Pythia: A Privacy-enhanced Personalized Contextual Suggestion System for Tourism

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Summary of this work

- We present *Pythia*, a privacy–enhanced non–invasive contextual suggestion system for tourists
  - high quality personalized recommendations
  - non–invasive operation
  - protection of user privacy
- Make contextual suggestions (POIs) based on automatically built user profiles
- The user profile is POI–based using as personal data from user’s Smartphone:
  - Location traces
  - Browsing history
  - Web searches
- Strong privacy guarantees are achieved by placing both mechanisms at the user–side
- Proof of concept: a prototype implementation of Pythia
  - as an Android application, as well as a web application
Background

- Privacy
- Tourism recommendations
Privacy & Legislation

- **What is privacy?**
  - “The right to be let alone” [Warren and Brandeis, 1890]
  - “The right of the individual to decide what information about himself should be communicated to others and under what circumstances” [Westin, 1970]
  - The right to informational self-determination [1983]

- **Personal Data:** Any information that refers to a person

- **Related Legislation:** e.g. EU Data Protection Directive 95/46/EC
  - Indicative principles:
    - Reported and transparent processing
    - Finality & Purpose Limitation
    - Personal data quality
    - Security
    - Personal data traffic outside EU
A recommender system requires some input data in order to make appropriate suggestions

- Simple preferences: needs, interests and constraints
- Evaluations and ratings of other tourists (collaborative filtering)
- Travelers who are in close spatial and temporal proximity often share common travel interests

Common practice of such systems

- Users have to enter their personal information into some system
- User profiles have to be stored and managed by the recommender service
- The recommendations are performed in server–side

The usage of personal data concerns privacy issues

Pythia system combines a set of unique features in the field of mobile recommendation systems

- User–centric architecture
- Privacy–preserving
- Rich user profiles
- Non–invasive creation of user’s profile
The Pythia System
The architecture of the Pythia system

Personal Cloud Storage

POI Collector

Update Service

PostgreSQL POI Database

Mobile App
- Content Collector: Collect contents and upload encrypted to Cloud
- POI-based Profiler
- Contextual Suggestion Engine

Web App (Client Side Only)
- Content Retriever: Retrieving encrypted contents from Cloud
- POI-based Profiler
- Contextual Suggestion Engine

User-side

Google Drive

OneDrive

Dropbox
Interaction of Pythia components

Content Collector in Mobile Devices

- Locations
- Browsing History
- Web Searches

Profiling Algorithms

POI Database

POI-based Profiler

Current Location of User

POI-based Profile

Pool of Geotagged POIs

Indexing and Recommendation Algorithms

Suggestions for User

Contextual Suggestion Engine
Personal Data Collection

- **Content Collector in Mobile Devices**
- **POI-based Profiler**
  - Locations
  - Browsing History
  - Web Searches
- **POI Database**
- **Current Location of User**
- **POI-based Profile**
- **Pool of Geotagged POIs**
- **Indexing and Recommendation Algorithms**
- **Suggestions for User**

G. Drosatos – NATA – COMPSAC '15
Personal Data Collection

- **Content Collector** collects personal data of the digital trace generated by the everyday usage of the smart devices.
- This data is stored locally on each device.
- Focus on the following types of personal data:
  - **Location traces**: Records of locations in a particular time frequency
    - [Latitude, Longitude]: GPS or Network provider
    - Speed, Altitude, Bearing
    - Accuracy
    - Time
  - **Browsing history**: Records of browsing history
    - Title
    - URL
    - # of visits
    - Time of last visit
  - **Web searches**: Query logs
    - Query
    - Submission time
POI Collection Framework

- **Content Collector in Mobile Devices**
  - Locations
  - Browsing History
  - Web Searches

**POI-based Profiler**

**POI Database**

- **Current Location of User**
- **POI-based Profile**
- **Pool of Geotagged POIs**

**Contextual Suggestion Engine**
- **Indexing and Recommendation Algorithms**
- **Suggestions for User**
This framework implements a **Web API** which is used by other Pythia components to access the **POI database**.

The POIs can be retrieved via API:
- one by one
- as chunks corresponding to a specific county or area

The data available for each POI are:
- title
- geo-location
- address
- phone number
- categories
- several URLs
- rating
- total unique visitors and total visits
- a collection of terms describing the POI

An update service continuously updates and extends the database with new information about POIs from **Foursquare** and **Google Places**.
POI-based Profiling Process

1. **Content Collector in Mobile Devices**
   - Locations
   - Browsing History
   - Web Searches

2. **POI-based Profiler**
   - Profiling Algorithms

3. **POI Database**

4. **Contextual Suggestion Engine**
   - Current Location of User
   - POI-based Profile
   - Pool of Geotagged POIs
   - Indexing and Recommendation Algorithms

5. **Suggestions for User**
POI-based Profiling Process

Data processing steps:

1. **Significant places extraction**: Apply time-based clustering on location traces
2. **POI matching**: Match significant places with POIs from the POI database
3. **POI rating**: Estimate the user’s interest for the POI based on the user’s number of visits and the average number of visits per user to this POI
4. **Enrichment of Rated POI**: Adjust the POI ratings based on the web searches and titles of browsing history by applying an information retrieval approach
The Rocchio-like Contextual Suggestion model*

- Content Collector in Mobile Devices
  - Locations
  - Browsing History
  - Web Searches
  - Profiling Algorithms
  - POI Database

- POI-based Profiler

- Current Location of User

- POI-based Profile

- Pool of Geotagged POIs

- Indexing and Recommendation Algorithms

- Contextual Suggestion Engine

- Suggestions for User
The Rocchio-like Contextual Suggestion model*

Step 1
- Indexing: Title, Description, POI Categories
- Index of Current POIs

Step 2
- User’s POI-based Profile
- Generate Personalized Queries with Rocchio Algorithm
- Weighted Query of User

Step 3
- Retrieve the Results of Query
- Suggestions for User

\[ Q = \sum_{j=0}^{4} \left( j - 2 \right) \frac{1}{|S_j|} \sum_{i:p_i \in S_j} P_i \]

* TREC 2013, Contextual Suggestion Track: We ranked with this algorithm at 2nd place among 15 research groups
The Pythia Prototype
Current status of implementation

- Fully implemented
  - POI Collector (PHP, PostgreSQL)
  - Content Collector (Android platform)

- Only implemented as web application
  - POI-based Profiler (JavaScript)
  - Contextual Suggestion Engine

- The current prototype are implemented as a collection of standalone applications
  - Communicate through the personal Cloud storage of the user
Conclusions
Conclusions

- Proposed the Pythia system: a privacy-enhanced non-invasive contextual suggestion system for tourists
- The main system components operate in the background without user interaction
- The personal data of the user are kept on his own device
- Utilize sensitive personal data for personalized suggestions without violating the individuals’ privacy
- The protection of user privacy is achieved by placing the profiling and recommendation procedures at the user-side
  - Mobile device OR desktop
- Developed prototype implementation

Future work
- Improve the automatic POI matching and POI rating algorithms
- Upgrade the implementation to a more complete and stable system
- Perform a more extensive evaluation of the complete system
Thank you, any questions?
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ATLAS: Advanced Tourism Planning System.
http://atlas.web.auth.gr/

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