

Search Ranking and Personalization at Airbnb

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SEARCH RANKING TEAM



Airbnb

Worldwide Accommodations Leader

- **4M listings in 190 Countries**
- **2M guest stay at Airbnb every night**

2-sided Marketplace:

- **Hosts:** looking to rent their space
- **Guests:** looking for a place to stay

Our job:

Connect guests with hosts

Search At Airbnb

query: location, dates, guests, map, filters



results:

Screenshot of the Airbnb search results page for San Francisco, showing eight listing cards and a map.

The search filters at the top are: San Francisco, Anytime, 1 guest, FOR YOU, HOMES (selected), EXPERIENCES, PLACES, Room type, Price range, Instant Book, More filters.

The map on the right shows San Francisco with price overlays for different neighborhoods:

- Marin City: \$129
- Golden Gate National Recreation Area: \$79
- Marin Headlands: \$105
- PRESIDIO: \$129
- RICHMOND DISTRICT: \$145
- OUTER RICHMOND: \$125
- Francisco: \$139
- MISSION DISTRICT: \$115
- OUTER MISSION: \$149
- DOGPATCH: \$200
- OUTER SUNSET: \$125
- SUNSET DISTRICT: \$140
- TWIN PEAKS: \$72
- WESTLAKE: \$140
- Lake Merced Park: \$125
- Visitacion Valley: \$140
- HUNTERS POINT: \$125
- Daly City: \$140
- Colma: \$140
- Brisbane: \$140
- South San Francisco: \$140

Listing details:

- From \$79 · Perfectly located Castro**
Private room · 1 bed
★★★★★ 335 · Superhost
- From \$149 · Grand and Cozy 1920's SF Studio**
Entire apartment · 2 beds
★★★★★ 280 · Superhost
- From \$185 · Garden Retreat steps from Haight St**
Entire house · 2 beds
★★★★★ 186 · Superhost
- From \$105 · Charming SF 1911 Studio**
Entire condominium · 1 bed
★★★★★ 136 · Superhost
- From \$129 · Upscale Private Ensuite Bed & Bath**
Private room · 1 bed
★★★★★ 289 · Superhost
- From \$350 · Edwardian Style Pacific Heights 1BD**
Entire apartment · 1 bed
★★★★★ 56

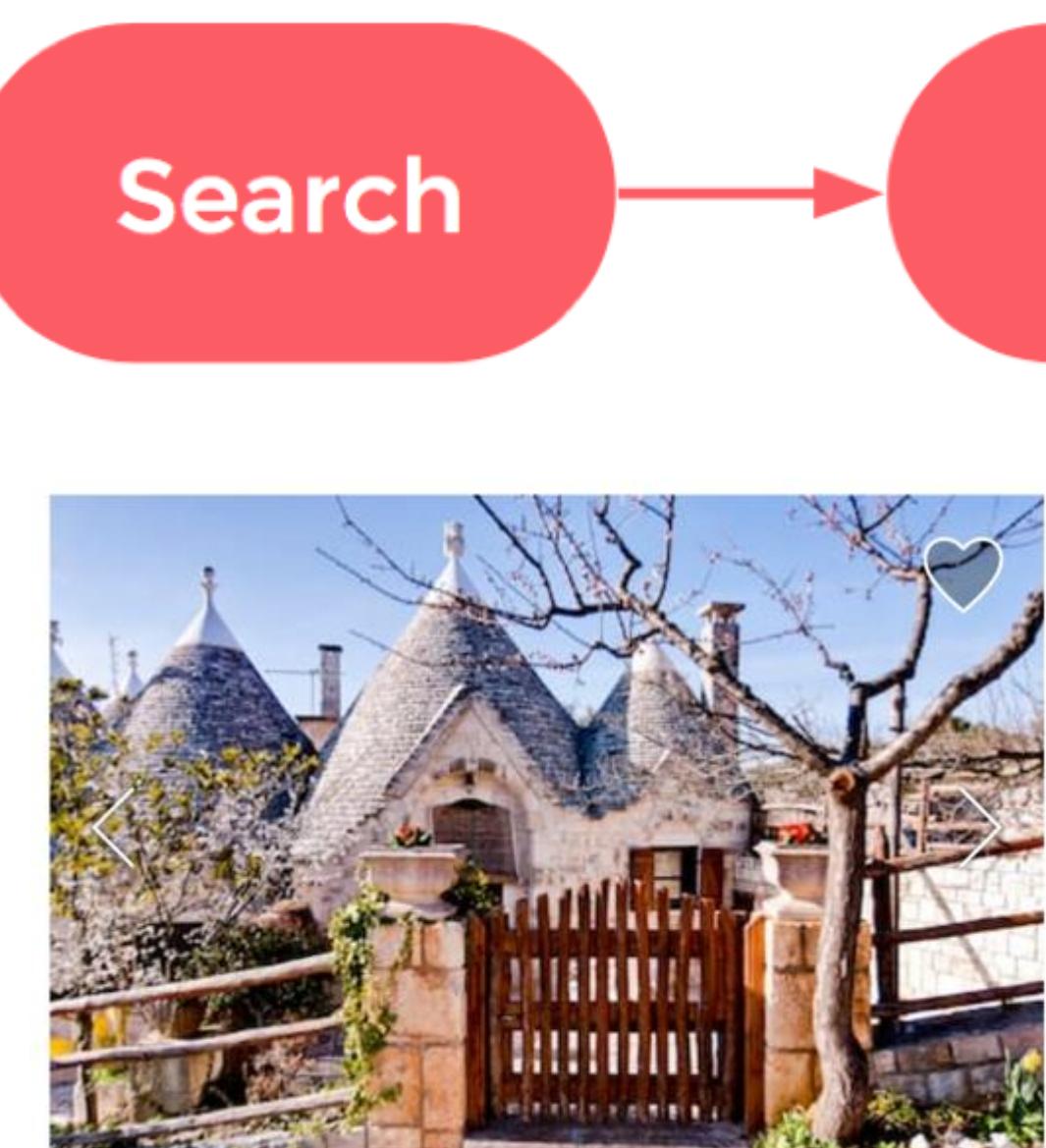
Search At Airbnb

Search Components

- **Retrieval of Listings**
 - **Location Queries** (e.g. **New York**): Rule based: fetch everything near by
 - **Broad Queries** (e.g. **Skiing in France**): Model based
- **Ranking of Listings**
 - **Model based:** query, user and listing features
 - **Trained using user actions:** clicks, wishlists, inquires, bookings and rejections
 - **Tradeoffs Guest and Host preferences**

Typical Guest Flow

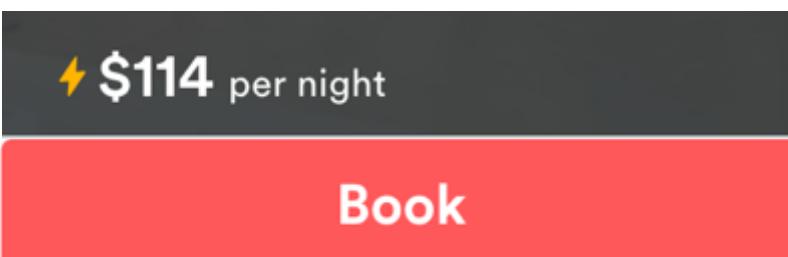
Guest actions



\$66
★★★★★ 71 reviews
I SETTE CONI - TRULLO EDERA
Entire home/apt · 2 beds · 4 guests · Business Travel Ready

- One listing can accept only one guest for a certain set of dates

Instant Book



Click

Book

Book

Request to Book

Booking Request

Contact host

Contact

Reject

Accept

No Response

Host actions

- dates
- minimum nights
- short notice
- long term
- pets
- kids
- discount
- parties
- smoking

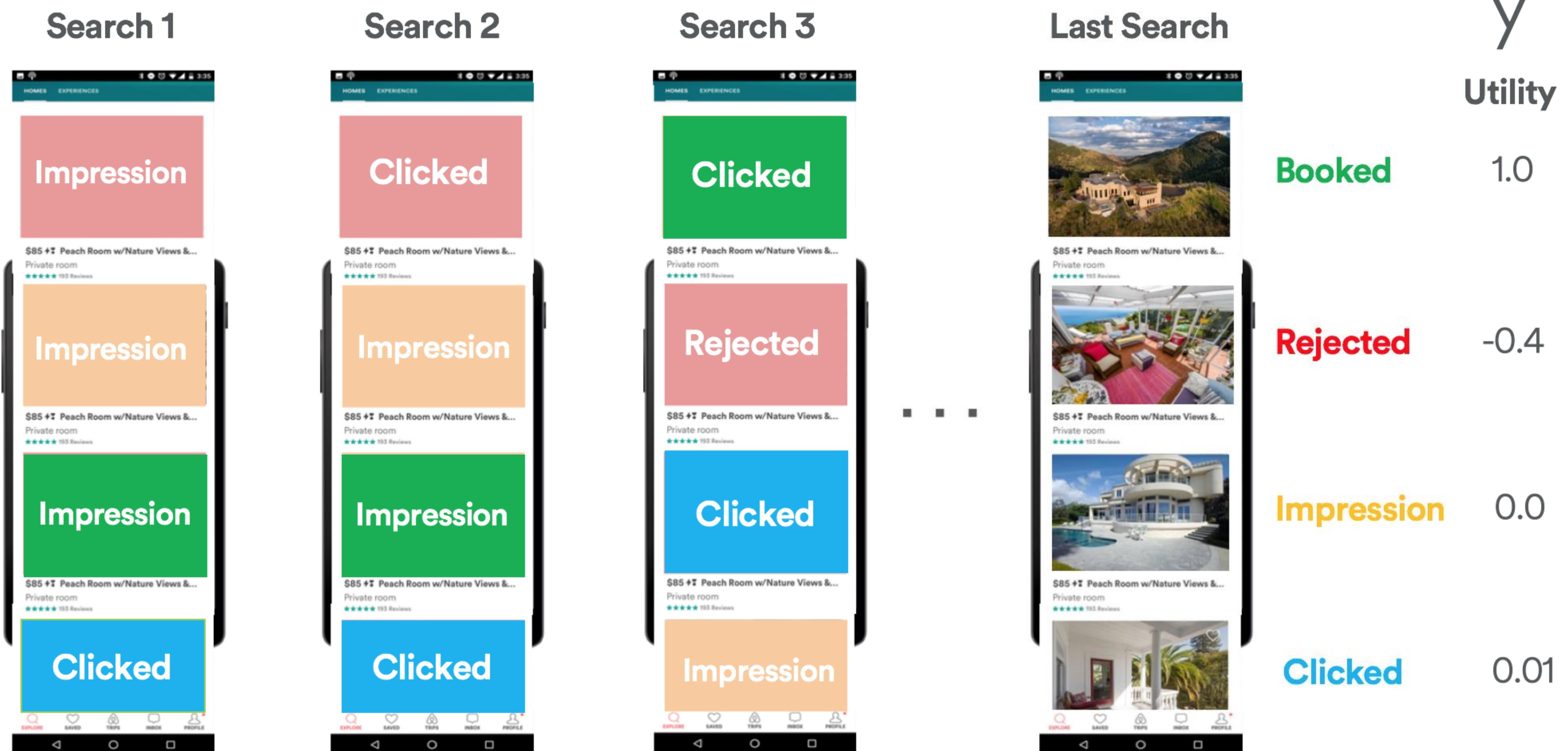
Guest Sessions

Average user does **dozens of searches over multiple days** before they book



Model v0:

Last Search (label propagation) + Utility Prediction



Model v0: Last Search + Utility Prediction

- Regression:

$$f(x) \rightarrow y$$

Display Results in Descending Order of Predicted Utility

- Features (X) :

- Listing Features (engagement, quality, type, capacity, etc.)
- Query Features (destination, nights, guests, etc.)
- Guest Features (origin, past bookings, listing preferences, short term history)
- **Rejection Probability**: output of separate model that predicts Host rejections

- Model (f) : GBM model



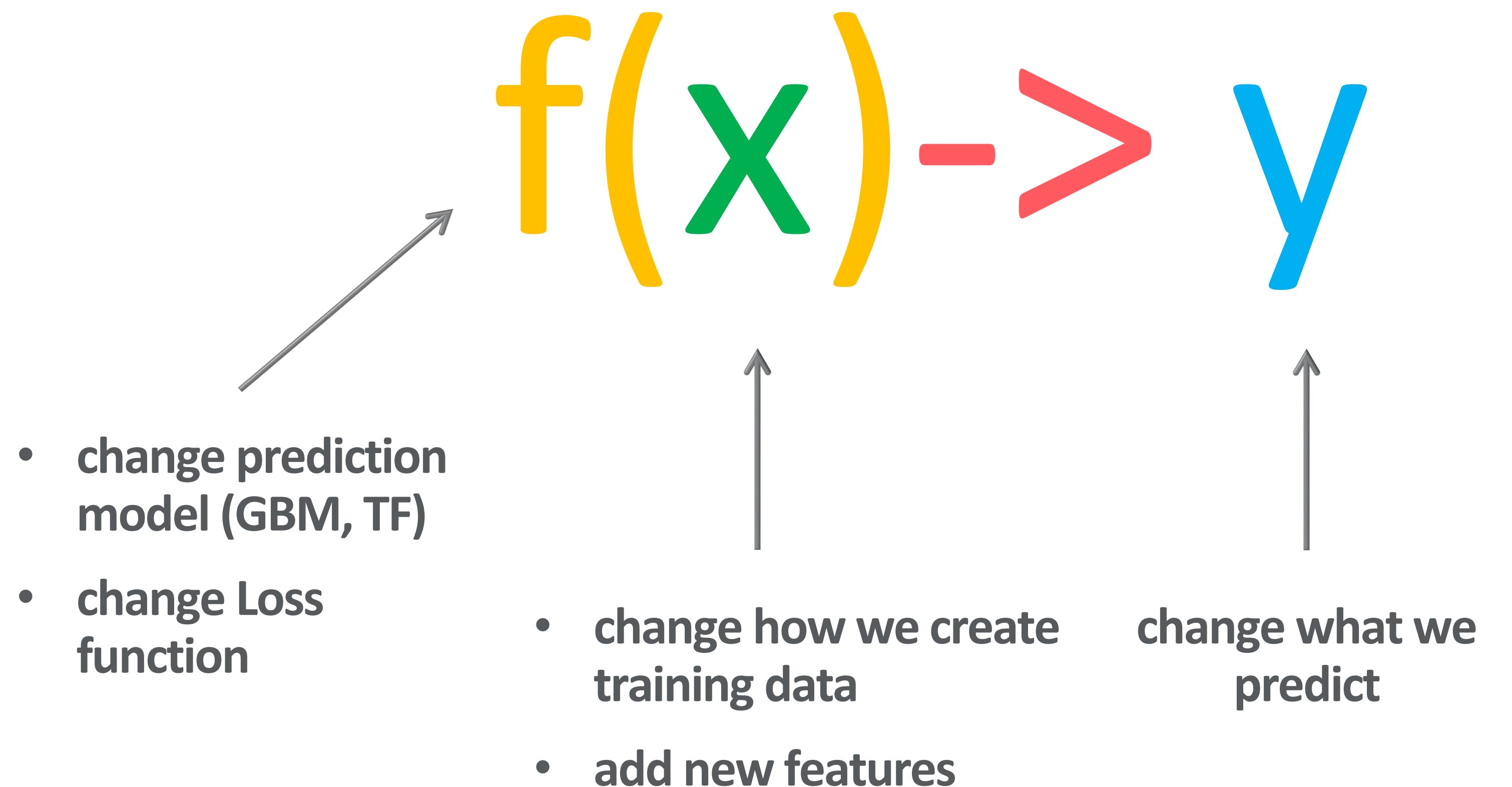
Search @ Airbnb

Airbnb · 11 months ago · 4,834 views

"Search Ranking: GBM & personalization Search is a universal problem among almost all internet companies. But Airbnb's search ..."

1:00:04

How we iterate?

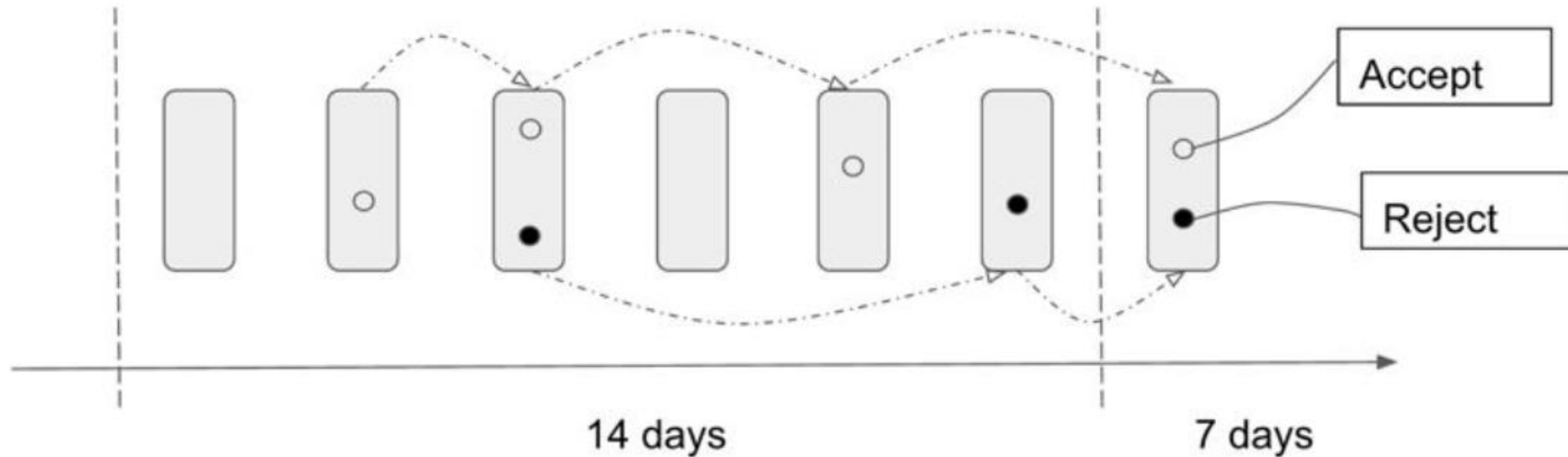


Examples of Successful Iterations

Significant Booking Gains

1. Early Attribution

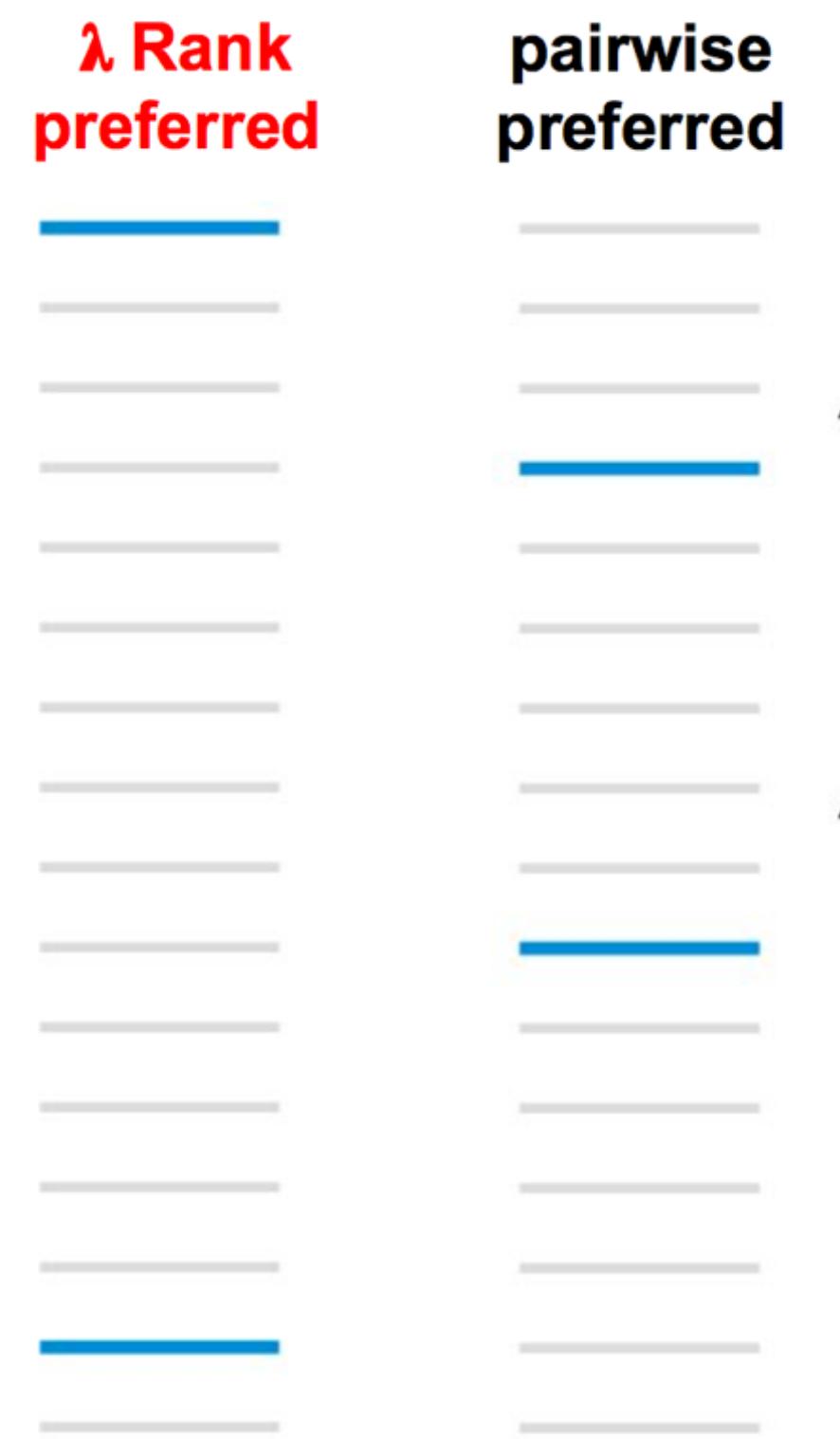
- Instead of only Last Search use Earlier Searches as well
- Propagate labels back



Examples of Successful Iterations

2. Pointwise to Pairwise

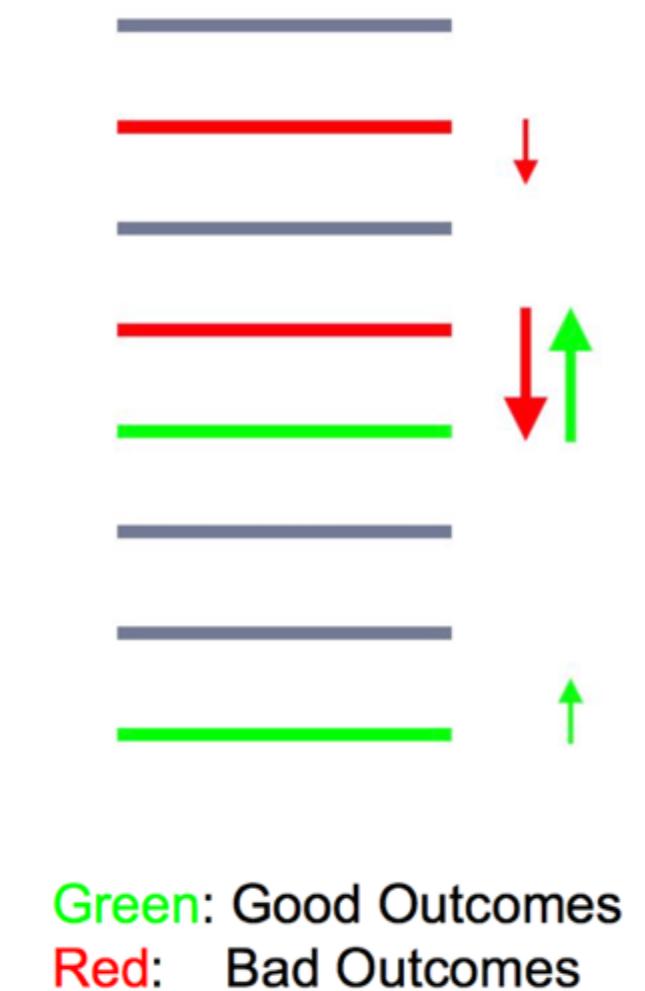
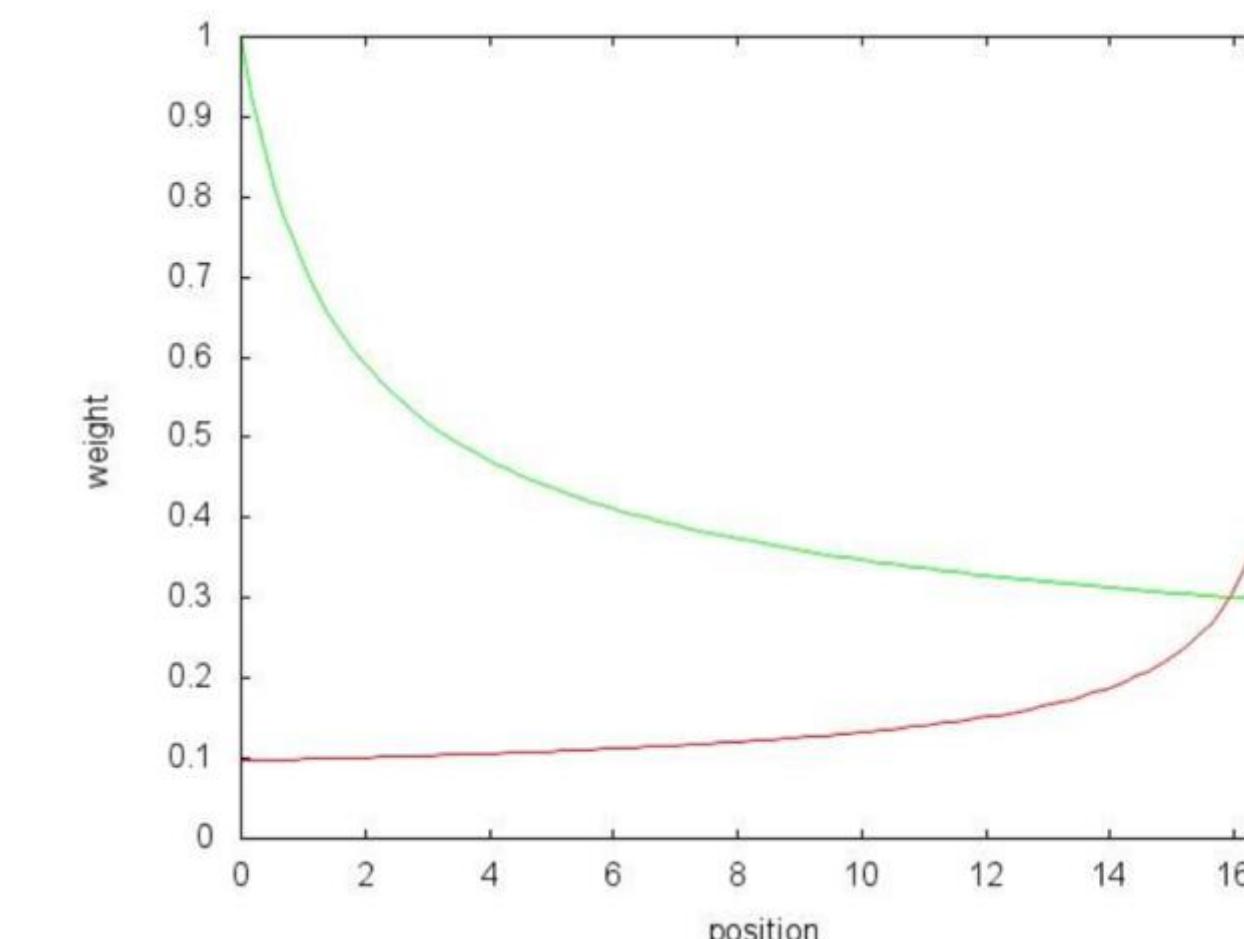
- Weighted Pairwise (LambdaRank)



Weight Top Positions
More in Pairwise
Loss

- Dual Discount Curve Pairwise (Modified LambdaRank)

- Lambda Rank focus only on **pushing good outcomes to the top**
- But its equally important to push **bad outcomes to the bottom**



Green: Good Outcomes
Red: Bad Outcomes

Examples of Successful Iterations

3. Real-time Personalization

Main Challenges

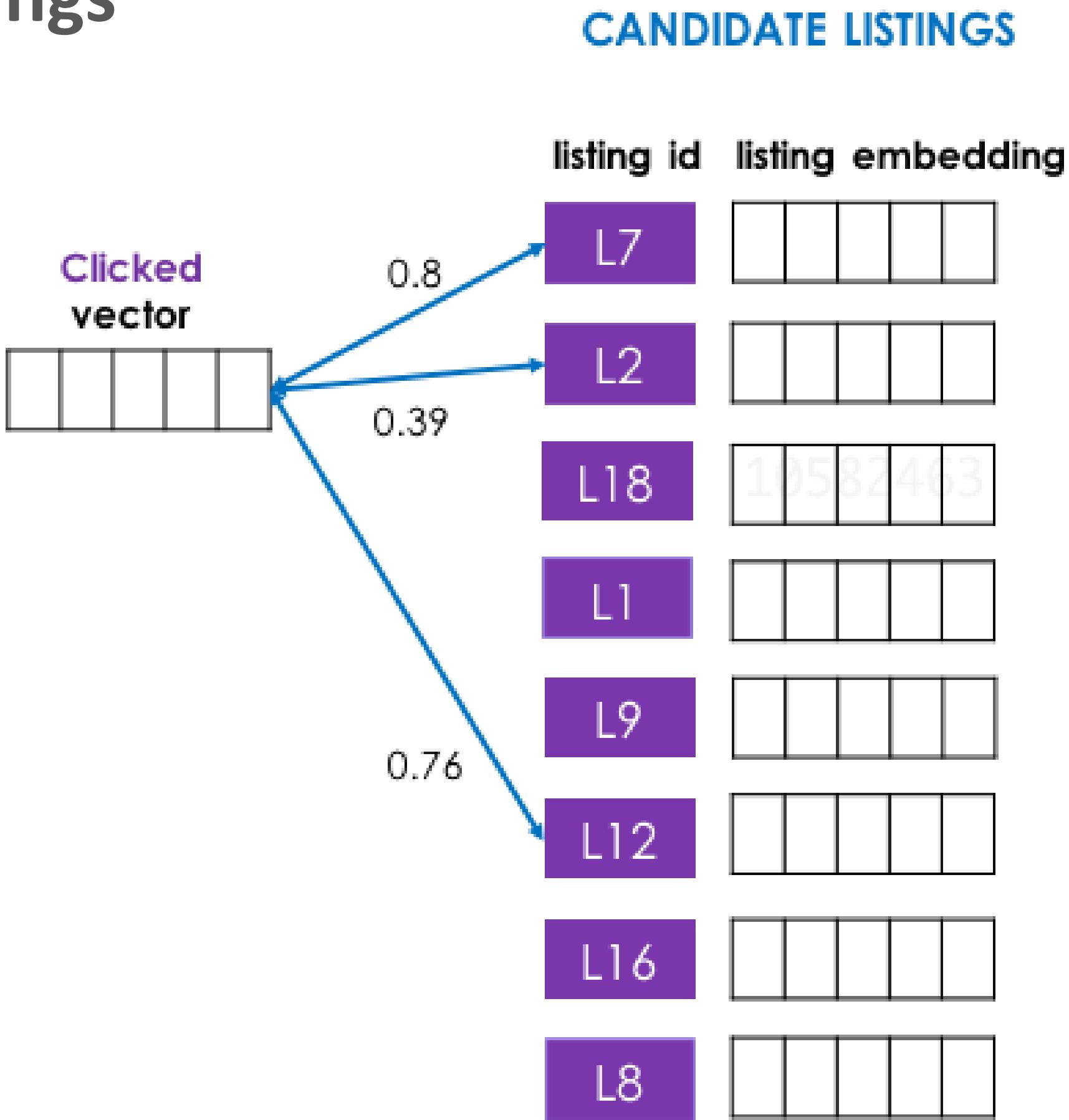
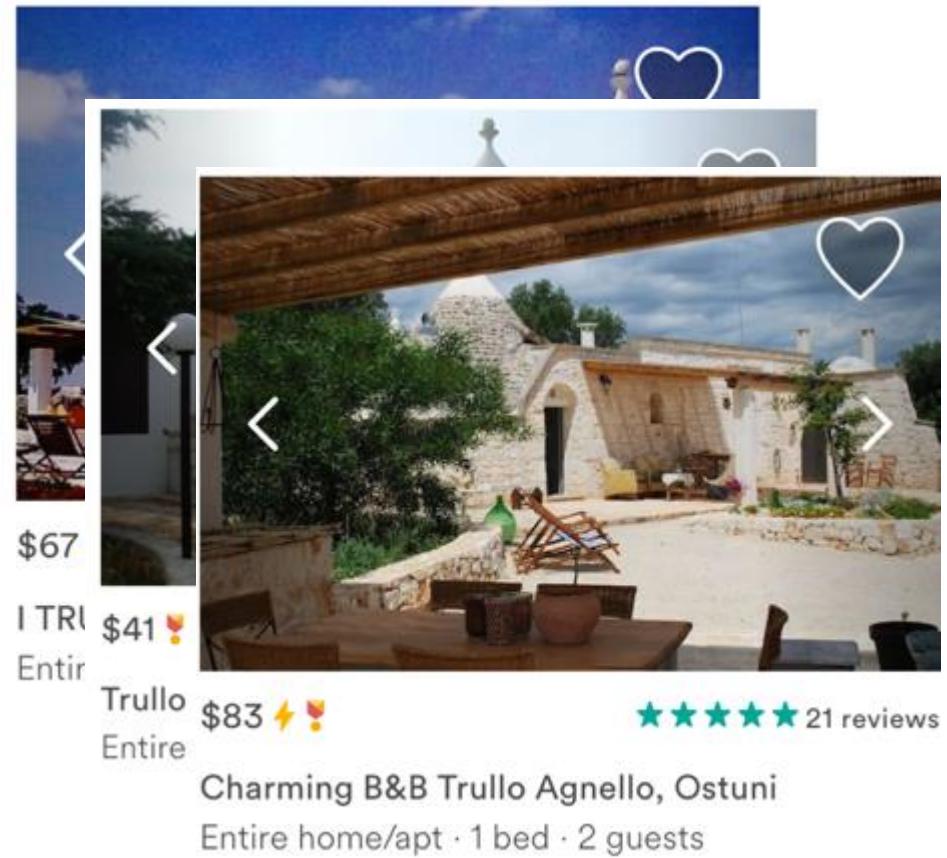
- Guests do not visit every day (most travel up to 2-3 times a year)
- Preferences may change from visit to visit
- Rarely go to same location twice

Approach: In-session personalization

1. Memorize listings you clicked on recently
2. Show similar listings to the one you liked (wishlist, long clicked, contacted)

Real-time Personalization using Embeddings

recently long-clicked listings
by user (>60 sec)



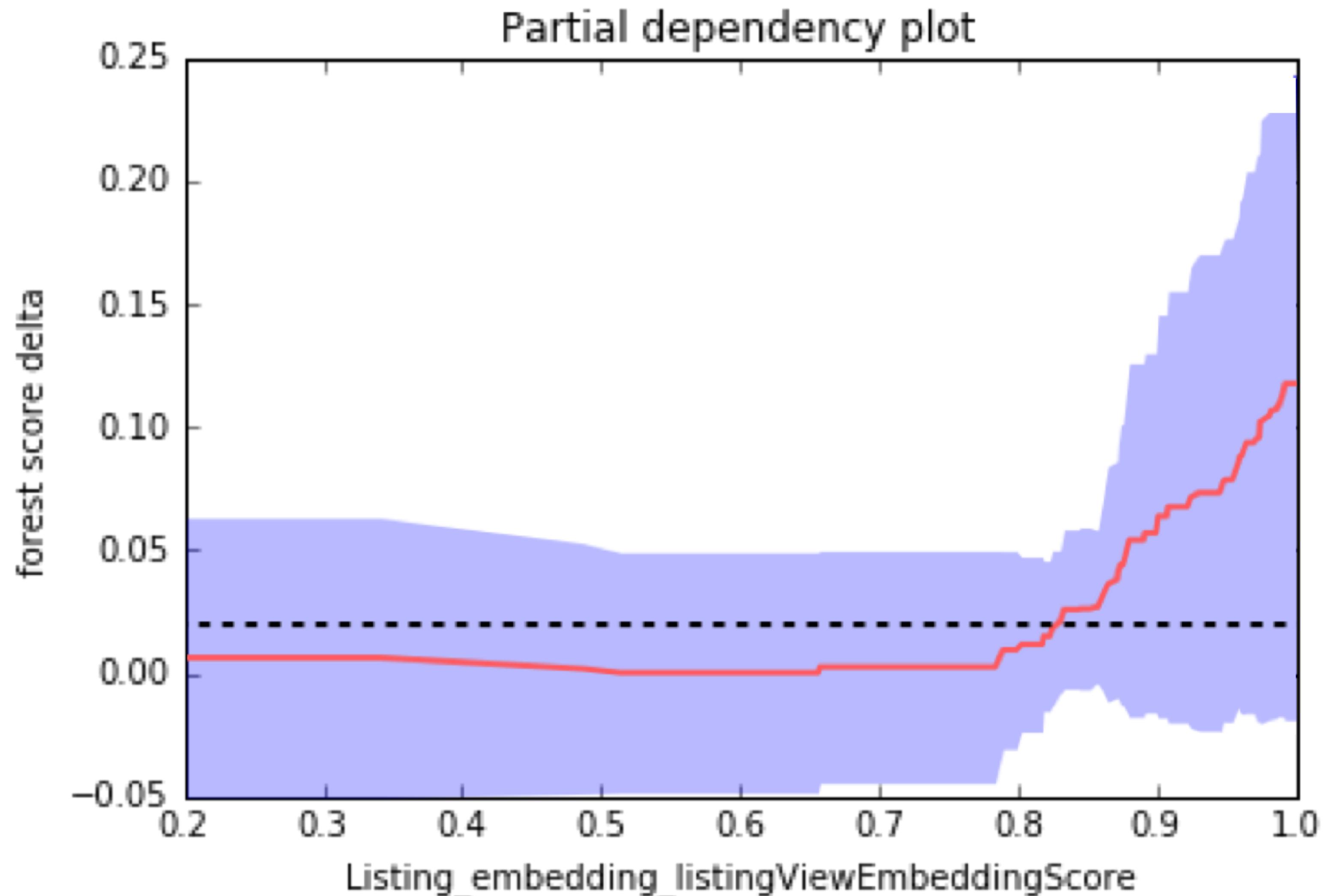
Embedding Features:

1. **longViewEmbeddingScore**
2. **wishlistEmbeddingScore**
3. **contactEmbeddingScore**

Real-time Personalization using Embeddings

Partial dependency plot

Feature Importance: top 10



A photograph of a group of people in a restaurant setting. Several individuals are gathered around a table, looking down at a menu or a document spread out on the surface. The room has warm lighting and a casual atmosphere. In the background, there are other tables, chairs, and what appears to be a bar area with stools.

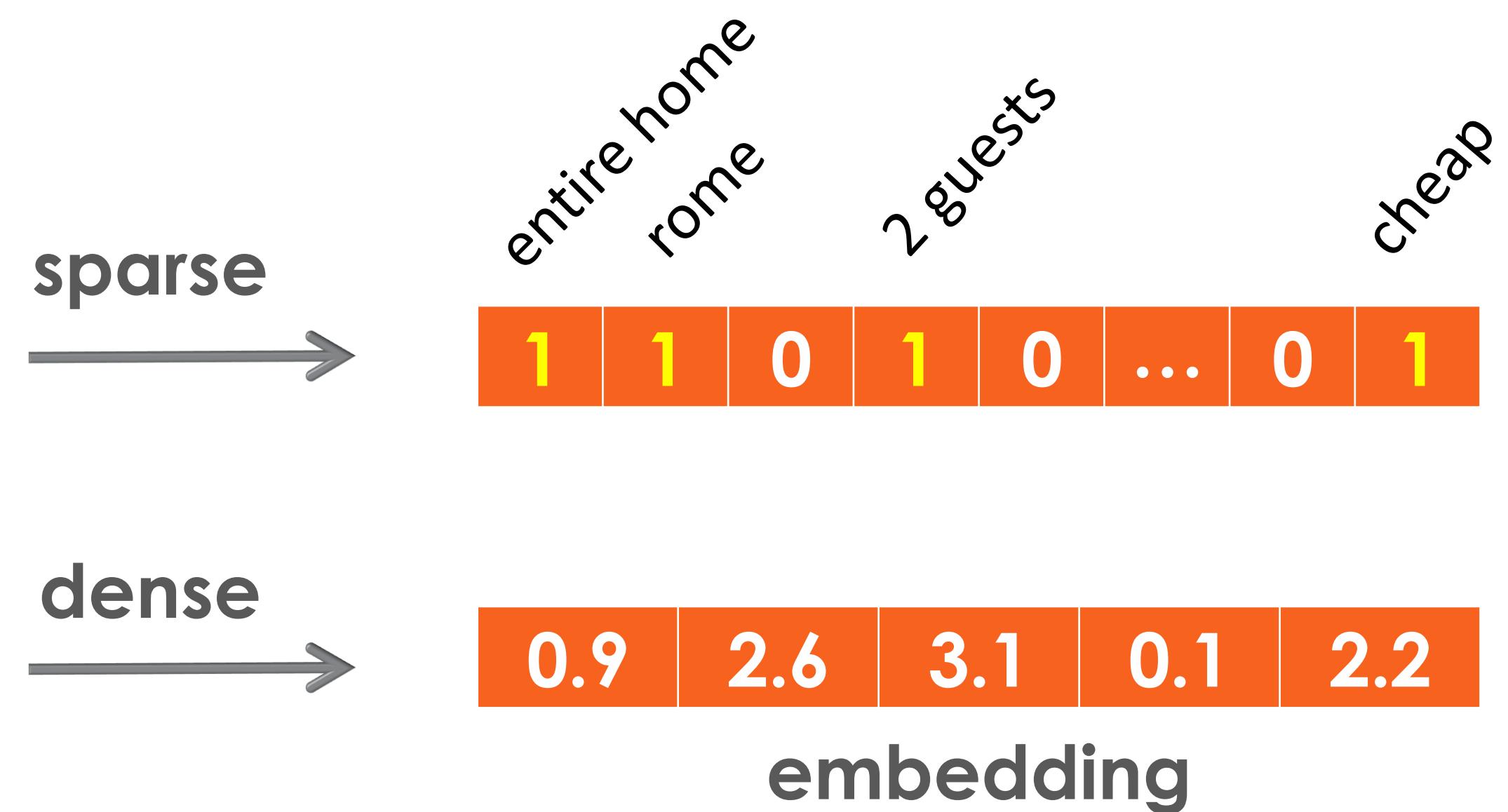
Listing Embeddings in Search

Listing Embeddings

How to represent a **listing**?

Listing

Casa Vacanze in Rome



- Represent **listings** as **numeric vectors**
- Vectors need to be learned using training data (**search sessions**)
- We want listings with **similar contexts** to have **similar vectors**
- Popular tool for training: **word2vec**

Search Sessions

Actions by single user (listing clicks, inquiries, bookings) ordered in time

S1 748612 4160766

S2 5473823 2582727 5473823 2582727 5473823 5473823

S3 6251934 9257649

S4 7924193 10116733 8998529 9075420 4113166

S5 5503478 4986017 5503478 5503478 5879904 4140396

S6 10237904 8680483 8718513 11691507 4831342 8004575 7866901

Search Sessions

We only use clicks that have >30 sec page view time (no accidental clicks)

10237904 **8680483** **24675234** ~~8718513~~ **11691507**

45sec 54sec 4sec 82sec 32sec

Session ends when there is more than 30 min inactivity

The diagram illustrates two sessions of five numbers each. Session 1 (left) contains the numbers 10237904, 8680483, 8718513, 11691507, and 4831342. Session 2 (right) contains the numbers 8004575, 7866901, and 4831342. A double-headed arrow connects the two sessions, with the label "2 hours" positioned below it.

Session 1	Session 2
10237904	8680483
8718513	11691507
4831342	8004575
7866901	

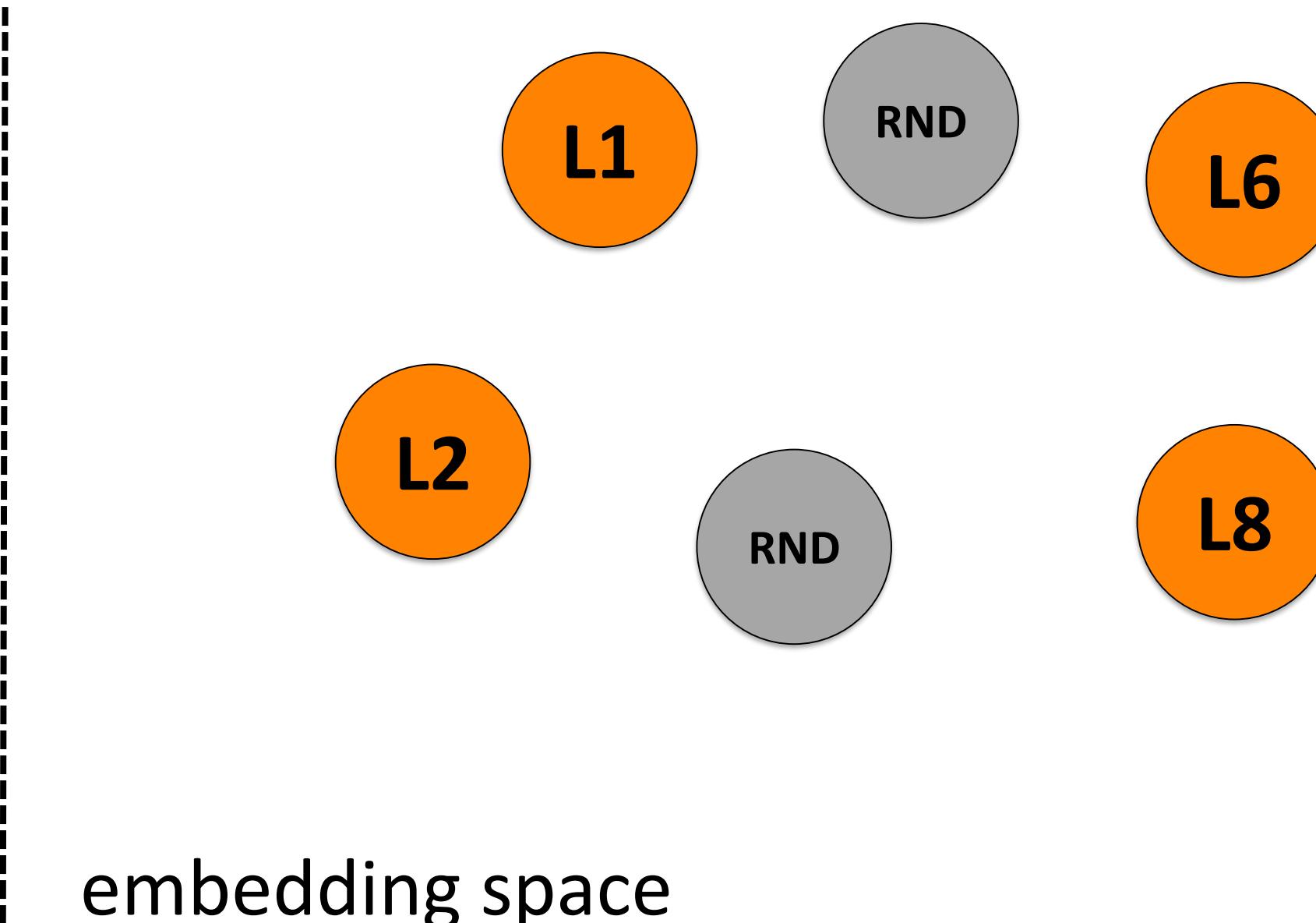
Training

Example search session:

[Listing8](#), [Listing1](#), [Listing2](#), [Listing6](#)

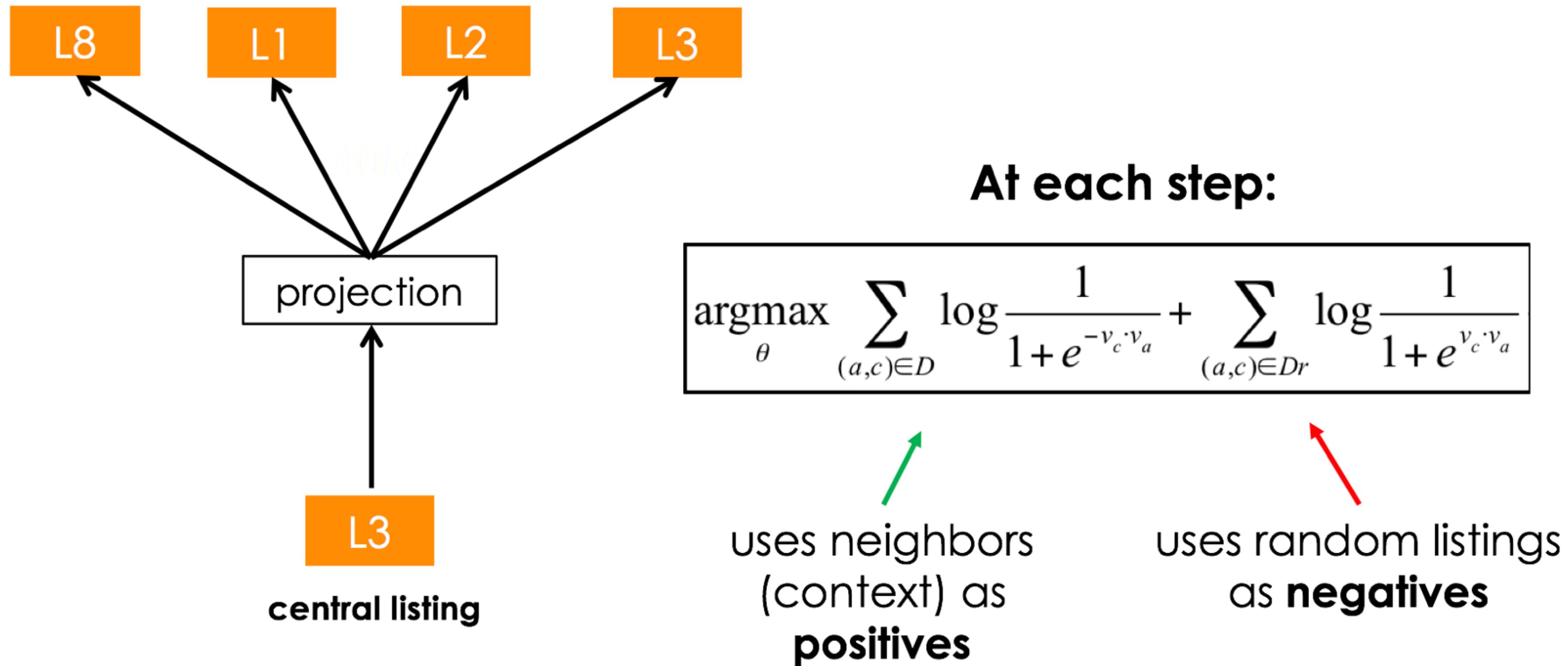
$$\mathbf{v}_i^{new} = \mathbf{v}_i + h \times (1 - S(\mathbf{v}_i^T \mathbf{u}_{neigh})) \times \mathbf{u}_{neigh}$$

$$\mathbf{v}_i^{new} = \mathbf{v}_i - h \times S(\mathbf{v}_i^T \mathbf{u}_{neg}) \times \mathbf{u}_{neg}$$



Training

Skip-gram model (word2vec)



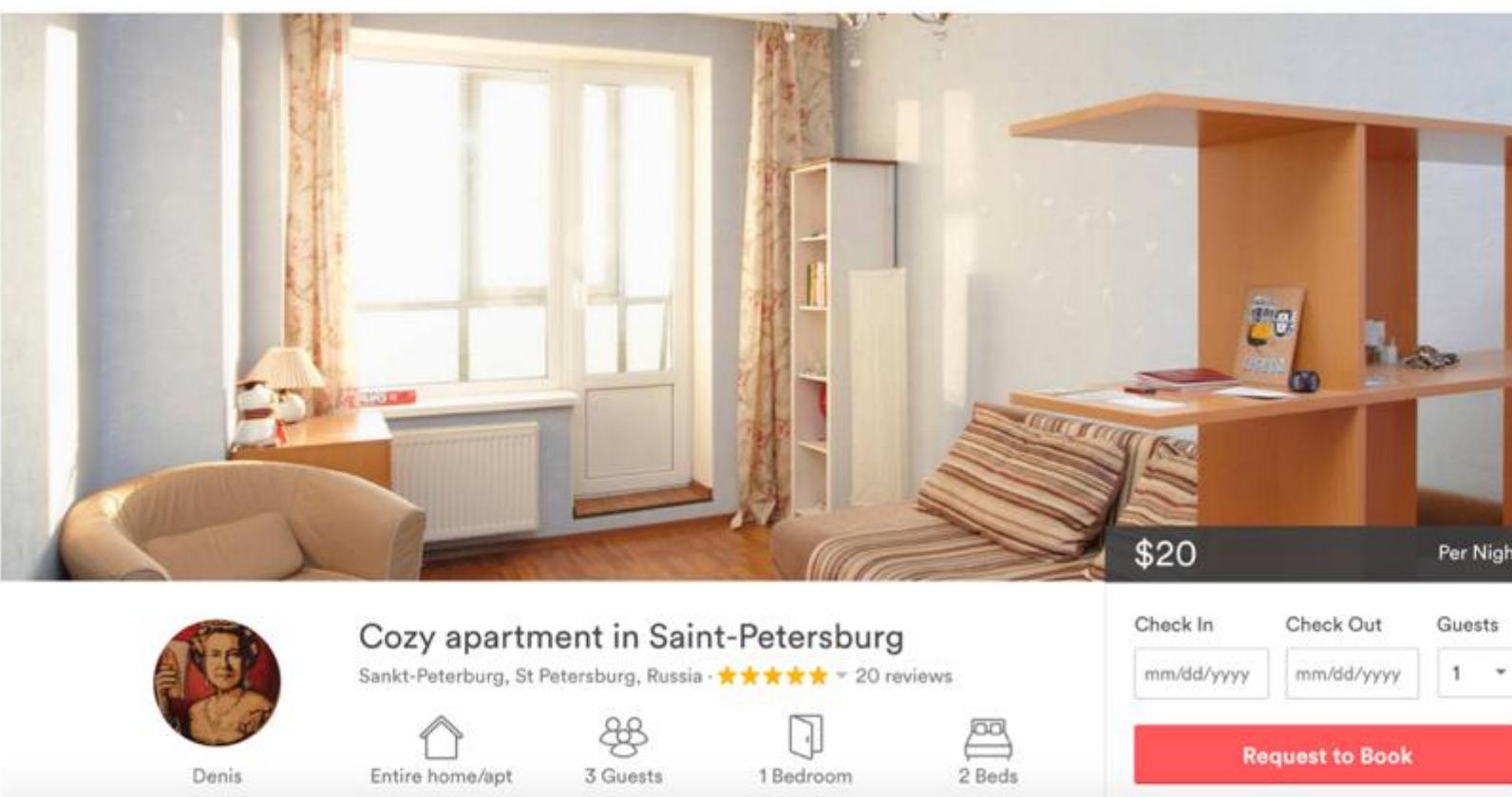
After Training

Can calculate similarity between any two listings



0.7 | 2.4 | 5.1 | 0.9 | 6.2

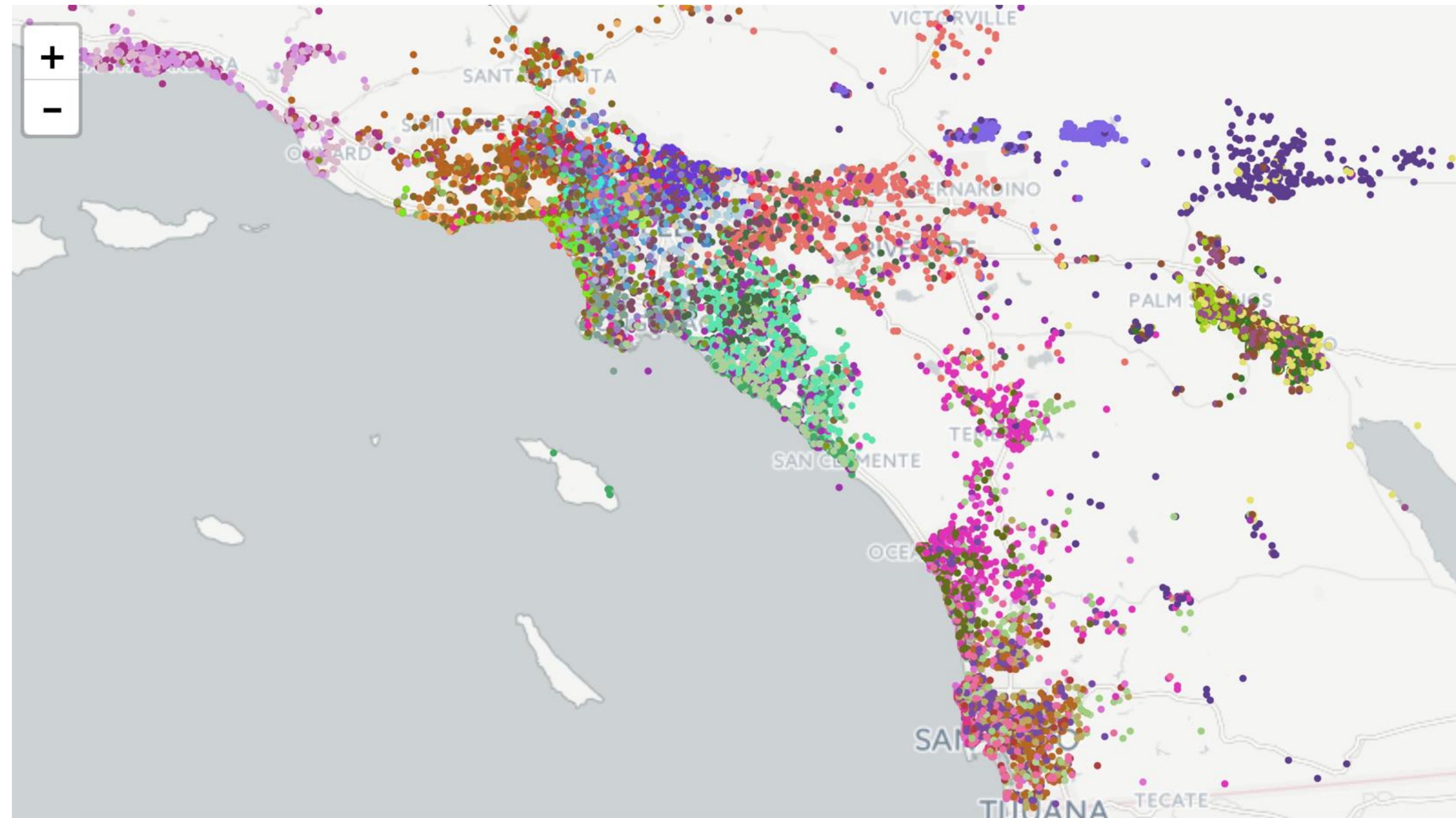
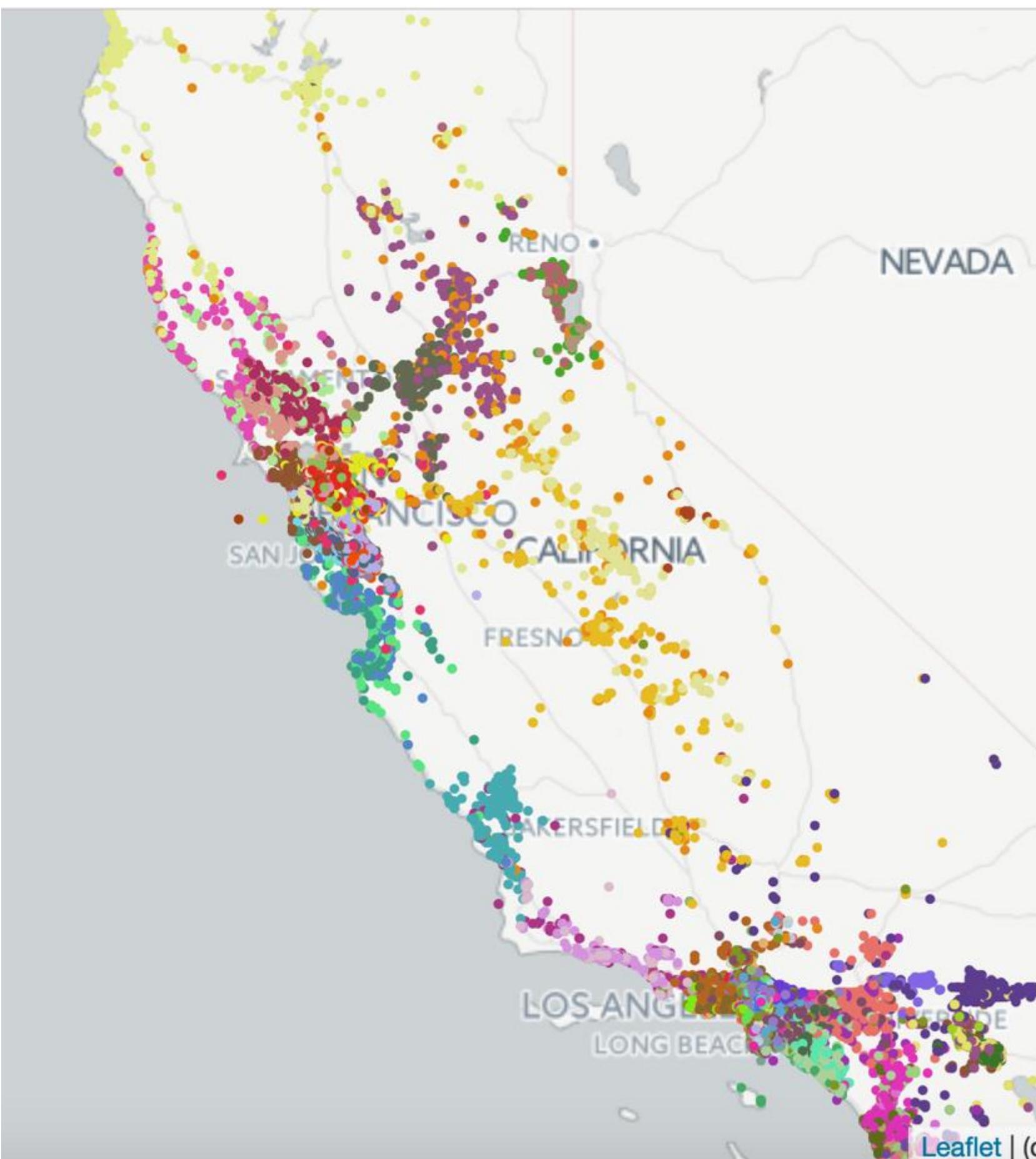
↑
cosine sim = 0.734



0.6 | 1.3 | 5.8 | 2.1 | 6.2

After Training

Can cluster listings: California



word2vec Modifications that Worked for us

1. Not all interactions between two **listings** are the same

co-click session: **5473823 2582727 5473823 2582727 5473823 5473823**

co-inquiry session: **6251934 9257649**

sessions that end in booking: **5473823 2582727 5473823 2582727 5473823 5473823**

Positive interactions

- co-click – default weight
- co-inquiry – larger weight
- booking sessions – larger weight

word2vec Modifications that Worked for us

2. Better **negative sampling**

- Random **negatives**: probability of sampling a negative from same city very low (not a problem if you have 1-2 cities but we have thousands)
- Random **negatives from same city**: leads to better within city listing similarities
- Analogous to learning word vectors when data comes from many languages

Applications

Can Find Similar Listings



\$156 🌟
★★★★★ 237 reviews

LUXURY INDEPENDENT STUDIO on SHIP : fr...
Private room · 2 beds · 3 guests

Listing	Cosine distance
579851	0.989346
851044	0.982895
64736	0.979351
2024269	0.976072
802052	0.974991
884329	0.974928
3850766	0.972117
5207034	0.968444
2126459	0.963931
1025482	0.963376

The image displays a grid of six houseboat listings, each with a thumbnail image, price, rating, and a brief description. Each listing includes a white heart icon in the top right corner.

- 

\$143 🌟 ★★★★★ 249 reviews
Studio on Spectacular Houseboat
Private room · 1 bed · 2 guests
- 

\$98 🌟 ★★★★★ 306 reviews
Houseboat,garden,center,freeparking
Private room · 1 bed · 2 guests
- 

\$133 🌟 ★★★★★ 318 reviews
HOUSEBOAT NOVA 80m2 + FREE BIKES
Private room · 3 beds · 4 guests
- 

\$138 🌟 ★★★★★ 245 reviews
Authentic houseboat with privacy and comfort
Private room · 1 bed · 2 guests
- 

\$100 🌟 ★★★★★ 263 reviews
Sleeping on a ship in the centre.
Private room · 1 bed · 2 guests
- 

\$161 🌟 ★★★★★ 71 reviews
Luxury Houseboat
Entire home/apt · 1 bed · 2 guests

Applications

Similar Listings



\$66 🌟

★★★★★ 71 reviews

I SETTE CONI - TRULLO EDERA

Entire home/apt · 2 beds · 4 guests · Business Travel Ready

Similar listings



\$55 TRADITIONAL HOUSE IN OSTUNI!!!!

Entire house · 1 bed

★★★★★ 55



\$57 PIETRACHIARAHOUSE PANORAMIC TE...

Entire house · 1 bed

★★★★★ 53



\$67 REHoUSE Ostuni

Entire apartment · 2 beds

★★★★★ 56

Before

Similar Listings



\$99 🌟

★★★★★ 147 reviews

Trullo of 1800 in the Itria Valley

Entire home/apt · 5 beds · 5 guests



\$76 🌟🌟

★★★★★ 17 reviews

Trulli Tramonti d'Itria - Trullo Luna

Entire home/apt · 3 beds · 4 guests



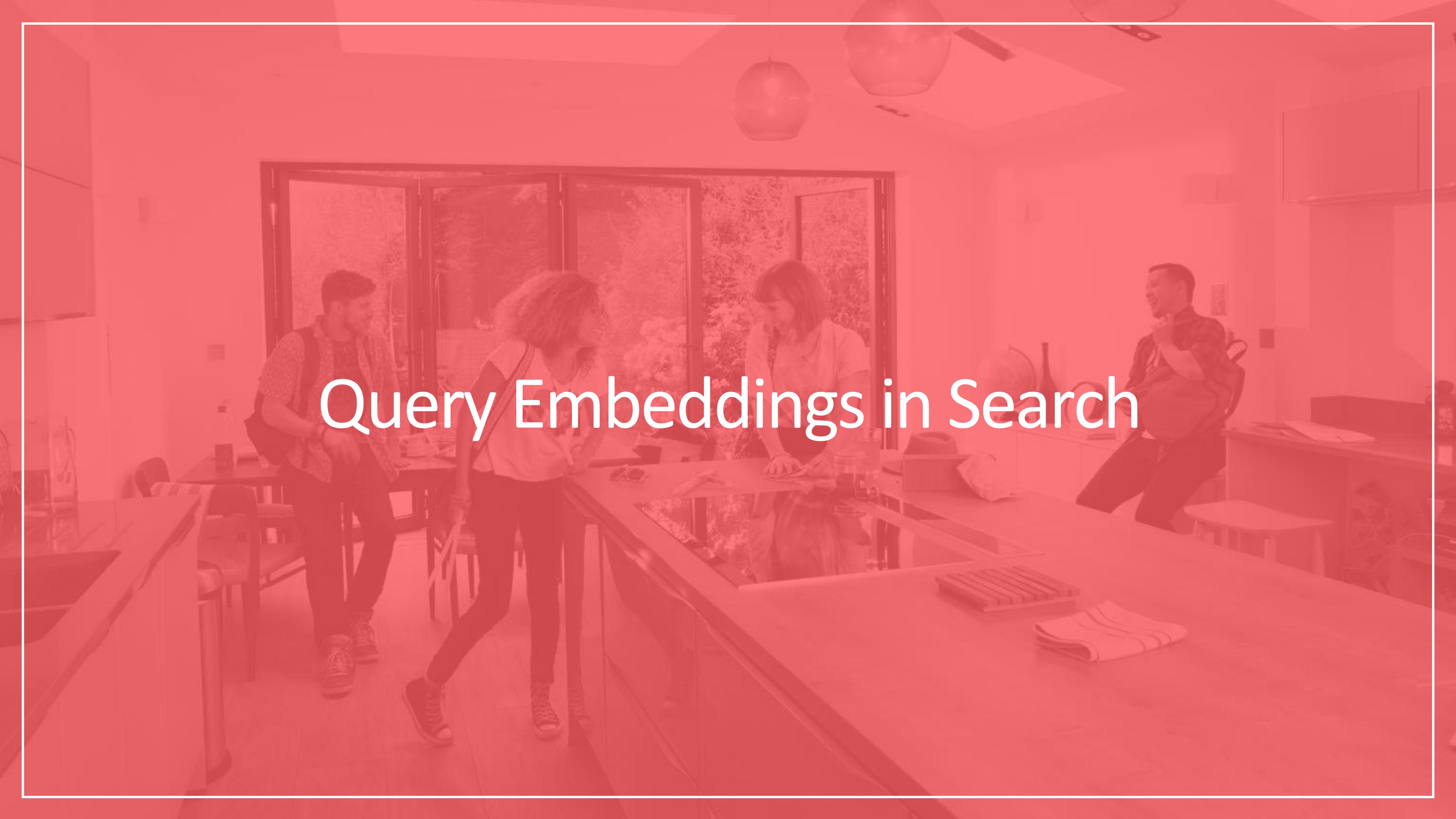
\$67 🌟🌟

★★★★★ 30 reviews

I TRULLINI OSTUNI - MARTINA FRANCA

Entire home/apt · 1 bed · 2 guests

After

A photograph of a group of people in a restaurant setting. A woman in the foreground is looking down at a menu or a screen. Behind her, several other people are seated at a long table, engaged in conversation. The restaurant has a warm, ambient lighting with hanging pendant lights.

Query Embeddings in Search

Query Embeddings

Query (geo_id available)

San Francisco, California, USA



embedding:

0.2	1.1	7.2	0.8	3.1
-----	-----	-----	-----	-----

Query (geo_id not available)

Skiing France



embedding:

0.7	3.4	2.8	0.1	2.2
-----	-----	-----	-----	-----

- ❑ Represent **queries** as **numeric vectors**
- ❑ Vectors need to be learned using training data (**search sessions**)
- ❑ We want queries with **similar contexts** to have **similar vector**

Search Sessions

Actions by single user (queries) ordered in time

- | | | |
|----|--|------------------------|
| S1 | skiing_germany geo_fs2342f61IHgQ | Garmisch-Partenkirchen |
| S2 | winter_wanderland winter_wonderland winter_wonderland_neitherlands skiing geo_f23432dfHf | |
| S3 | portugal_surfing portugal_surf geo_MgsRQfBOHA geo_Hw0RU41424Da | Peniche, Portugal |
| S4 | grant_park_chicago lollapalooza grant_park_chicago geo_LIq58sDogRHf1 | |
| S5 | geo_Kyvb07vZg french_quarter_mardi_gras geo_ChIJf5407f1 | |

After Training

We can calculate similarities between queries

mardi_gras

0.2	1.2	7.1	0.8	3.2
-----	-----	-----	-----	-----

0.993



geo_ChIJf5407BG

French Quarter, New Orleans, LA, United States

0.2	1.1	7.2	0.8	3.1
-----	-----	-----	-----	-----

Application:

Autocomplete (Type-ahead)

Before

The screenshot shows the Airbnb search interface. At the top, there is a search bar with the query "oktoberfest". Below the search bar, there are three filters: "Anyti..." (likely a typo for "Anytime") and "1 guest". To the left of the search bar, the word "FOR YOU" is displayed above a teal-colored section. The results list contains five entries:

- Oktoberfest Pub, Bucharest, Romania
- Oktoberfest, East 21st Street, Tulsa, OK, United States
- Oktoberfest Grounds, La Crosse, WI, United States
- Oktoberfest, Brighton 4th Street, Brooklyn, NY, United States
- OKTOBERFEST BEAG CORK, Centre Park Road, Cork, Ireland

After

The screenshot shows the Airbnb search interface after the update. The search bar now displays "Oktoberfest" correctly. The filters remain the same: "Anytime" and "1 guest". The "FOR YOU" section is still present on the left. The results list has been updated to show experiences related to Oktoberfest in Munich, Germany:

- Theresienwiese, Munich, Germany
- Moosach, München
- Münchner Oktoberfest, Theresienhöhe, Munich, Germany
- Laim, München
- Munich, Germany

Before

The screenshot shows the Airbnb search interface with the search bar containing "Greek Islands". Below the search bar, there are five suggestions listed:

- Greek Islands, South Halsted Street, Chicago, IL, United States
- Greek Islands Taverna, North Ocean Boulevard, Fort Lauderdale, FL, United States
- Greek Islands, East 22nd Street, Lombard, IL, United States
- Greek Islands, Center Street, Omaha, NE, United States
- Greek Islands, East Andreas Road, Palm Springs, CA, United States

After

The screenshot shows the Airbnb search interface with the search bar containing "Greek Islands". Below the search bar, there are five suggestions listed:

- Santorini, Thira, Greece
- Mykonos, Greece
- Ionian Islands, Greece
- Lesvos, Greece
- Cephalonia, Greece

Before

The screenshot shows the Airbnb search interface with the following details:

- Search Bar:** The search term is "California beach towns".
 - Filters:** The date is set to "Anyti..." and there is "1 guest".
- FOR YOU:** A section labeled "FOR YOU" is visible.
- Room Type:** A section labeled "Room Type" is visible.
- Results:** The search results are listed:
 - Township, North California Avenue, Chicago, IL, United States
 - California Street, Johannesburg, South Africa
 - Township High School District 211, California Avenue, Palatine, IL, United States
 - California Avenue, Pleasanton, CA, United States
 - Township High School District 211, California Street, Elk Grove Village, IL, United States

After

The screenshot shows the Airbnb search interface with the following details:

- Search Bar:** The search term is "California Beach Towns".
 - Filters:** The date is set to "Anytime" and there is "1 guest".
- FOR YOU:** A section labeled "FOR YOU" is visible.
- Experiences:** A section labeled "Experiences" is visible.
- Results:** The search results are listed:
 - Laguna Beach, CA, United States
 - Santa Monica, CA, United States
 - Huntington Beach, CA, United States
 - Santa Catalina Island, Avalon, CA, United States
 - Newport Beach, CA, United StatesThe result for "Santa Monica, CA, United States" is highlighted with a teal background.

Before

The screenshot shows the Airbnb search interface with the search bar containing "France Skiing". Below the search bar, there are three filter buttons: "Anyti...", "1 guest", and "FOR YOU". The results list contains five items:

- France Skiing, Castellan Avenue, Romford, United Kingdom
- Courchevel Tourisme, Saint-Bon-Tarentaise, France
- Ecole du ski Français Cambre d'Aze Eyne, Place de l'Europe, Eyne, France
- Skiing at Isola 2000, Isola, France
- Ecole De Ski La Foux D'Allos (ESF), Les Pointus, Allos, France

After

The screenshot shows the Airbnb search interface with the search bar containing "France Skiing". Below the search bar, there are three filter buttons: "Anytime", "1 guest", and "FOR YOU". The results list contains four items, with "Chamonix, France" highlighted by a teal background:

- Morzine, France
- La Rosière
- Chamonix, France
- Sainte-Foy-Tarentaise
- French Alps, Courmayeur, Aosta Valley, Italy

Questions?

Press questions:

press@airbnb.com

We are hiring ML
Scientists

Contact me:

mihajlo.grbovic@airbnb.com



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