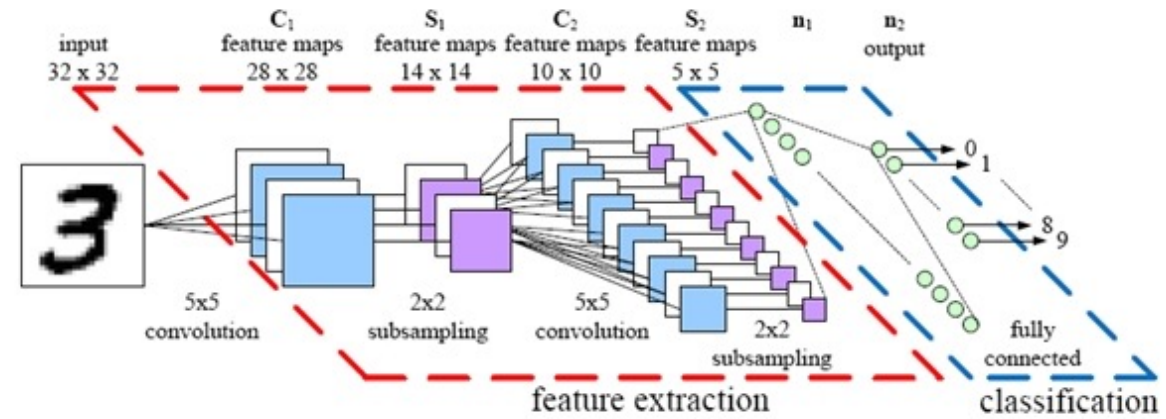
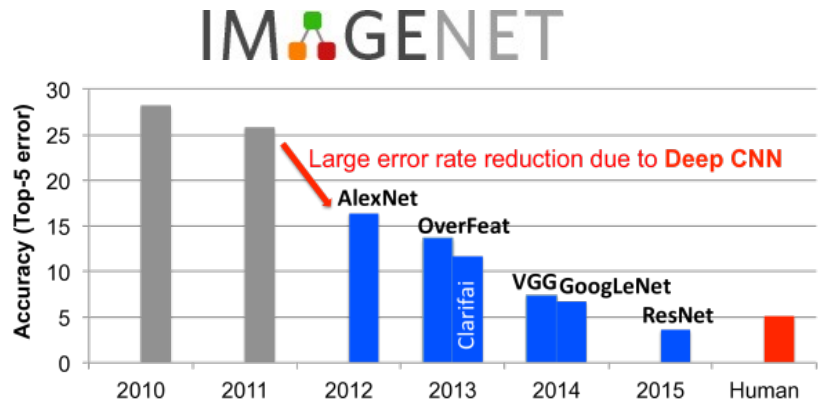


Image Classification    Object Detection

**COMPUTER VISION**

Voice Recognition    Language Translation

**SPEECH & AUDIO**

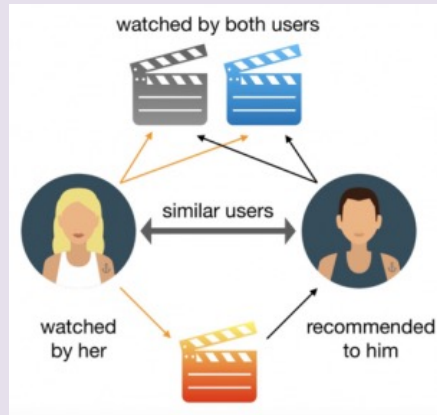
Deep Learning: Recurrent Neural Network

Recommendation Engines    Sentiment Analysis

**NATURAL LANGUAGE PROCESSING**

# Deep Recommender Systems

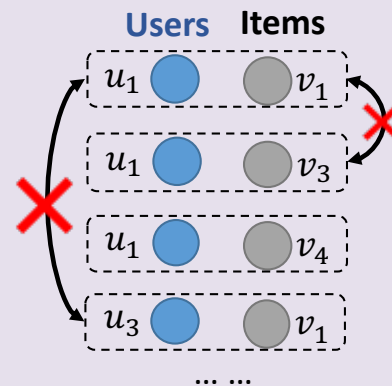
## Fundamentals of Deep Recommender Systems



### Recommendation Policies

- Offline optimization
- Short-term reward

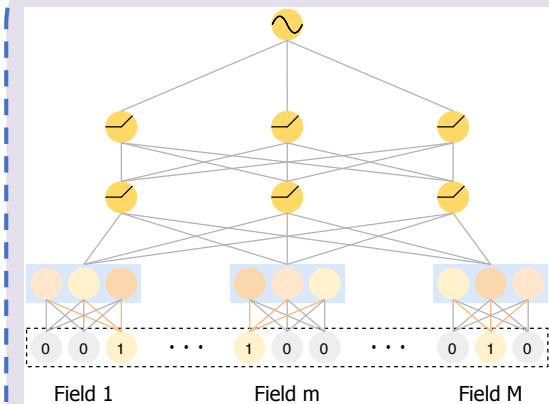
### Reinforcement Learning (RL)



### Graph-structured Data

- Information Isolated Island
- Issue: ignore implicit/explicit relationships among instances

### Graph Neural Networks (GNNs)




### Manually Designed Architectures

- Expert knowledge
- Time and engineering efforts

### Automated Machine Learning (AutoML)

# Agenda



- 9:00 – 9:10 Introduction to Recommender Systems (Jiliang Tang)
- 9:10 – 9:35 Fundamentals of Deep Recommender Systems (Wenqi Fan)
- 9:35 – 10:15 Reinforcement Learning for Recommendations (Xiangyu Zhao)
-  **10:15 – 10:25 Coffee Break (10 mins)**
- 10:25 – 11:00 Graph Neural Network for Recommendations (Wenqi Fan)
- 11:05 – 11:35 AutoML for recommendations (Xiangyu Zhao)
- 11:35 – 11:45 Conclusion and QA session