

# Users' Evaluation of Next-POIs Recommendations



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NOT WHAT WE NEED



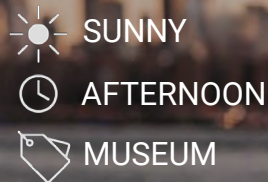
# Motivation

Support tourists in finding points of interest (POIs)

Huge variety of different POIs

Harness human-environment interactions  
enabled sensors (GPS, IoT)

Understanding User preferences in Context

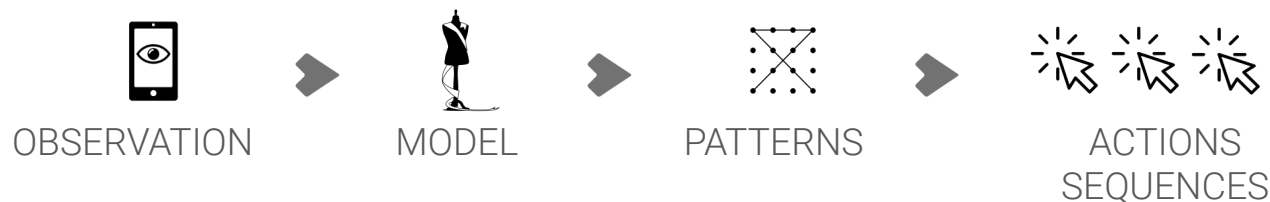


Adapt recommendation to learnt user behavior

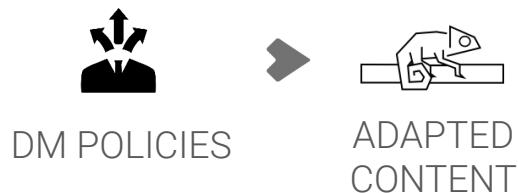
# Related Works

## SEQUENTIAL RECOMMENDATIONS

Pattern-discovery (B. Mobasher et al., D. Jannach)



Reinforcement Learning (G. Shani et al., O. Moling et al.)



B. Mobasher, H. Dai, T. Luo, and M. Nakagawa. "Using Sequential and Non-Sequential Patterns in Predictive Web Usage Mining Tasks" (2002)

D. Jannach, I. Kamehkhosh, and L. Lerche. "Leveraging multi-dimensional user models for personalized next-track music recommendation" (2017)

G. Shani, D. Heckerman, and R. I. Brafman, "An mdp-based recommender system" (2005)

O. Moling, L. Baltrunas, and F. Ricci, "Optimal radio channel recommendations with explicit and implicit feedback" (2012)



# MEH



WHAT A USER WILL DO  
ANYWAY



Behaviour Model

Recommendation  
Model



# THE APPROACH

# Complete Picture



## CASE STUDY

 **1668**

User POI-visit trajectories  
(Muntean et al.)

 Geolocalized

 Temporally ordered



Context



Weather summary



Temperature



Daytime



POI Features



Category



Historic period



Historic related person



# USER BEHAVIOUR LEARNING

# Technical Approach

## PROBLEM SETUP

Markov Decision Process (MDP)

**S** State space

**A** Action space

**T** Transition model

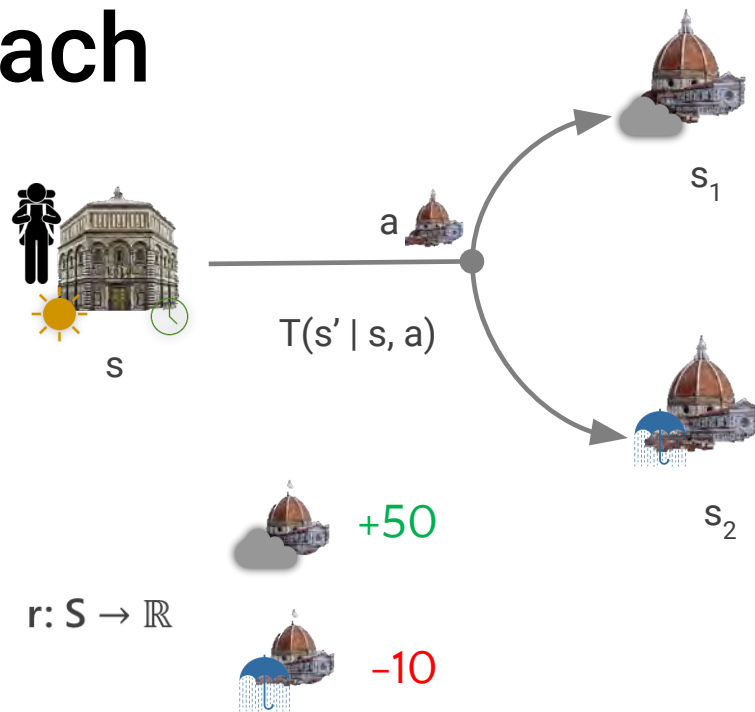
**Z** Users observations

**r** Reward

**$\gamma$**  Discount factor

**POLICY**  $\pi^*: S \rightarrow A$

Maximises the cumulative reward  
by acting according to  $\pi^*$  (optimal policy)



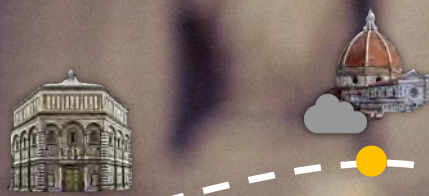
Reward and Action-selection policy are learnt via  
**Inverse Reinforcement Learning**

A person is seen from behind, wearing a wide-brimmed hat and holding a camera up to take a picture. The entire image is overlaid with a semi-transparent red filter. The background is out of focus, showing what appears to be an outdoor setting with some structures.

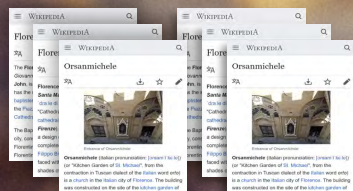
Often there is not enough user  
specific behavioural data



# Clustering



POI-visit trajectory

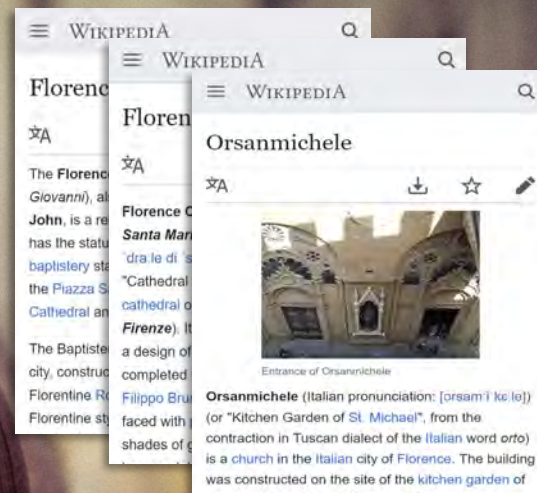


Documents  
all the POI-Visit trajectories



NMF

DOC-Like representation



TOPICS

Term	Cluster A	Cluster B	Cluster C	Cluster D	Cluster E
1	morning	hot	cloudy	warm	freezing
2	cold	afternoon	cold	cloudy	cloudy
3	square	16 <sup>th</sup> century	church	14 <sup>th</sup> century	afternoon
4	palace	palace	square	church	14 <sup>th</sup> century
5	15 <sup>th</sup> century	church	13 <sup>th</sup> century	square	palace
6	13 <sup>th</sup> century	square	palace	building	building
7	church	19 <sup>th</sup> century	rain	palace	13 <sup>th</sup> century
8	night	13 <sup>th</sup> century	museum	bridge	church
9	Dante	museum	Brunelleschi	13 <sup>th</sup> century	Foggini
10	10 <sup>th</sup> century	Brunelleschi	Tadda	19 <sup>th</sup> century	19 <sup>th</sup> century



# INTERESTING RECOMMENDATION GENERATION

# Technical Approach

## Recommendations

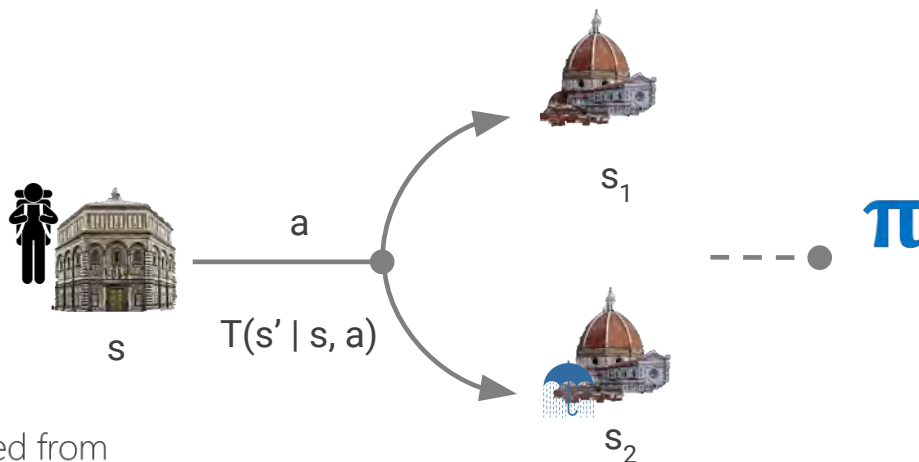
 POLICY

$$\pi: S \rightarrow A$$

 VALUE OF TAKING AN ACTION

$$Q_{\pi}(s,a) = \mathbf{E}^{s,a,\pi} [\sum_{k=0}^{K-1} \gamma^k r(s_k)]$$

Expected discounted cumulative reward obtained from **a** in state **s** and then following policy  **$\pi$**



# Optimizing for a Segment of Users

## 1 Q-BASE - Cluster Behaviour Based

When only **few observation** of a user behaviour of the cluster the user based optimal actions.



Cluster state-action values

$Q_{\pi_c}$

Previous offline Experiment

	Reward	Precision	Novelty
Q-BASE			
SKNN			



**RECOMMENDATION**

$a$  optimal action

$$\underset{a}{\operatorname{argmax}} Q_{\pi_c}(s, a)$$

# Hybrid Optimization: Q-BASE & Popularity Bias

## A Q-POP PUSH - Varying bias



Cluster state-action values

$$Q_{\pi_c}(s, a)$$



Count of action  $a$  in the data

$$\text{pop}(a)$$

min-max scaled

Harmonic mean of  $Q(s, a)$  and  $\text{pop}(a)$

$$\text{score}(s, a) = (1 + \beta^2) \frac{Q_{\pi_c}(s, a) \cdot \text{pop}(a)}{Q_{\pi_c}(s, a) + \text{pop}(a) \cdot \beta^2}$$



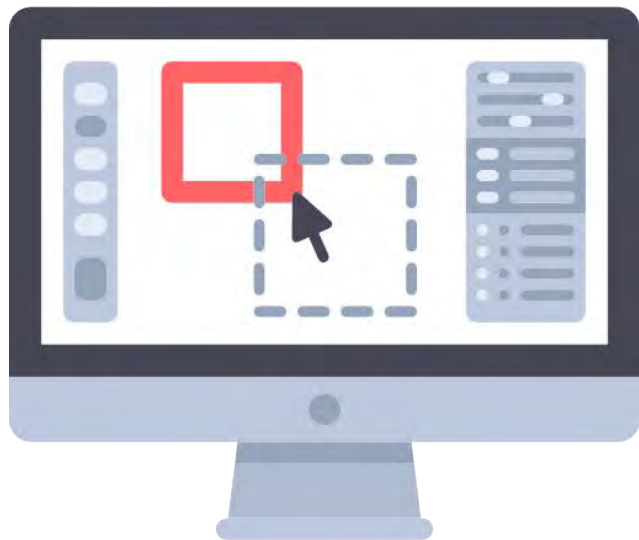
**RECOMMENDATION**

$$\underset{a}{\operatorname{argmax}} \text{score}(s, a)$$

HOW USERS  
EVALUATE **Q-BASE**,  
**Q-POP PUSH** AND  
**SKNN**?



# Interactive system



📍 795 POIs in Florence

📍 1668 POI-visit trajectories

👉 **Q-BASE, Q-POP PUSH AND SKNN**

## INTERACTION

1

Landing

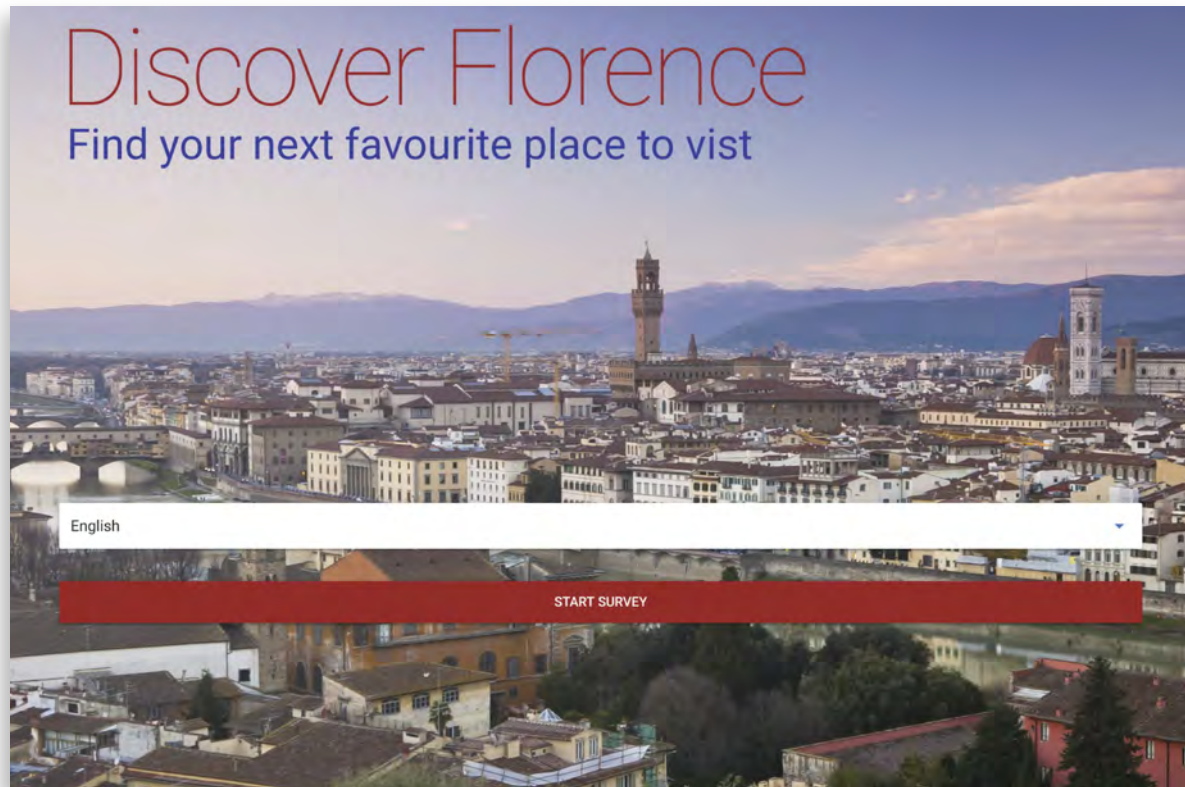
2

Preference elicitation

3

Evaluation phase

# ① Landing phase



🗣 Language selection

❓ I've been in Florence

✉ Post survey contact

## ② Preference elicitation phase

Tell us what you have already visited in Florence

Please, select the POIs that you have already visited in Florence (as many as you can)

Q You can use the search bar in order to access hundreds of POIs in the heritage city center of Florence!

≡ You can either click on items in the list below or search for them.

Old Bridge X Giotto's Bell Tower X Piazza della Signoria X Fountain of Neptune X Porta della Mandorla X

Loggia del Bigallo X Hercules and Cacus X Patroclus and Menelaus X

Florence POIs

Start typing here to Search

Most popular POIs

Old Bridge	Giotto's Bell Tower	Piazza della Signoria	Cathedral of Santa Maria del ...
Porta della Mandorla	Fountain of Neptune	Baptistry of San Giovanni	Basilica of Santa Croce
Torre dei Pulci	Loggia del Bigallo	Palazzo Vecchio	Vasari Corridor
Brunelleschi's dome	Funeral monument of the anti...	Piazza Santa Croce	Equestrian statue of Cosimo I...
Uffizi Gallery	Hercules and the Centaur Ne...	Rape of the Sabine Women	Consortium Tower
Perseus with the head of Med...	Piazza San Giovanni	Old Market	Ponte Santa Trinita
Piazzale Michelangelo	Hercules and Cacus	Museum of the History of Sci...	Palazzo dei Canonici
Bottegone	Patroclus and Menelaus	Piazza San Lorenzo	Piazza Santa Croce fountain
Work of St. John	Loggia della Signoria	Ponte alle Grazie	Piazza Santa Maria Novella
Rivoire	Piazza del Capitolo	Torre del Mannelli	Paszkowski
Monument to Giovanni delle ...	Torre dei Marignolli	Cavalcanti Annunciation	Fontana del Porcellino
Palazzo Piccioli	Tower of the Reds-Circles	Church of Santa Maria del Ba...	Palazzo Bormicci
Palazzo dei Vescovi in San Mi...	Church of San Cristoforo degl...		

NEXT



POIs selection



Search



Popular



POI description and media



Loggia del Bigallo

The Loggia del Bigallo, with its adjoining palace, is located in Piazza San Giovanni, that is the west side of Piazza del Duomo in Florence. The building was built for the Company of Santa Maria della Misericordia between 1352 and 1358, where once there was a house-tower of the Adimari destroyed after the expulsion from the city of the family because of its Guelph creed (1248). The new lodge in ancient times served to expose lost or abandoned children to the public so that they could be traced, ...

## ③ Evaluation phase

### Itinerary

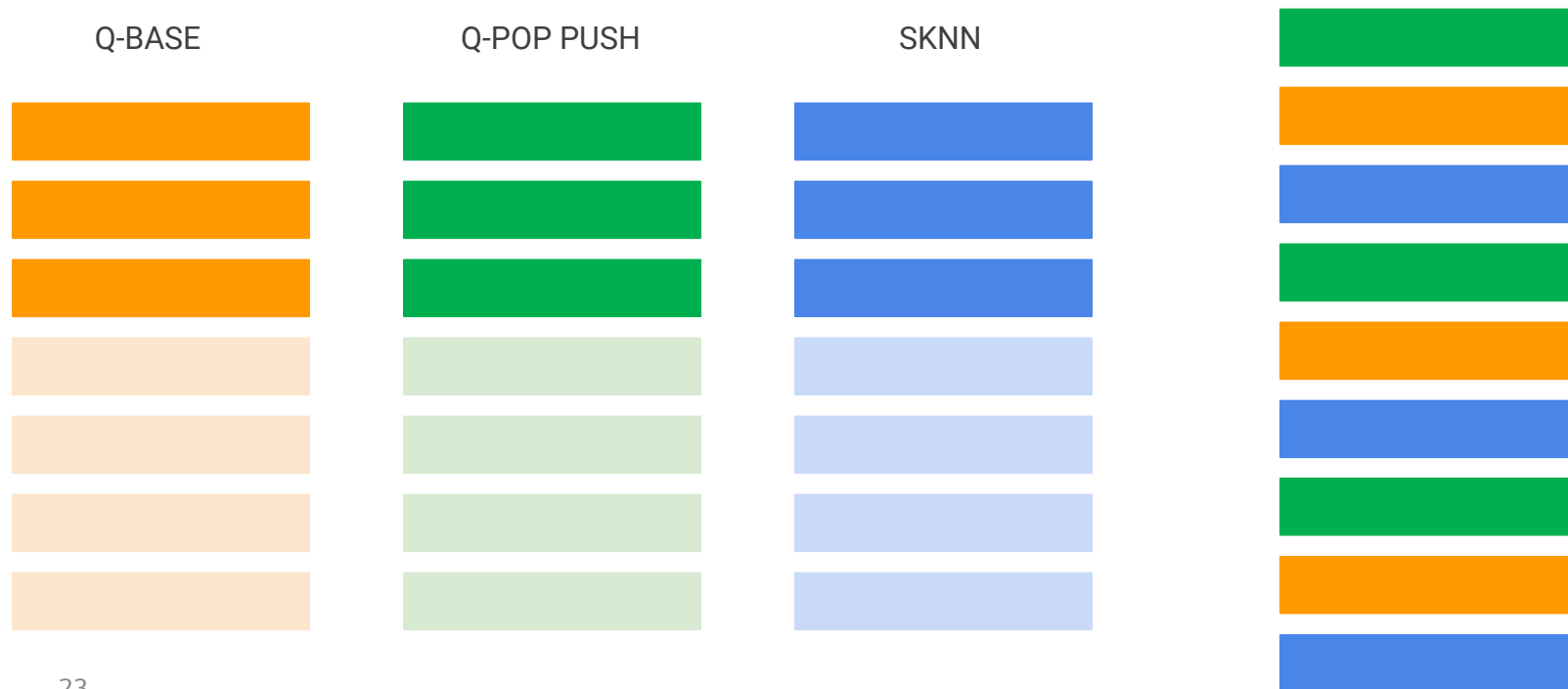


## ③ Evaluation phase

☰ Recommendation list

Item selection order

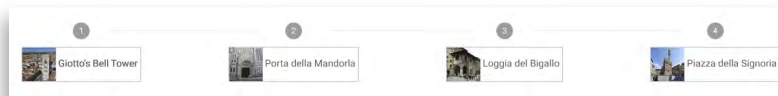
Q-POP PUSH > Q-BASE > SKNN








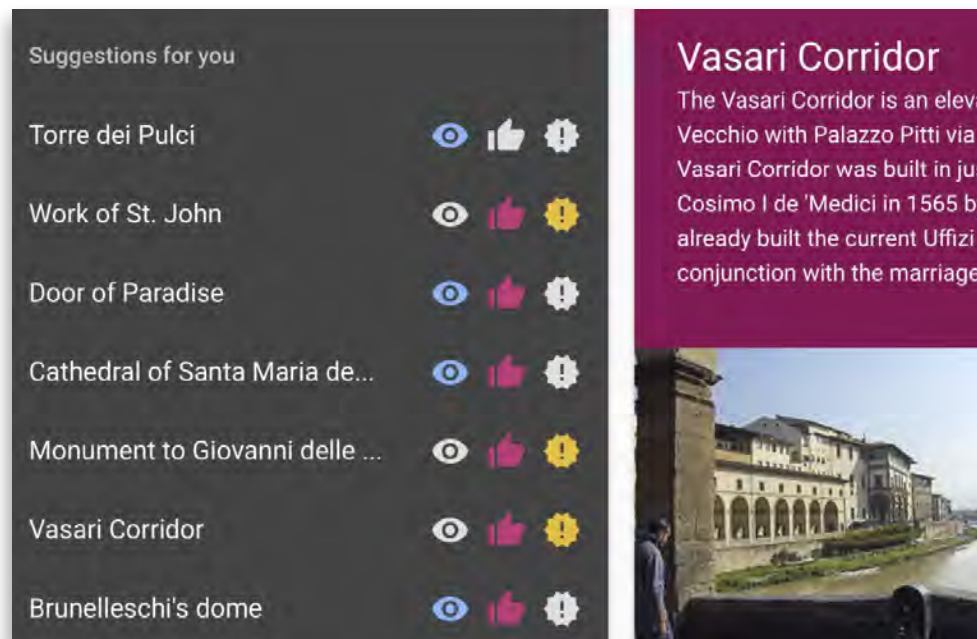
## ③ Evaluation phase

Itinerary

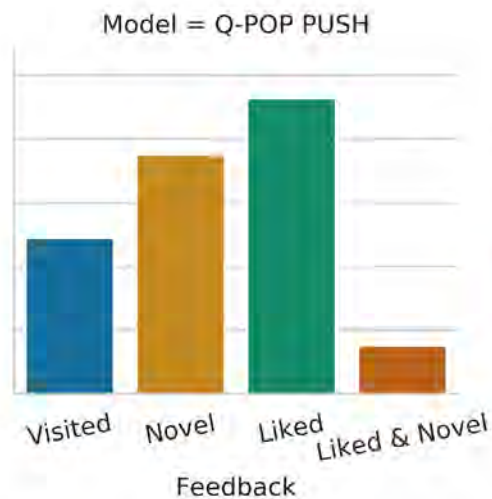
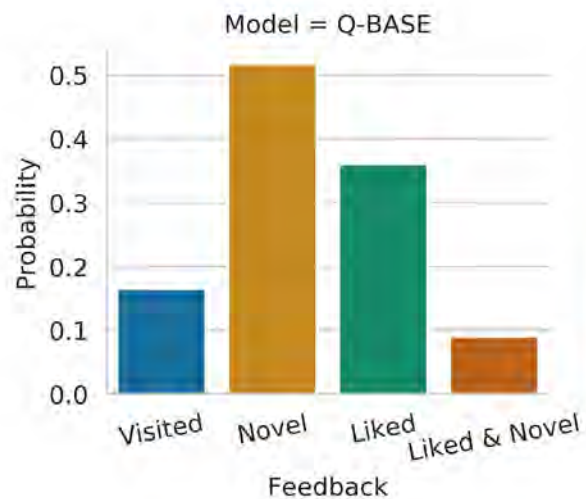


### ④ Evaluate recommendations

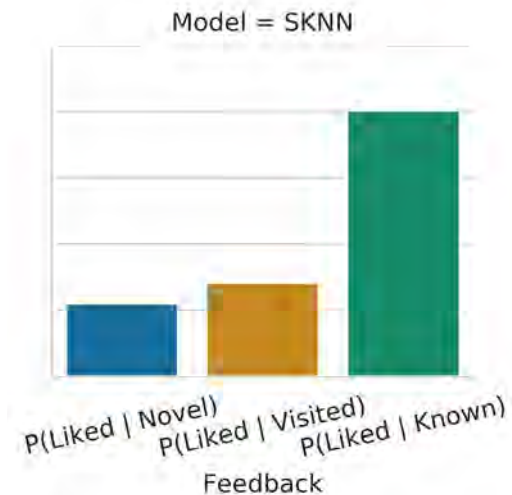
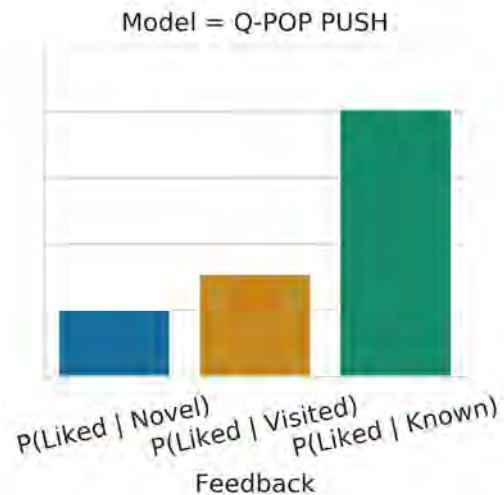
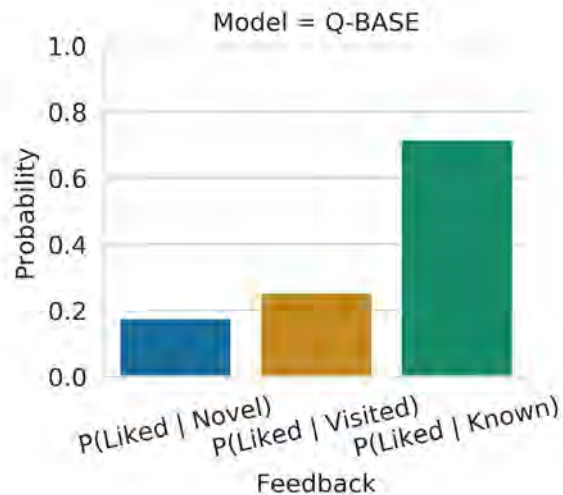
-  Visited the POI
-  Likes the recommendation
-  Didn't know the POI



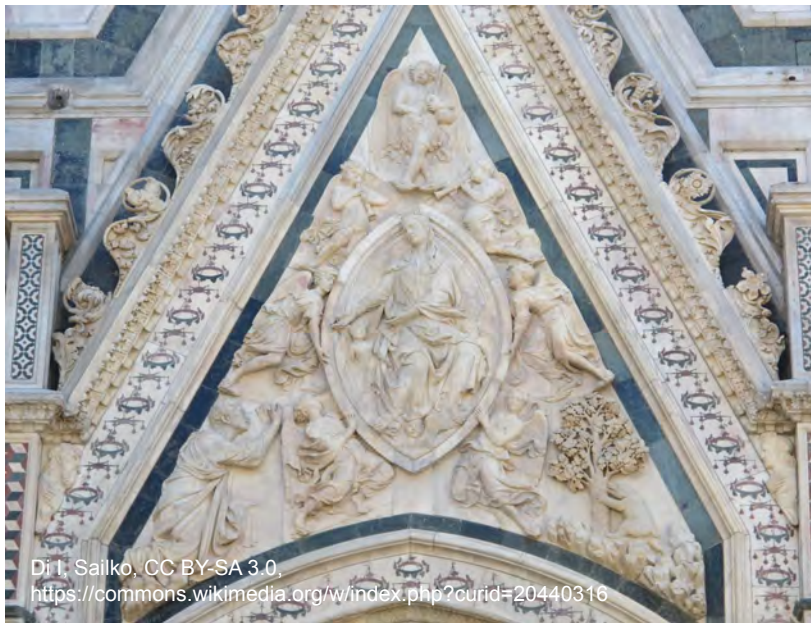
# Results



# Results



# Results



Porta della Mandorla  
Q-BASE



Duomo di Firenze  
Q-POP PUSH and SKNN

# Wrap Up

IRL based approach

Q-BASE + Pop. bias performs substantially equal to SKNN

Q-POP PUSH and Q-POP COMBINED

Offline and Online evaluation

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Accomplish the most important task of a tourism RS

Suggest POIs that are unknown and relevant





Discover what surrounds you!



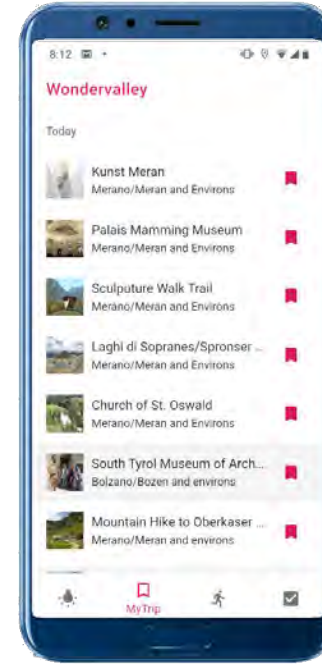
Get personalized tips and **discover** hidden gems in South Tyrol!

**Plan** the activities you would like to do.

**Evaluate** the places you visited.



**Discover**



**Plan**



**Evaluate**



Wondervalley is a project of the Faculty of Computer Science and the Faculty of Economics and Management at the Free University of Bolzano.



<http://wondervalley.unibz.it>