به نام یگانه معبود بخشنده مهربان

مبانی یادگیری ماشین

Machine Learning Foundations

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ترم اول سال تحصیلی ۰۲ - ۰۳

ارائه دهنده : پیمان ادیبی

مثالی از شبکه های عصبی

An Example of Neural Networks

مطالب

Outline

Embeddings

Dropout Regularization

Recommender Systems

جانشانی‌ها

Embeddings

متغیرهای نمادین

Symbolic variable

- Text: characters, words, bigrams...
- Recommender Systems: item ids, user ids
- Any categorical descriptor: tags, movie genres, visited URLs, skills on a resume, product categories...

Notation:

Symbol s in vocabulary V

کدگذاری تک فعال

One-hot representation

$$onehot(\text{'salad'}) = [0, 0, 1, \ldots, 0] \in \{0, 1\}^{|V|}$$

- Sparse, discrete, large dimension $|V|$
- Each axis has a meaning
- Symbols are equidistant from each other:

euclidean distance = $\sqrt{2}$

جانشانی

Embedding

$$embedding(\text{'salad'}) = [3.28, -0.45, \ldots 7.11] \in \mathbb{R}^d$$

- Continuous and dense
- Can represent a huge vocabulary in low dimension, typically: $d \in \{16, 32, \ldots, 4096\}$
- Axis have no meaning *a priori*
- Embedding metric can capture semantic distance

Neural Networks compute transformations on continuous vectors

جانشانی - یک نوع پیاده سازی

Implementation with Keras

Size of vocabulary $n = |V|$, size of embedding d

```
# input: batch of integers
Embedding(output_dim=d, input_dim=n, input_length=1)
# output: batch of float vectors
```

- Equivalent to one-hot encoding multiplied by a weight matrix $\mathbf{W} \in \mathbb{R}^{n \times d}$:

$$embedding(x) = onehot(x). \mathbf{W}$$

- $\mathbf{W}$ is typically **randomly initialized**, then **tuned by backprop**
- $\mathbf{W}$ are trainable parameters of the model

فاصله و شباهت در فضای جانشانی

Distance and similarity in Embedding space

Euclidean distance

$$d(x, y) = ||x - y||_2$$

- Simple with good properties
- Dependent on norm (embeddings usually unconstrained)

Cosine similarity

$$cosine(x, y) = \frac{x \cdot y}{||x|| \cdot ||y||}$$

- Angle between points, regardless of norm
- $cosine(x, y) \in (-1, 1)$
- Expected cosine similarity of random pairs of vectors is 0

فاصله و شباهت در فضای جانشانی

Distance and similarity in Embedding space

If x and y both have unit norms:

$$||x - y||_2^2 = 2 \cdot (1 - cosine(x, y))$$

or alternatively:

$$cosine(x, y) = 1 - \frac{||x - y||_2^2}{2}$$

Alternatively, dot product (unnormalized) is used in practice as a pseudo similarity

مصورسازی جانشانی ها

Visualizing Embeddings

- Visualizing requires a projection in 2 or 3 dimensions
- Objective: visualize which embedded symbols are similar

PCA

- Limited by linear projection, embeddings usually have complex high dimensional structure

t-SNE

Visualizing data using t-SNE, L van der Maaten, G Hinton, *The Journal of Machine Learning Research*, 2008

مصورسازی جانشانی ها

t-Distributed Stochastic Neighbor Embedding

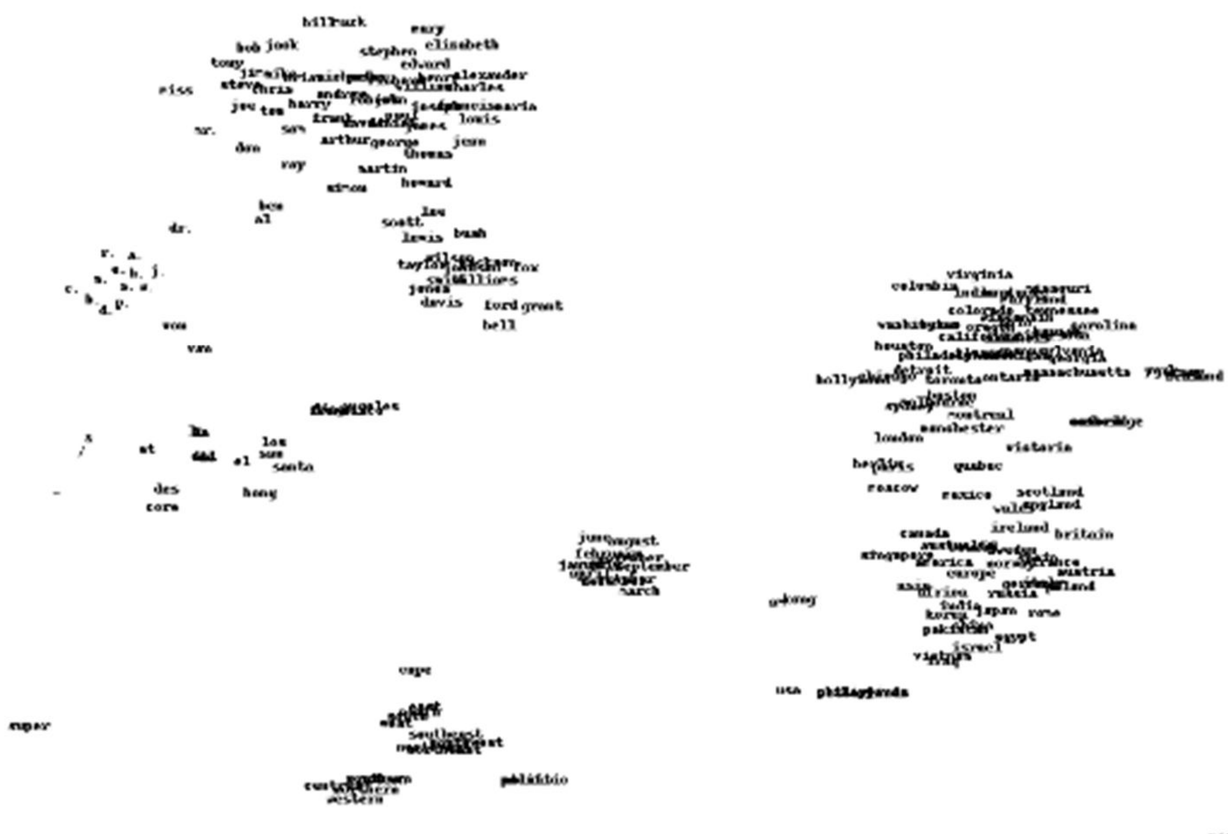
- Unsupervised, low-dimension, non-linear projection
- Optimized to preserve relative distances between nearest neighbors
- Global layout is not necessarily meaningful

t-SNE projection is non deterministic (depends on initialization)

- Critical parameter: perplexity, usually set to 20, 30
- See http://distill.pub/2016/misread-tsne/

مصورسازی جانشانی ها

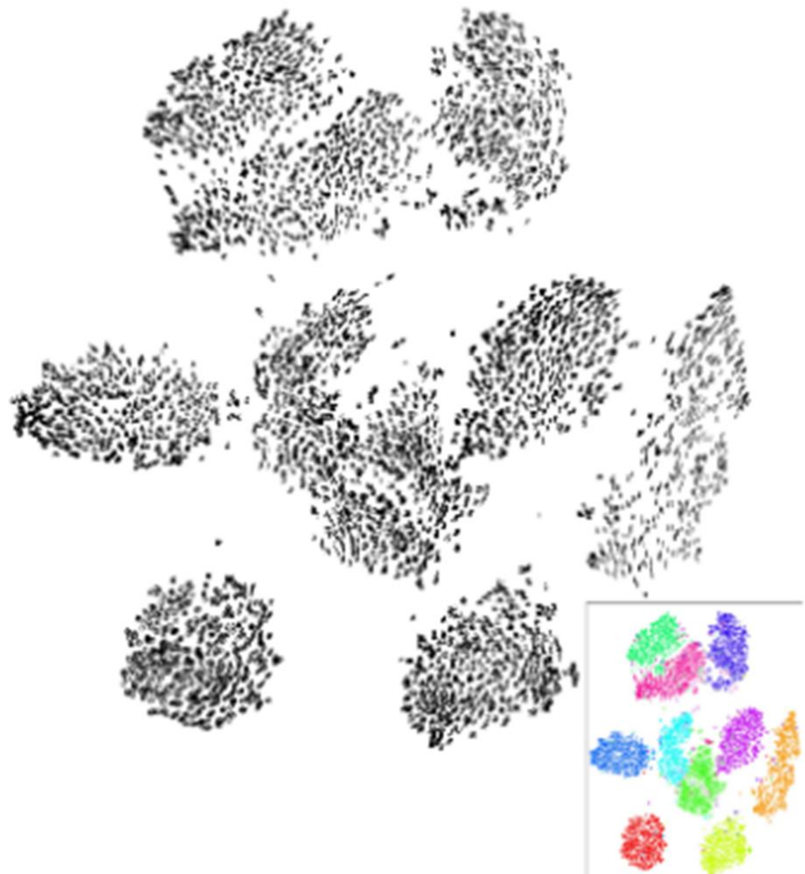
Example word vectors



excerpt from work by J. Turian on a model trained by R. Collobert et al. 2008

مصورسازی جانشانی ها

Visualizing Mnist



تنظیم با حذف تصادفی

Dropout Regularization

تنظیم

Regularization

Size of the embeddings

Depth of the network

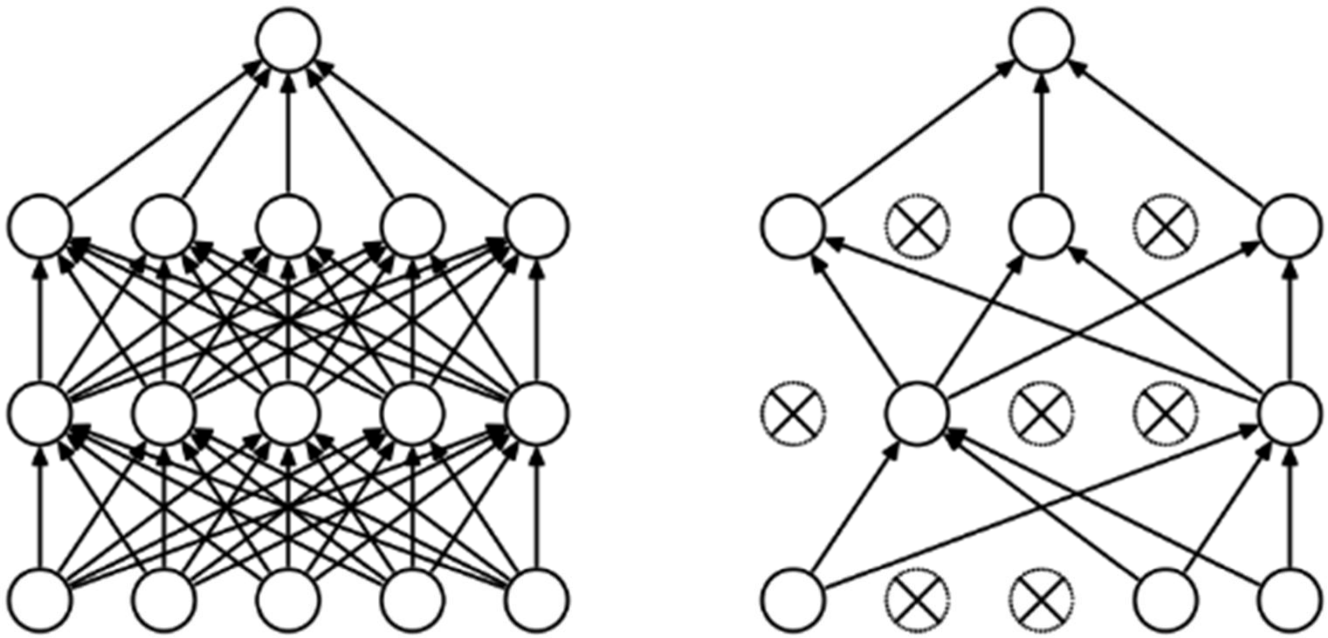
L_2 penalty on embeddings

Dropout

- Randomly set activations to 0 with probability p
- Bernoulli mask sampled for a forward pass / backward pass pair
- Typically only enabled at training time

حذف تصادفی

Dropout

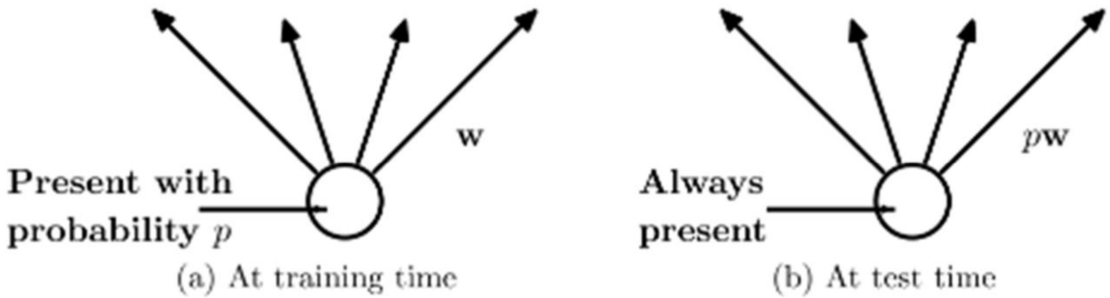


(a) Standard Neural Net (b) After applying dropout.

Dropout: A Simple Way to Prevent Neural Networks from Overfitting, Srivastava et al., *Journal of Machine Learning Research* 2014

حذف تصادفی

Dropout



At test time, multiply weights by p to keep same level of activation

Interpretation

- Reduces the network dependency to individual neurons

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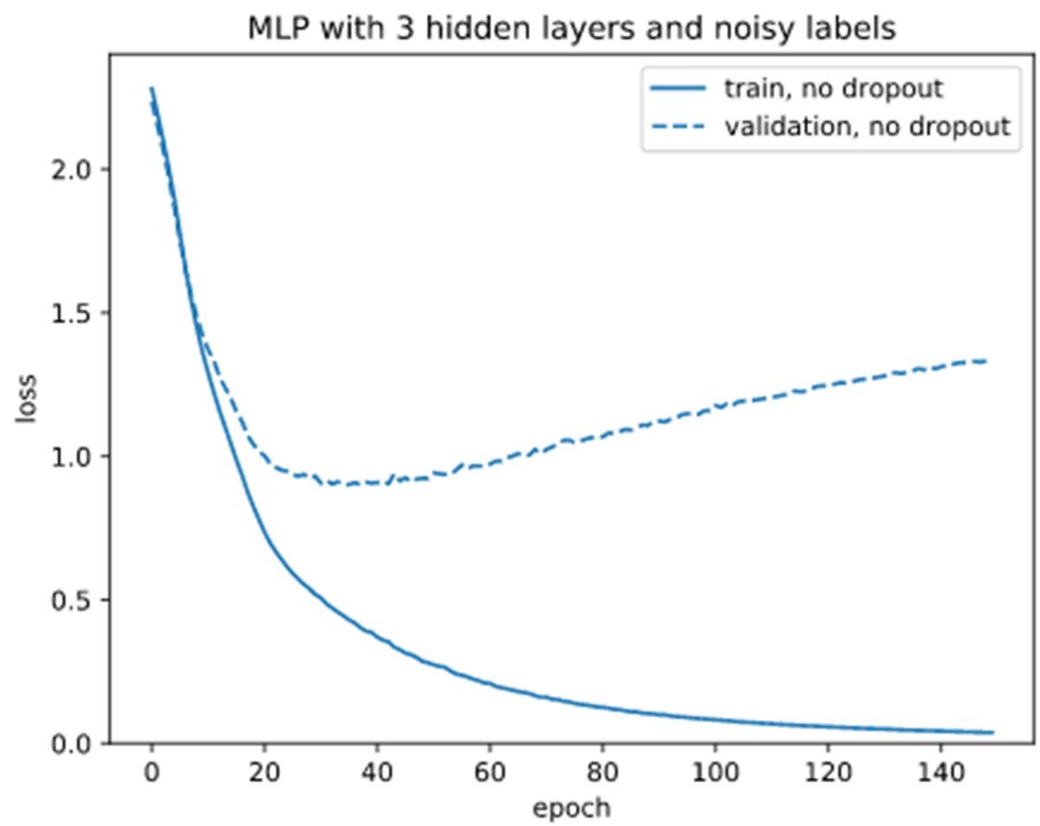
Dropout: A Simple Way to Prevent Neural Networks from Overfitting, Srivastava et al., *Journal of Machine Learning Research* 2014

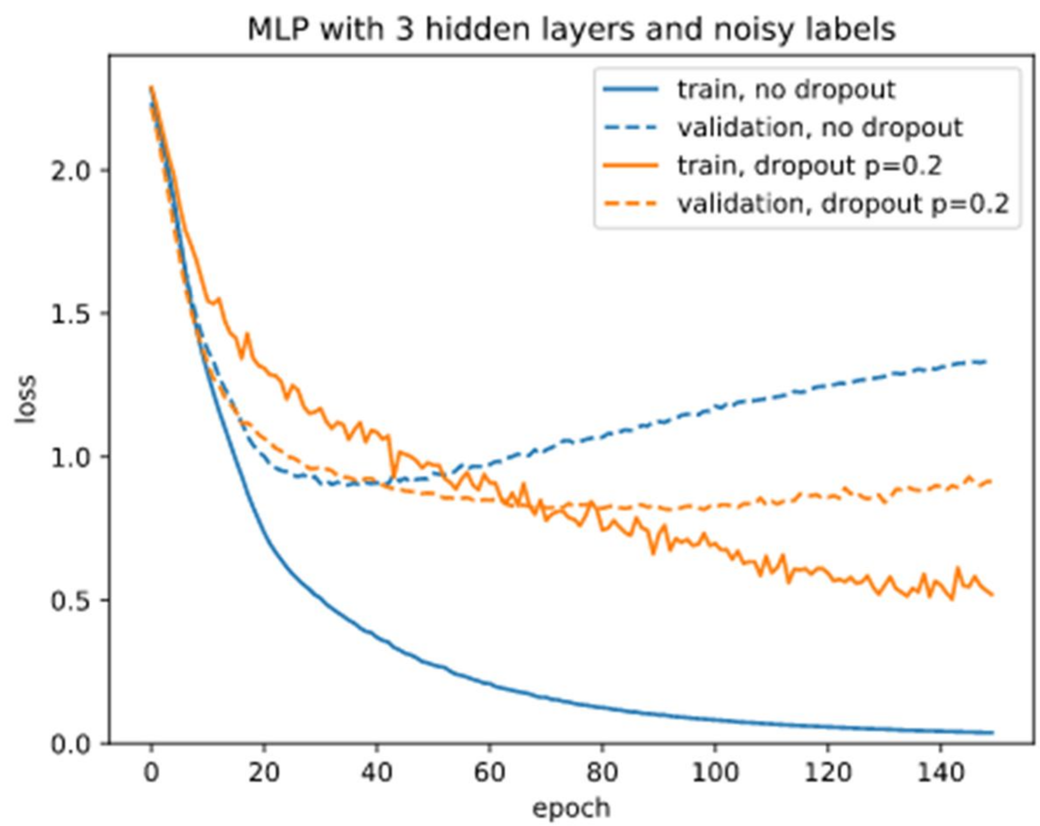
بیش برازش بدون حذف تصادفی

Overfitting Noise



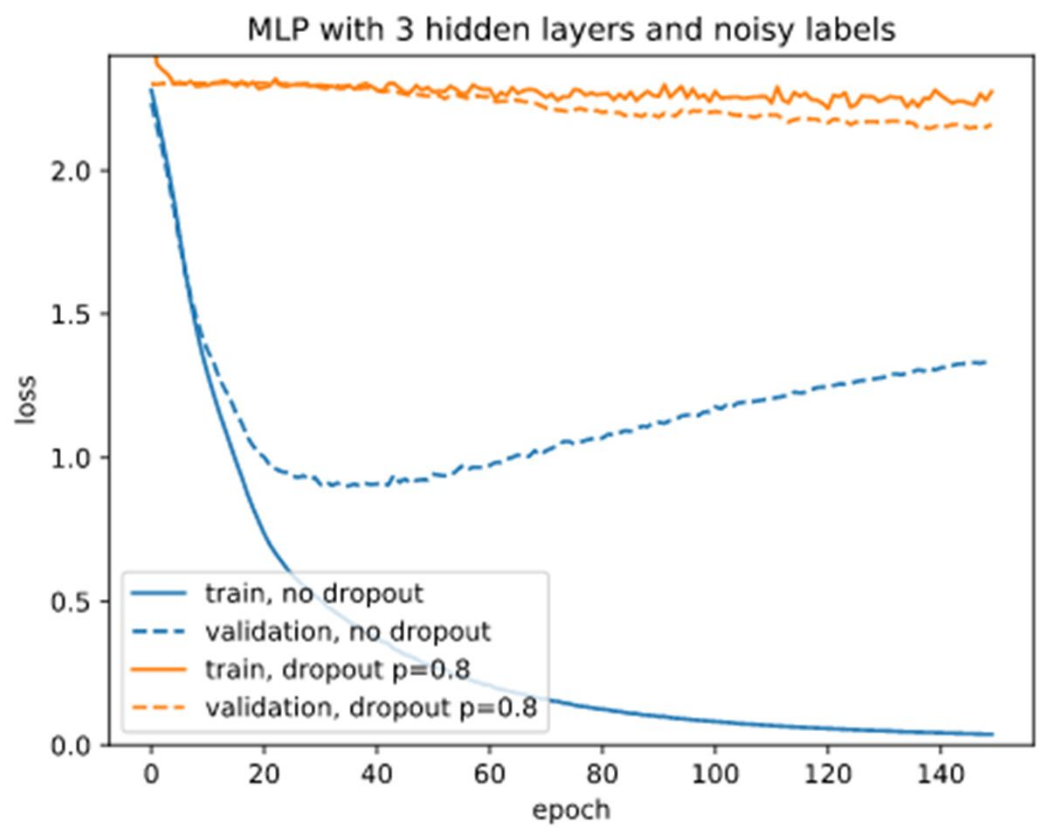
برازش مناسب با حذف تصادفی

A bit of Dropout



برازش ناکافی با حذف تصادفی

Too much: Underfitting



سامانه های توصیه گر

Recommend contents and products

Movies on Netflix and YouTube, weekly playlist and related Artists on Spotify, books on Amazon, related apps on app stores, "Who to Follow" on twitter...

Prioritized social media status updates

Personalized search engine results

Personalized ads and RTB

مبتنی بر محتوا در برابر فیلترسازی همکارانه

Content-based vs Collaborative Filtering (CF)

Content-based: user metadata (gender, age, location...) and item metadata (year, genre, director, actors)

Collaborative Filtering: passed user/item interactions: stars, plays, likes, clicks

Hybrid systems: CF + metadata to mitigate the cold-start problem

بازخورد صریح دربرابر ضمنی

Explicit vs Implicit Feedback

Explicit: positive and negative feedback

- Examples: review stars and votes
- Regression metrics: Root Mean Squared Error (RMSE), Mean Absolute Error (MAE)...

Implicit: positive feedback only

- Examples: page views, plays, comments...
- Ranking metrics: ROC AUC, precision at rank, NDCG...

بازخورد صریح دربرابر ضمنی

Implicit feedback much more **abundant** than explicit feedback

Explicit feedback does not always reflect **actual user behaviors**

- Self-declared independent movie enthusiast but watch a majority of blockblusters

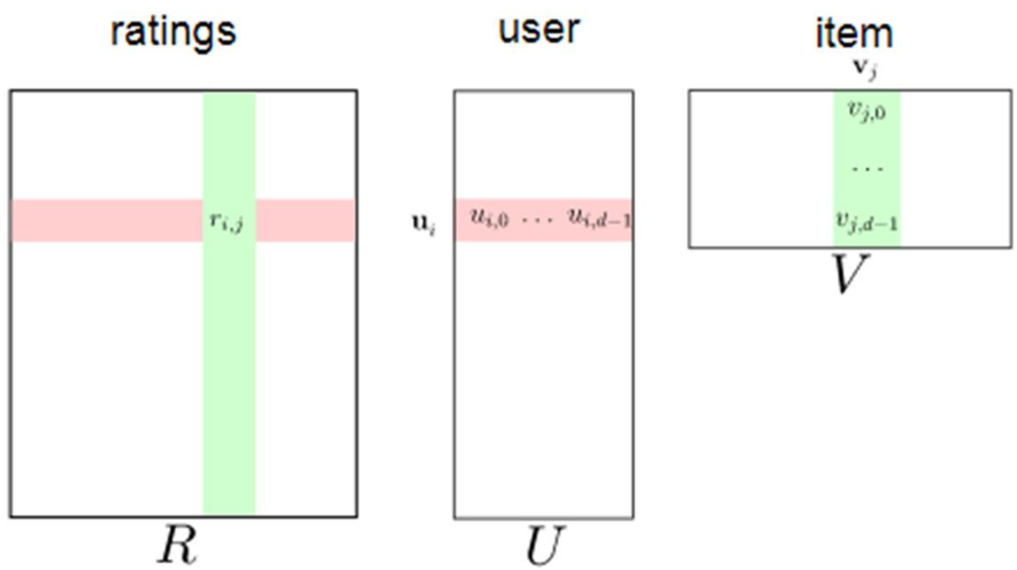
Implicit feedback can be **negative**

- Page view with very short dwell time
- Click on "next" button

Implicit (and Explicit) feedback distribution **impacted by UI/UX changes** and the **RecSys deployment** itself.

تجزیه ماتریسی در فیلترسازی همکارانه

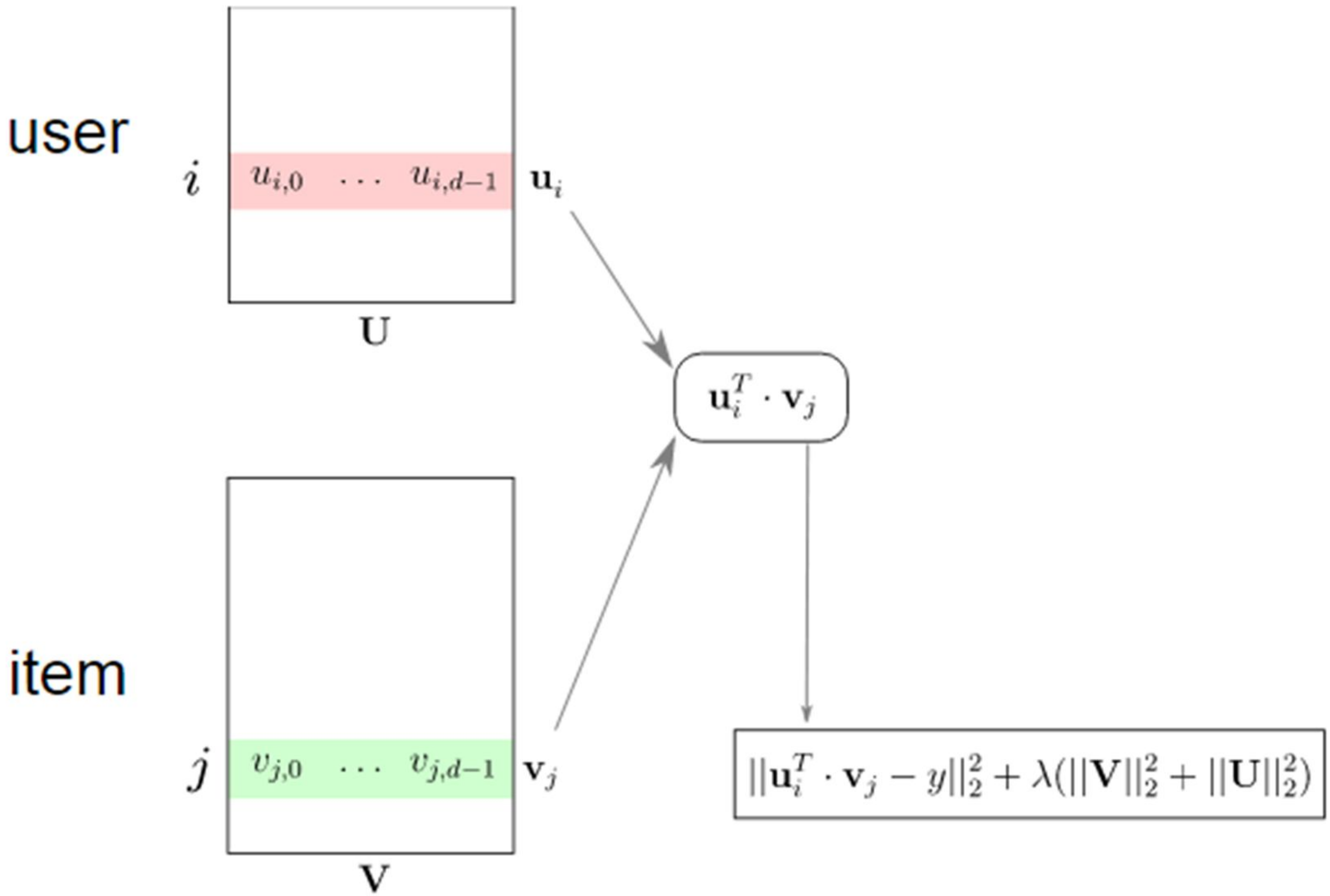
Matrix Factorization for CF



$$L(U,V) = \sum_{(i,j)\in D} ||r_{i,j} - \mathbf{u}_i^T \cdot \mathbf{v}_j||_2^2 + \lambda(||U||_2^2 + ||V||_2^2)$$

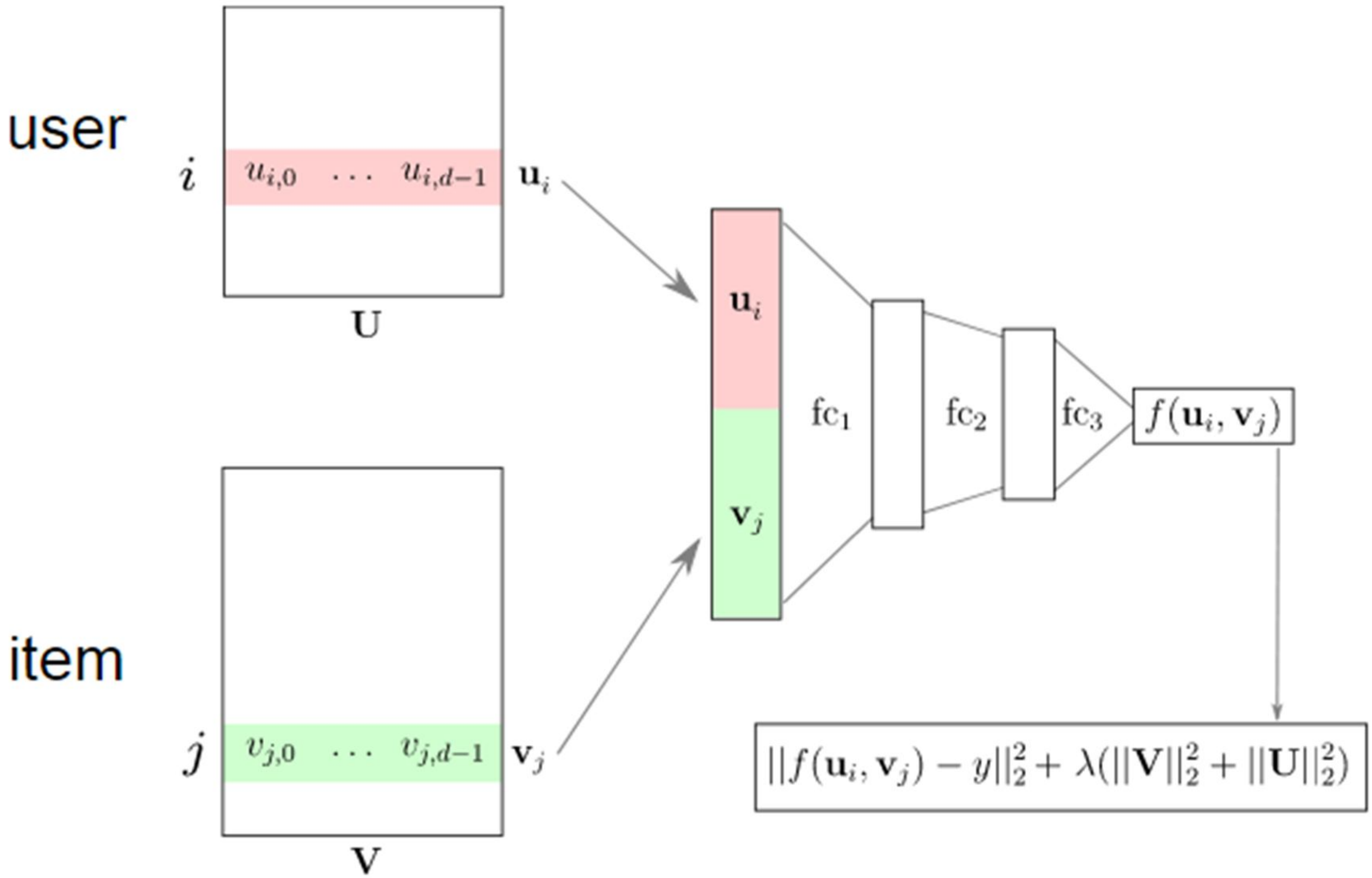
- Train U and V on observed ratings data $r_{i,j}$
- Use $U^T V$ to find missing entries in sparse rating data matrix R

معماری و تنظیم
RecSys with Explicit Feedback



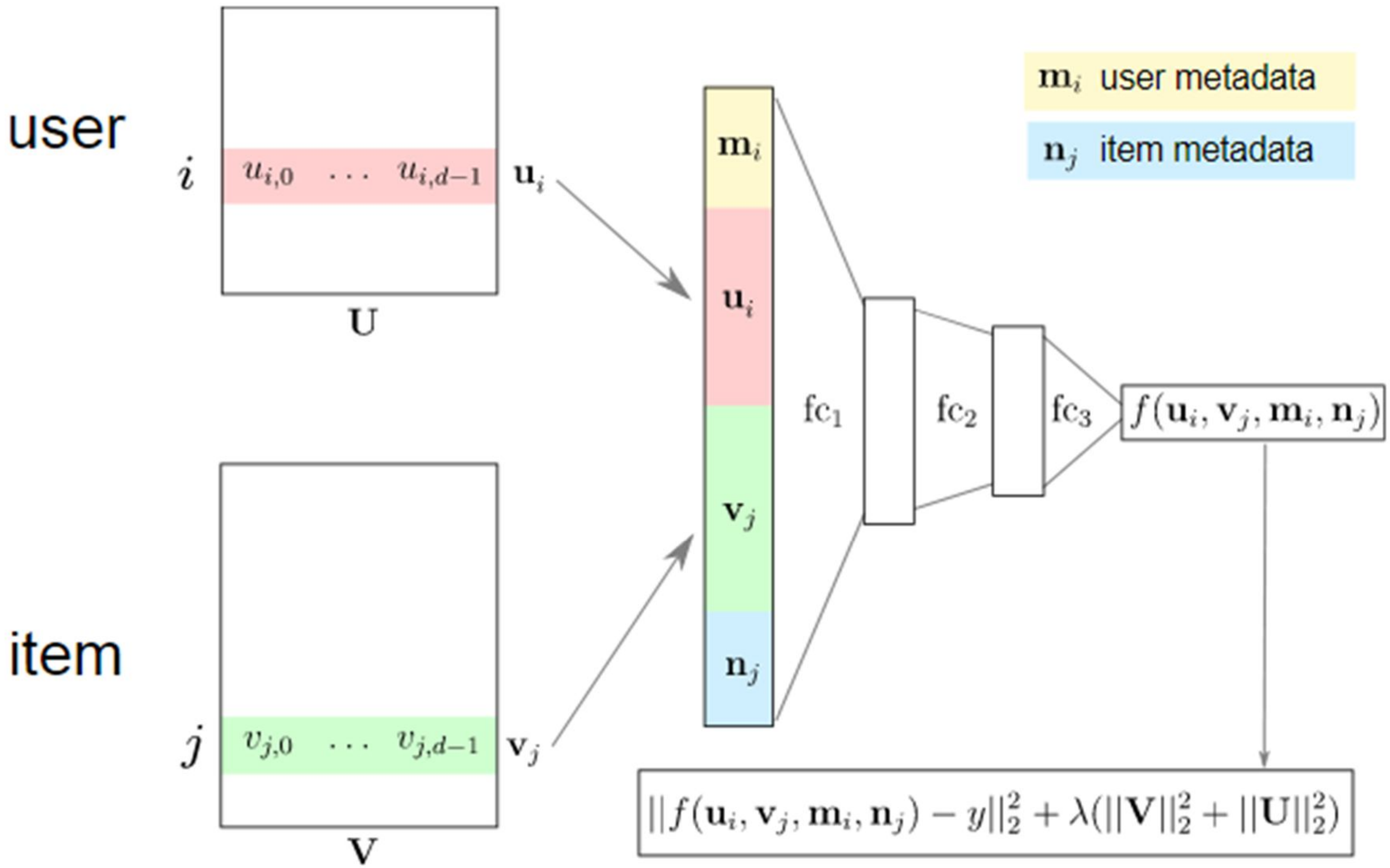
معماری و تنظیم

Deep RecSys Architecture



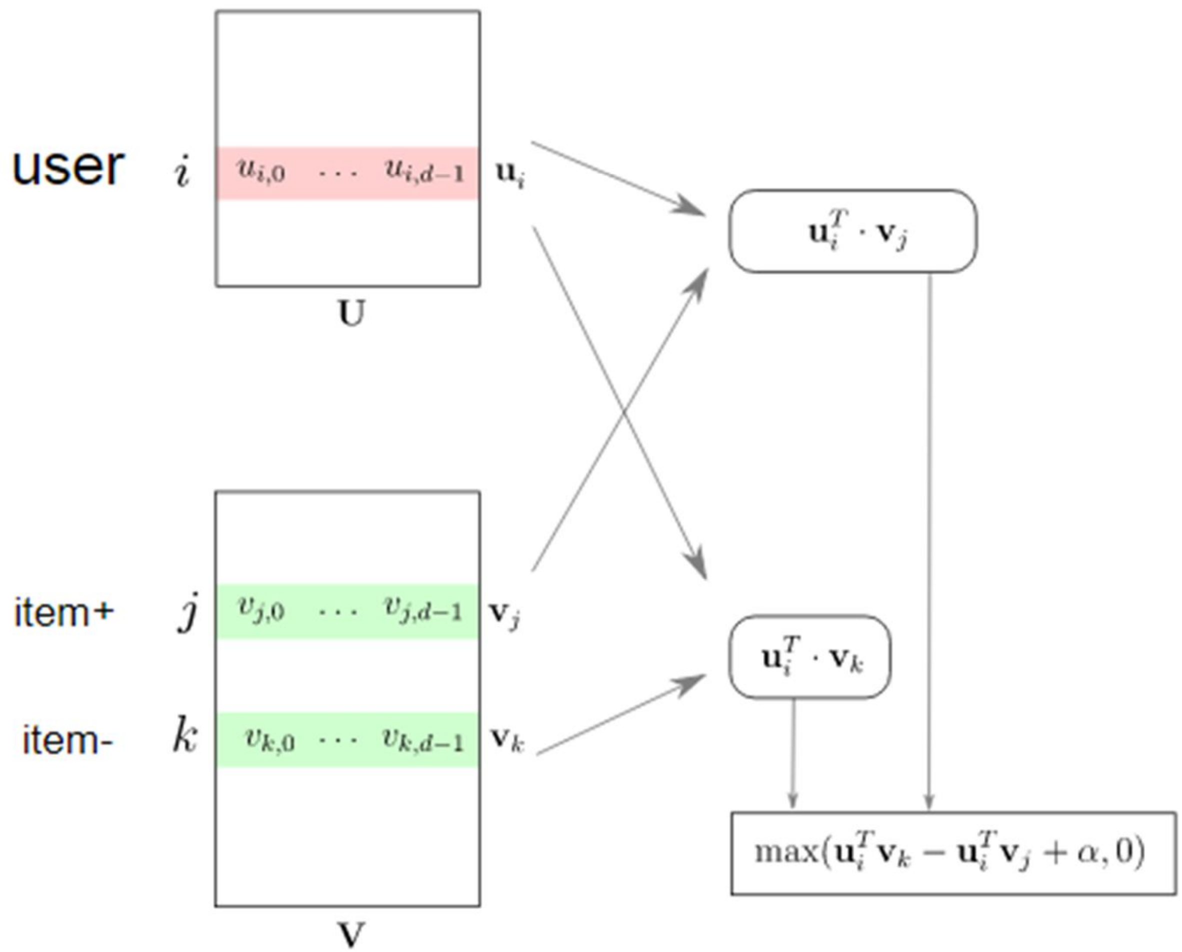
معماری و تنظیم

Deep RecSys with metadata



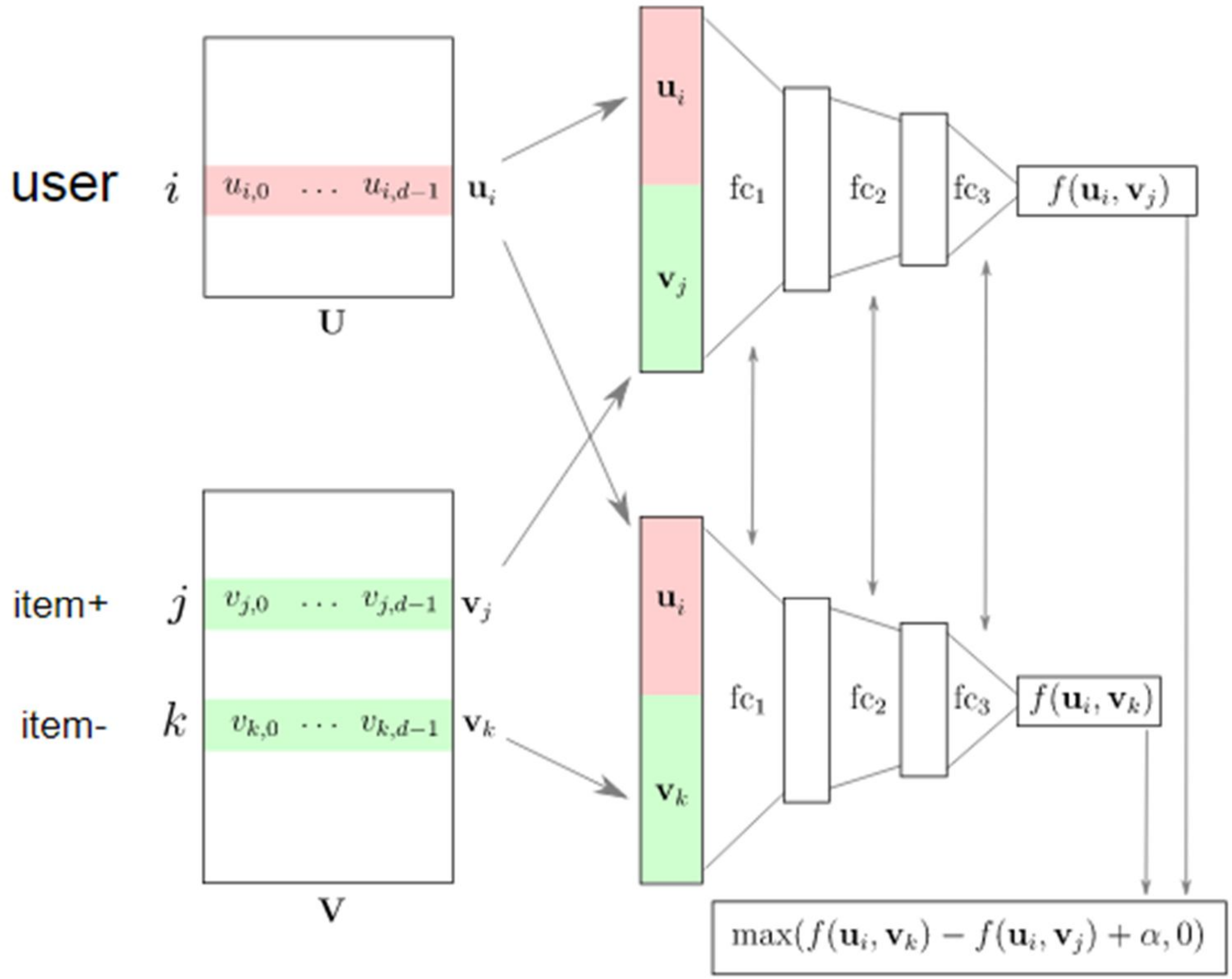
معماری و تنظیم

Implicit Feedback: Triplet loss



معماری و تنظیم

Deep Triplet Networks

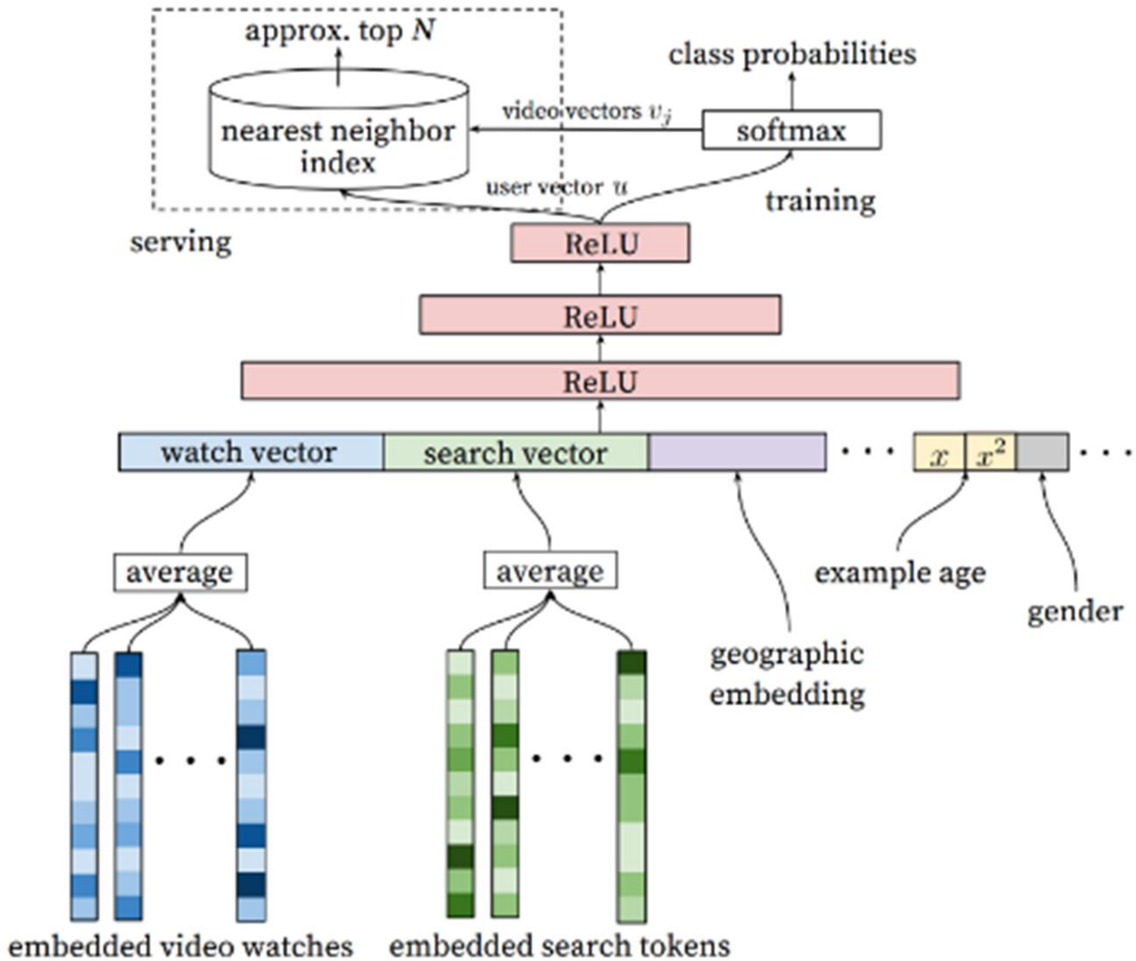


معماری و تنظیم

Training a Triplet Model

- Gather a set of positive pairs user i and item j
- While model has not converged:
  - Shuffle the set of pairs (i, j)
  - For each (i, j):
    - Sample item k uniformly at random
    - Call item k a negative item for user i
    - Train model on triplet (i, j, k)

معماری و تنظیم



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Deep Neural Networks for YouTube Recommendations

https://research.google.com/pubs/pub45530.html