Ubiquitous and Mobile Computing
CS 528: *Automatically Characterizing Places with Opportunistic CrowdSensing using Smartphones*

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Automatically Characterizing Places with Opportunistic CrowdSensing using Smartphones

- UbiComp'12, Pittsburgh, USA
  - Best Paper Award
- Authors:
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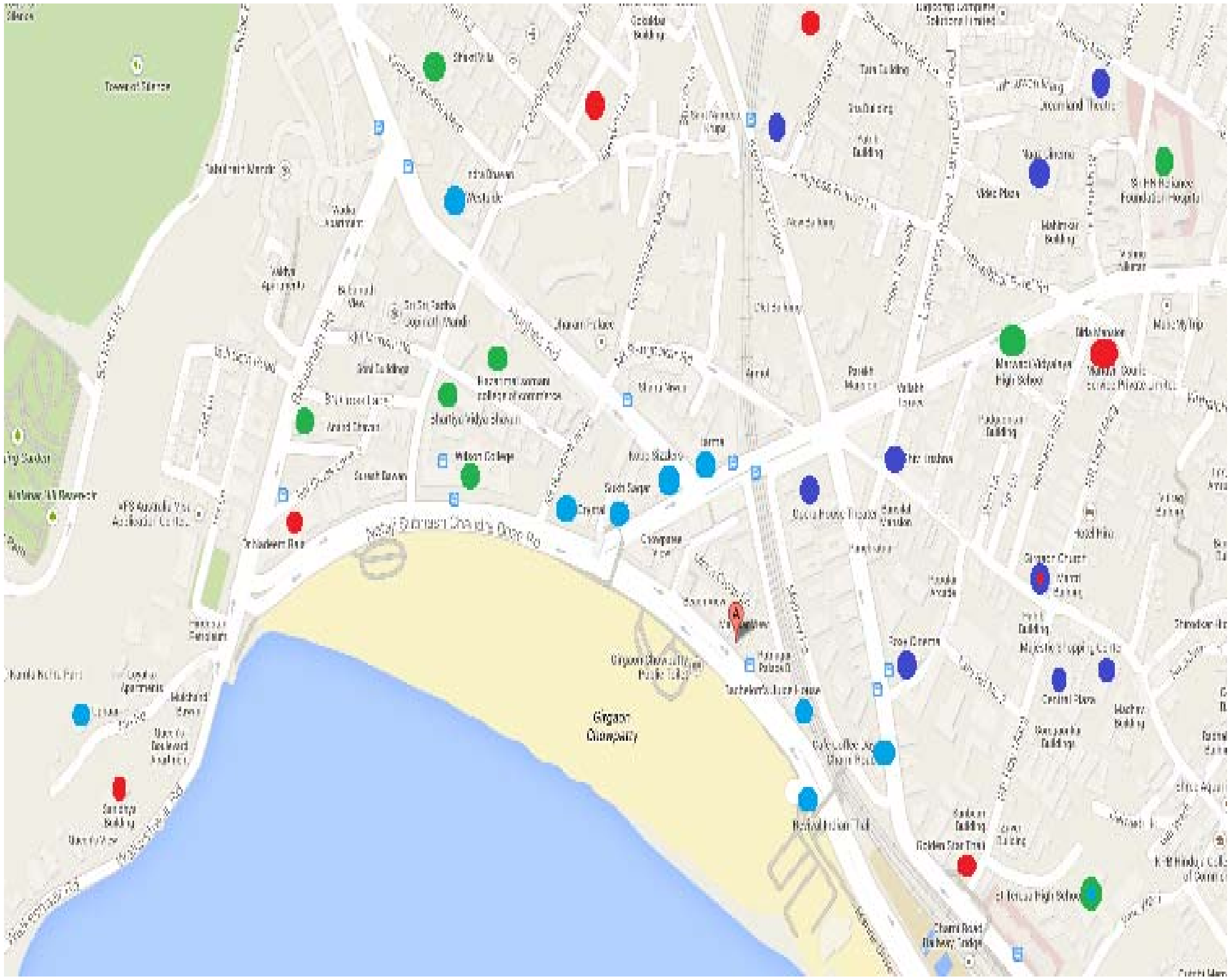
Characterizing Places



Marine Drive,
Mumbai, India

Legend:

- Educational Institutions
- Restaurants
- Hospitals
- Shopping

Design Approach

Low Level Sensor Data - Location

High Level Meaningful Data - Place

CrowdSense@Place (CSP)

- Categorizes places
- Logical location meaningful to user
- Links places with
  - Place categories
    - Grocery store, restaurant, hospital, university
  - Activity
    - Shopping, eating, working

Bloomingdale, USA

The Coffee Bean, India

Collecting Data: How?

- Location and user trajectories using Wi-Fi/GPS
- Samples data from sensors
  - Microphone
  - Camera
- Crowdsourcing
  - Collect large volumes of data

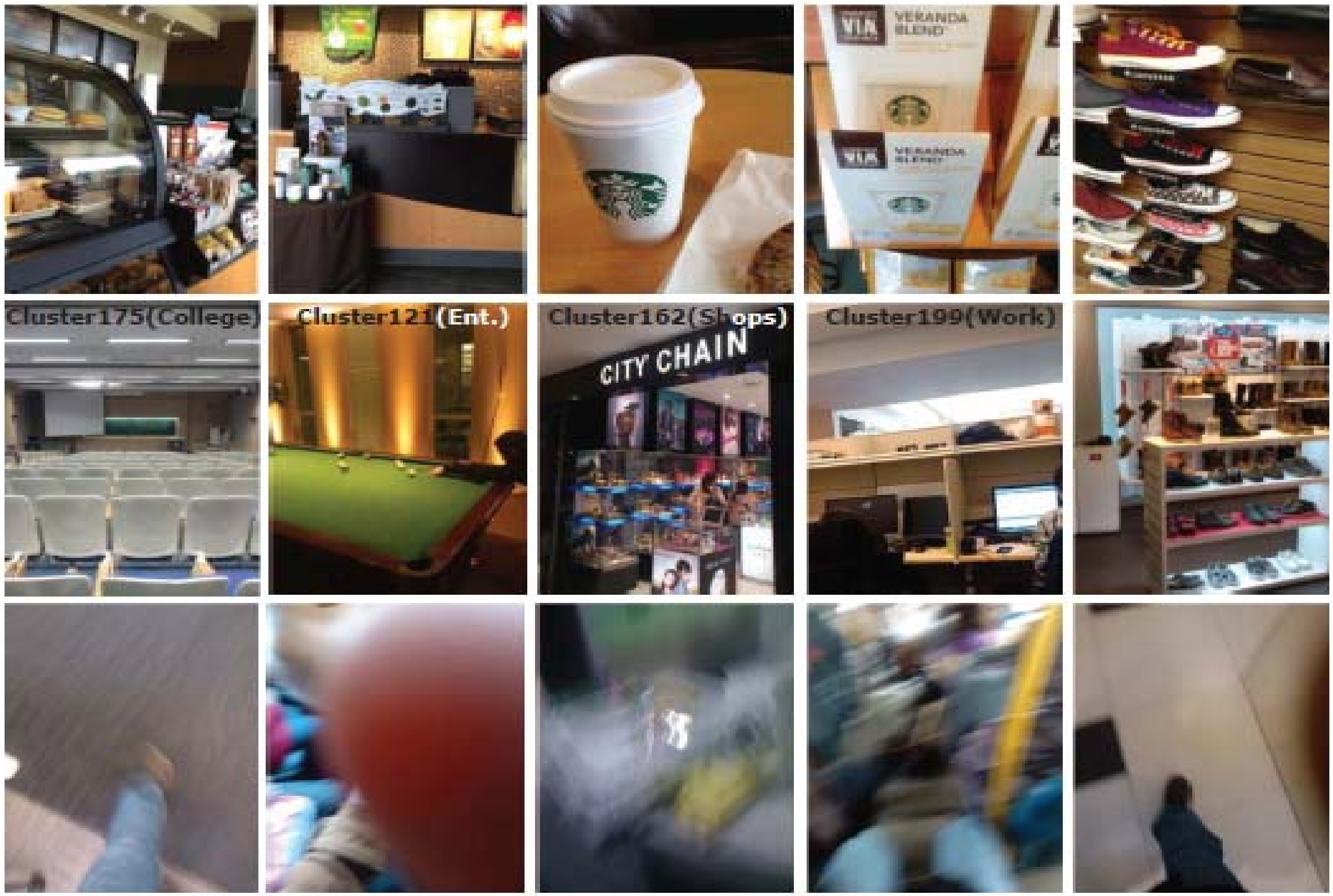
Collecting Data: What?

- Audio and visual place hints mined from opportunistic sensor data
  - Spoken words
    - “Can I have a Cappuccino please?”
  - Physical objects
    - Cups, shoes, clothes
  - Written texts
    - Menu, posters, hoardings

Collecting Data: When?

- User uses phone
  - Calls, emails, or browses
- Concern: Privacy
  - Full control of data collection
  - Buffered before transmission
  - Review collected data
  - Option to delete before upload

Example of Captured Images



Hints

Noise

Automatically Characterizing Places with Opportunistic CrowdSensing using Smartphones

Extracting Hints

- Image and audio classifiers
  - Scene classification
  - Object recognition
  - Optical character recognition
  - Speech recognition
  - Sound recognition
- Output merged with location based signals
  - Wi-Fi, GPS

Let’s Try To Pick Up Hints

Bloomingdale, USA

Bloomingdale’s

Outlet Store

Mannequins

Bag

Skirt

Trousers

Jackets

Belts

Let's Try To Pick Up Hints

The Coffee Bean, India

- The Coffee Bean
- Order Here
- Can I get a Latte to go please?

Let’s Try To Pick Up Hints

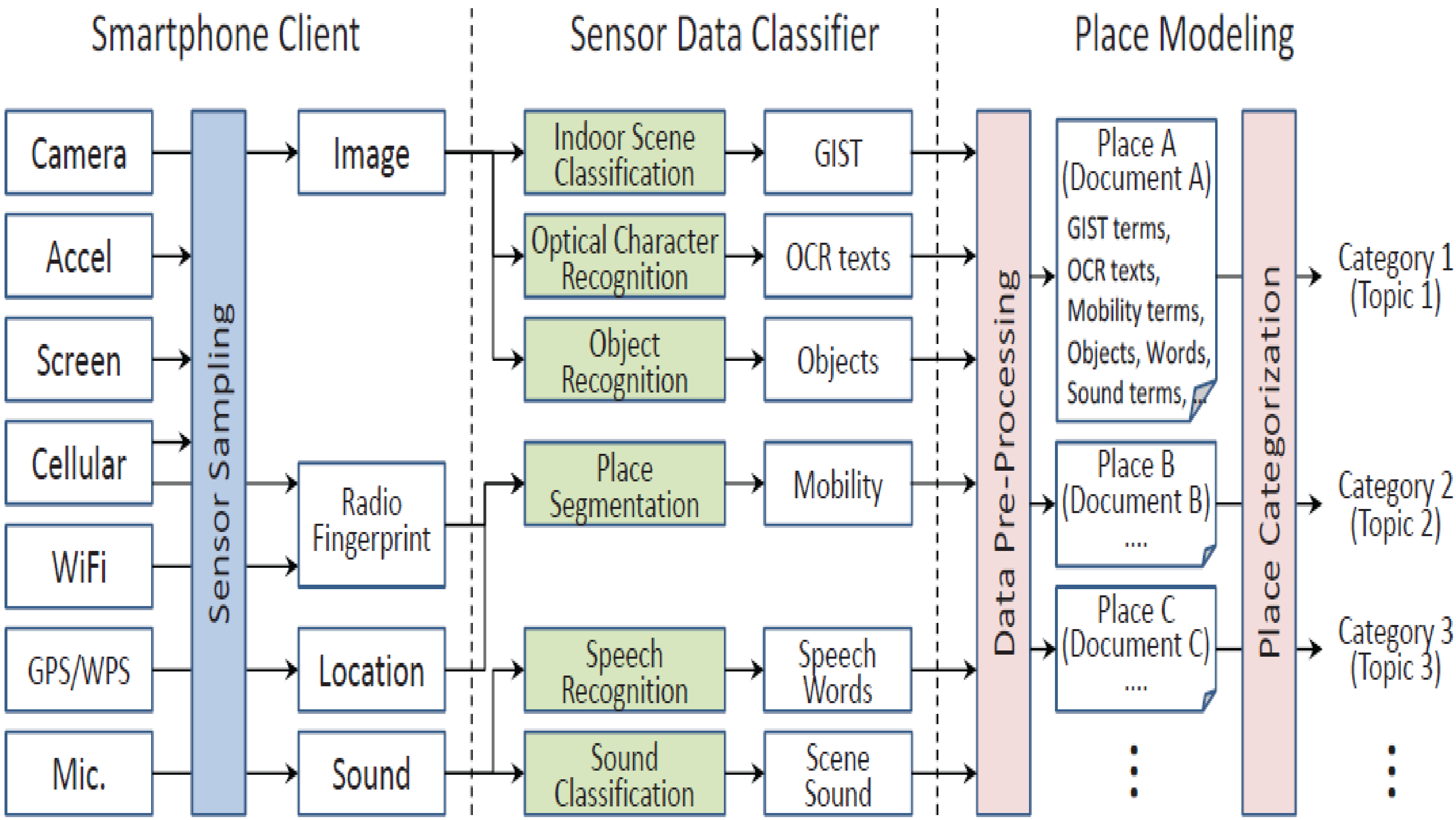
- Laptop
- Dell
- SSD
- Store

CSP Working

- Place as a document
- Builds the document with sensor based hints

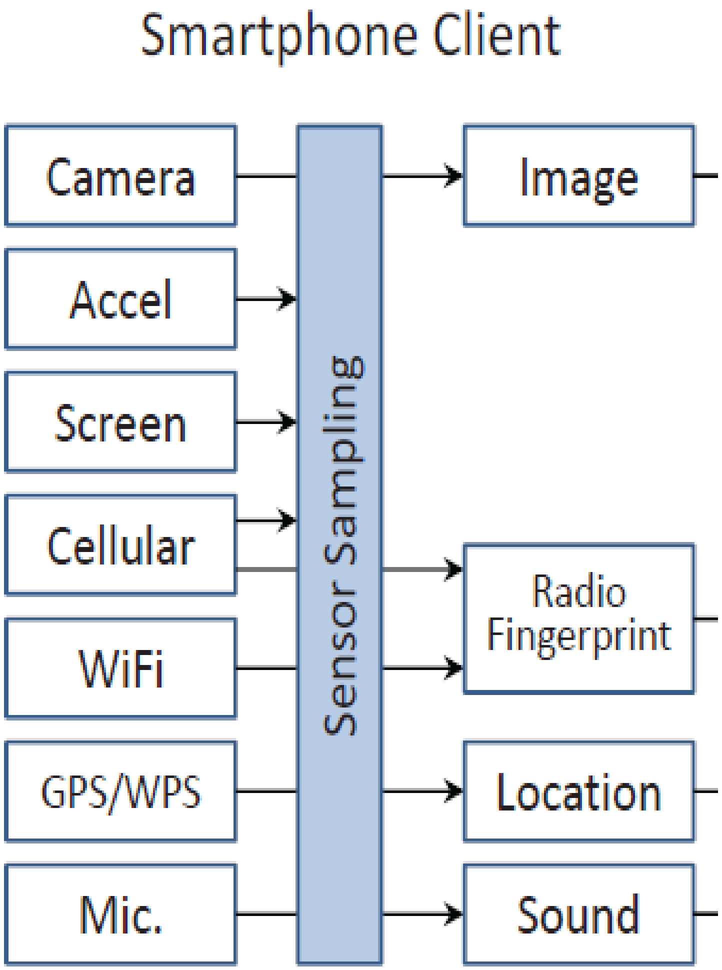
ID: WiFi Fingerprint
Bloomingdale (0.75)
mannequin (0.87)
trouser (0.83)
blouse (0.65)
shirt (0.76)
belt (0.4)
bag (0.56)
outlet (0.87)
store (0.76)
35-75% (0.23)

CSP Framework

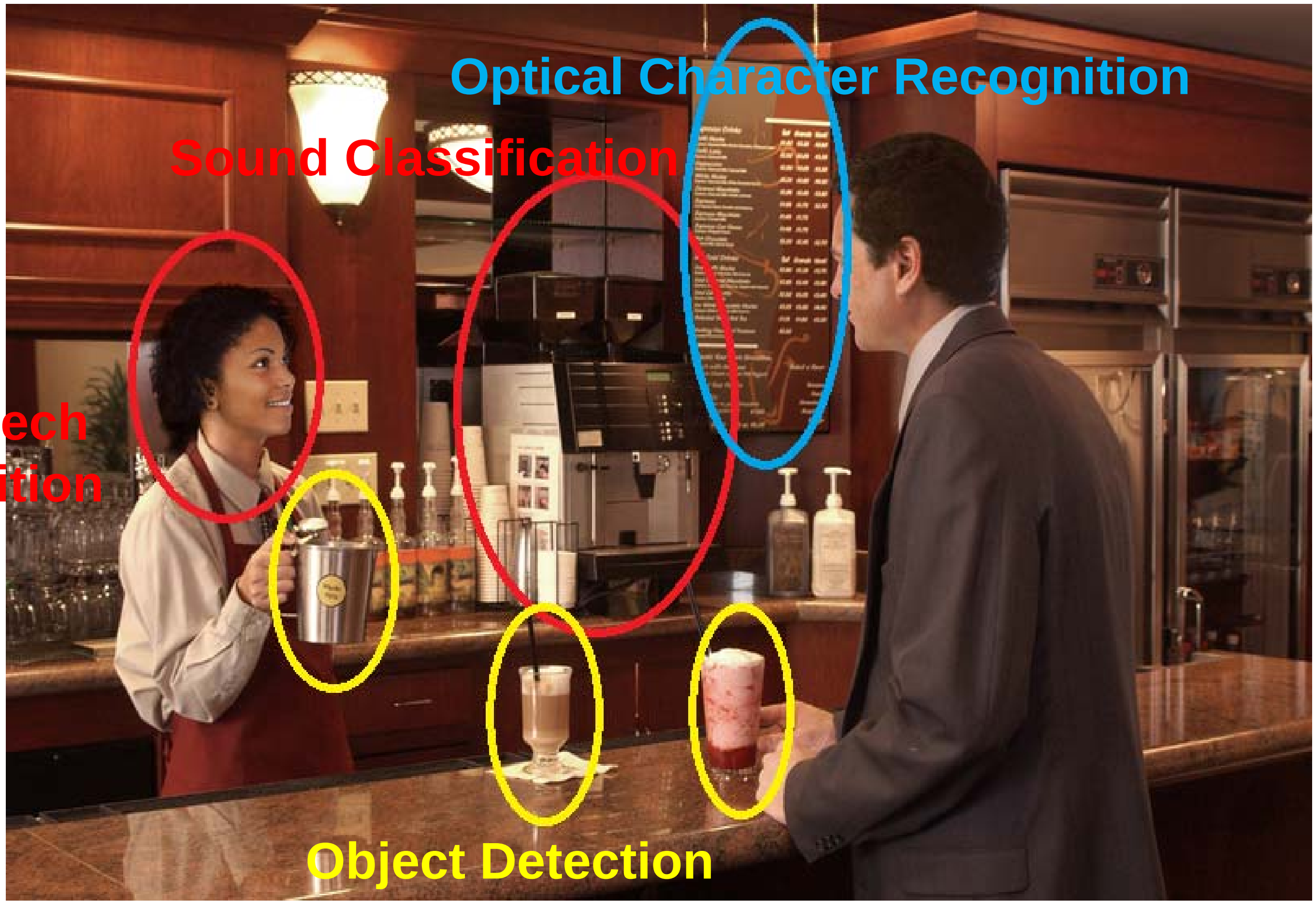


Opportunistic Sensing of Data

- Smartphone
- Application usage
  - Phone calls, browsing
- Piggy-back on user actions
- Screen state and light sensor
- Accelerometer
  - Orientation, movement
- GPS & Wi-Fi
- Microphone
- Camera



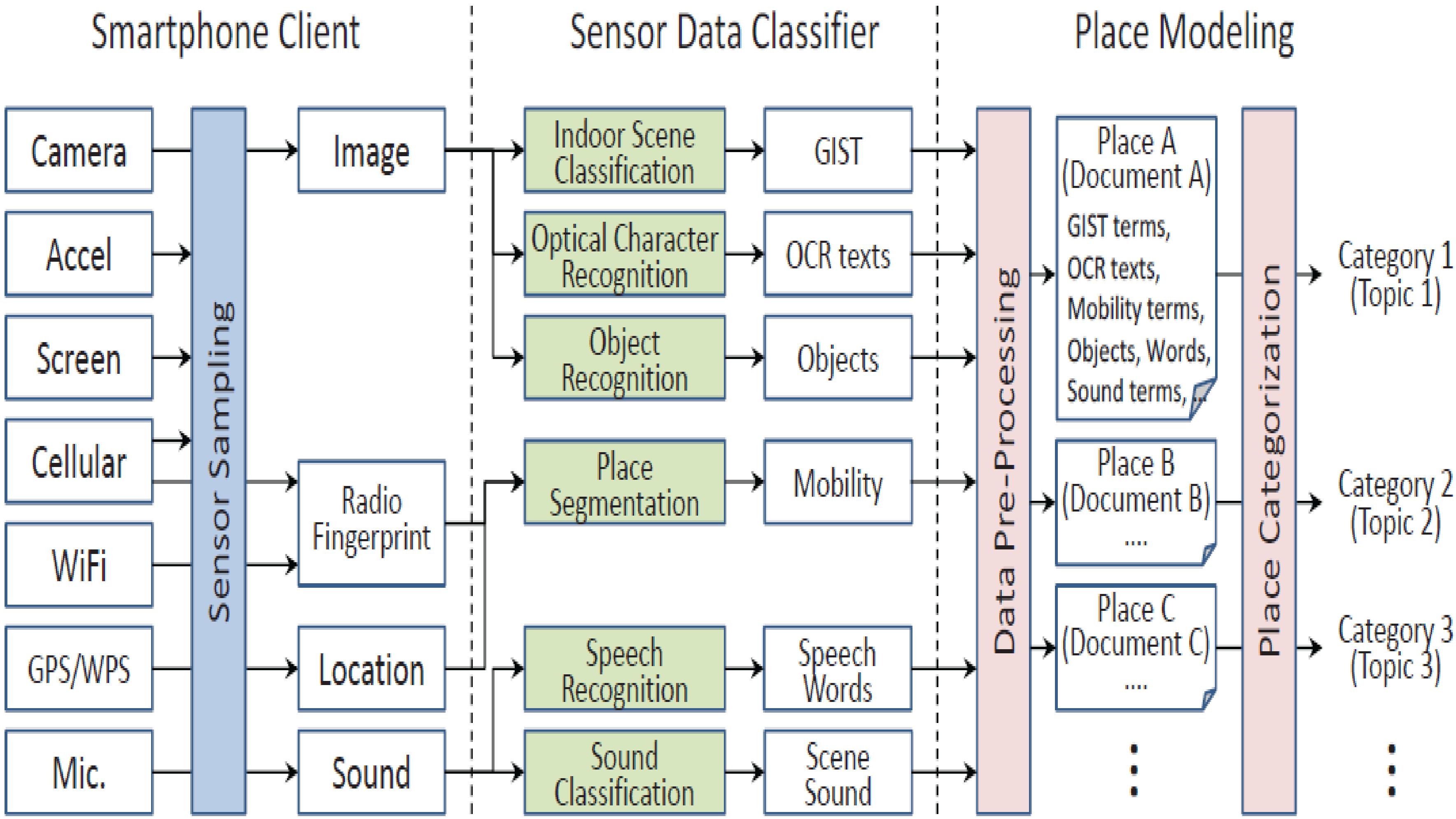
Sensor Data Classifier



Sensor Data Classifier

- Hints v/s Noise
  - Filter out the data
    - Phone is shaky or facing down
  - Crowdsourcing
  - Repeated visits to place

CSP Framework



Applications

- Location based reminders
- Content Delivery
- Activity recognition
- Understanding City-Scale Patterns
- Enhanced Local Search & Recommendations
  - Awareness of the types of places a user frequently visits leading to additional user profile attribute
- Rich CrowdSourced Point-of-Interest Category Maps
  - Maps that relate places to place categories
  - A targeted advertising app

Limitations

Limited Accuracy: 69%

Speech, object recognition contribute little

Future: Train the classifier using a small amount of specific place hints

Completely opportunistic

Accumulates high quality slowly

Learns slowly over long time period

Energy Issues

Power consuming Wi-Fi & GPS

Clicking pictures, capturing videos drains battery

Privacy

Users have choice to upload photos

Future: Local processing & Anonymous

Evaluations

- Statics:
  - 36 users
  - 5 locations
  - 1241 places
  - 1,300 places
  - 46,000 hours
  - 2,300 images
  - 4,200 audios
  - 22% of images are either blurred or completely black
  - Accuracy: 69%

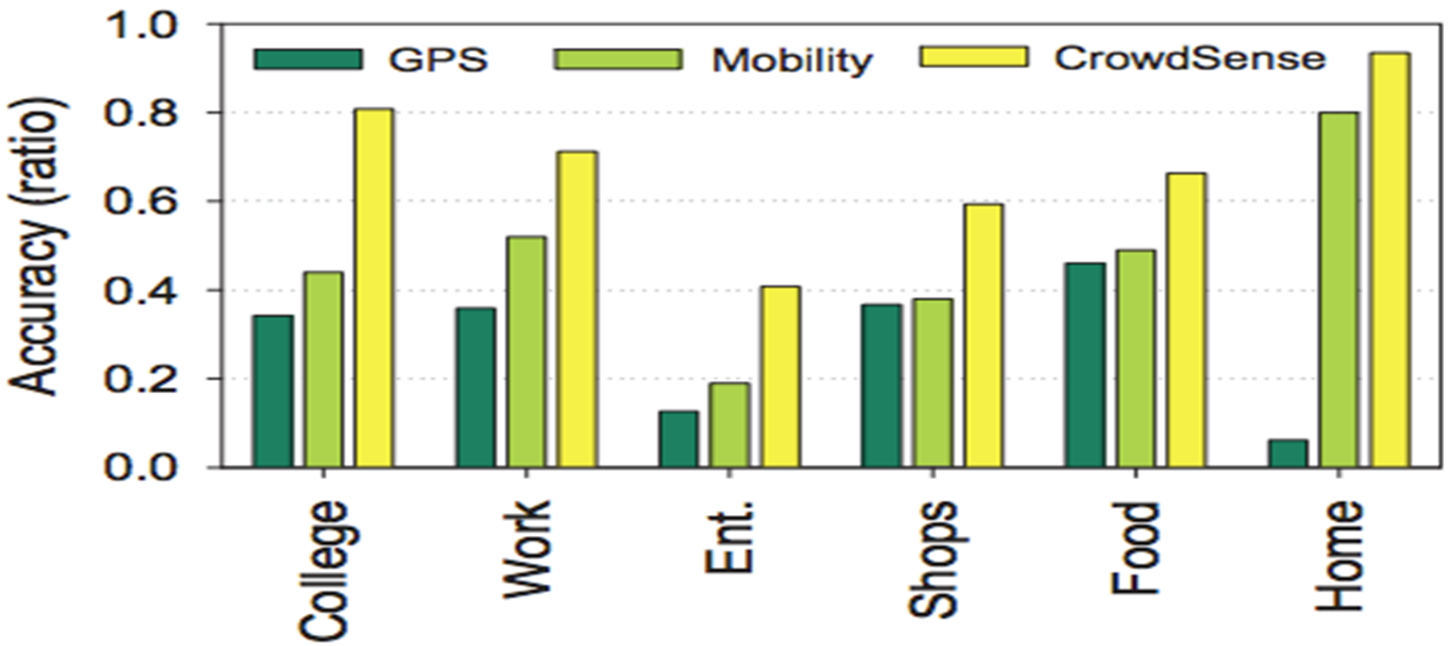
Evaluations

- Questions
  - How accurate?
  - Which features types are most discriminative?
  - How well do certain feature types operate in noisy environments?

Evaluations

- Categories
  - College & Education, Arts & Entertainment, Food & Restaurant, Home, Shops, Workplace, Others
- Metrics
  - Accuracy of place categorization:
    - (No of correctly recognized places)/(No of places evaluated)

Evaluations



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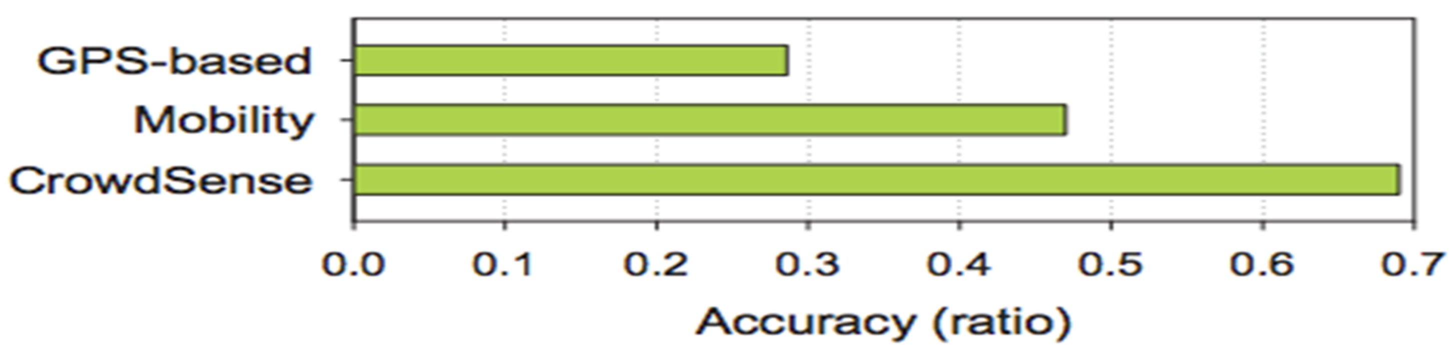

Conclusion

- Efficient categorization of places
- Uses hints, like humans do
- Effective use of crowd sensing
- Accurate classifier
- Advanced applications
- Large scale evaluations

- Power consumption
- Privacy concern

- Future,
  - User participation
  - Social Networking Sites

References

- *http://www.msr-waypoint.com/en-us/um/people/zhao/pubs/ubicomp12_cps.pdf*
- *D. Ashbrook and T. Starner. Using GPS to Learn Significant Locations and Predict Movement Across multiple users.*
- *http://foursquare.com*

Questions


THANK
YOU