CSIS

SEZAKI LAB

[Urban Sensing and Mobility Analysis]

Center for Spatial Information Science

Information and Communication Engineering

Socio-cultural Environmental Studies

Information & Communication Engineering

http://www.mcl.iis.u-tokyo.ac.jp

Recognizing Human Mobility Using Bluetooth

Purpose
- Developing low-cost system for sensing human mobility using Bluetooth

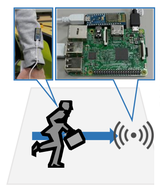
Significance
- Equalizing congestion or improving layout of indoor facilities
- Understanding human mobility in disaster for supporting evacuation

Approach
- Congestion sensing by detecting Bluetooth devices
- Direction detection by observing transition of signal strength of Bluetooth Low Energy beacon

Relationship between number of counted people and number of detected Bluetooth device at Makuhari Messe

Correlation coefficient between people and Bluetooth devices

BR/EDR	0.310
LE	0.188
BR/EDR+LE	0.303

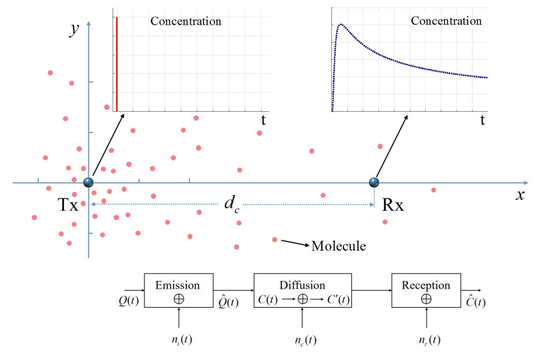


Bluetooth beacon approaching sensor

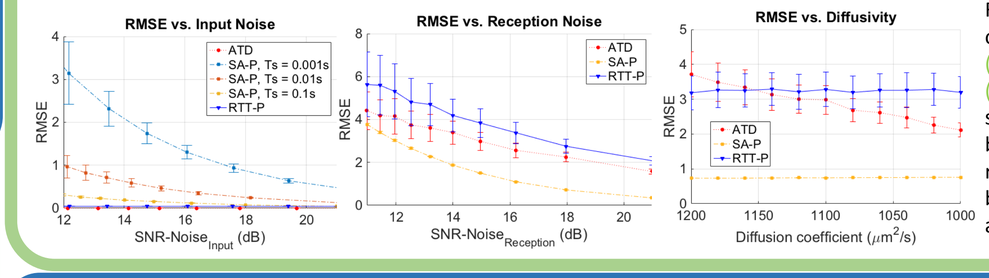
Observed received signal strength indication (RSSI) of approaching Bluetooth beacon

Distance Measurement in Diffusion-based Molecular Communication

- **Objective:** To measure *communication distance* from Tx to Rx more **efficiently** and **robustly** in *noisy diffusion-based molecular communication*
- **Significance:** Distance information is fundamental to high quality connection
- **Approach:** Arrival Time Difference (ATD)
  - *Step1:* Tx transmits *two impulse signals* on different types of molecules at the same time
  - *Step2:* Rx measures the *difference of arrival time* (different molecules usually have different diffusivity)
  - *Step3:* Rx estimates the communication distance according to the channel model
- **Advantages:** A)*Efficiency* (one-way-signal); B)*Robustness* (less error accumulation); C)*Optimizable performance* (selection of information molecules)



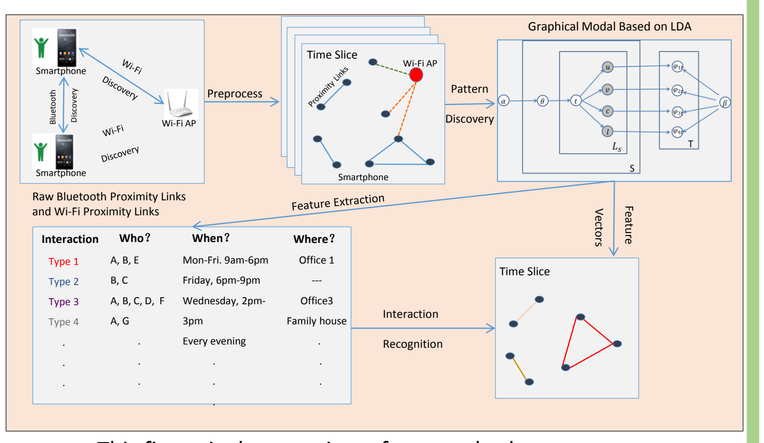
(a) System model (b) Noise model



RMSE comparison of (c) input noise, (d) reception noise, (e) diffusivity, with signal attenuation-based (***SA***) and round trip time-based (***RTT***) approaches

Inferring social relations with smartphone proximity networks

- Understanding social behavior and interaction pattern of mobile users play an important role in many applications.
- We propose a new probabilistic model for analyzing human interaction data, represented as a set of proximity links between pairs of users add with the interaction timestamp.
- Our idea is inspired from latent Dirichlet allocation (short for LDA). The figure on the right is the overview of our method.



This figure is the overview of our method

Analysis on Transportation Data for Recognizing Features of Cities

Today, ubiquitous computing enables dense transportation data to be available. Transportation data is very important because they are relevant to features of cities, such as the environment, human mobility and so on. Our objective is to grasp features of cities from these data. We use a method for analysis as known as NMF or NTF. We analyze on origin-destination data of smart cards.

The achievement of this study is analyzing smart card data in a certain prefecture.

➢ Most of passengers get off on the same line as entraining point.
(It is rare to transit other line except of City Central.)

➢ Some stations which don't follow patterns as mentioned above have e peculiar facilities
(such as Large Shopping Mall, Public Housing).

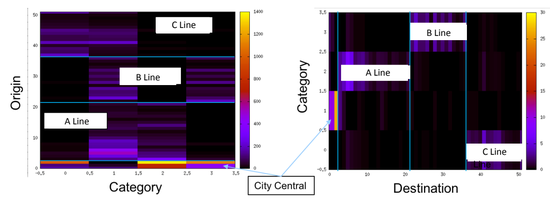
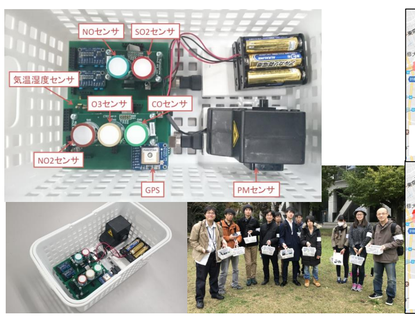


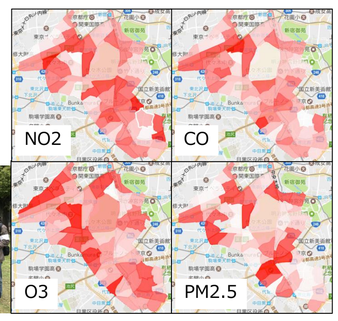
Fig. 1: Patterns of Stations in a Certain Railway

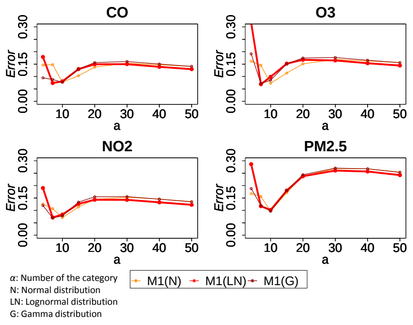
Estimating Reconstruction Accuracy of Data Perturbation in Mobile Sensing

Data Perturbation
- A technique to protect privacy by randomizing observed values by each user before sending to a server. The server can restore only statistical information from a collection of randomized sensor data.
- Problem: a server cannot estimate the accuracy of the restored statistical information.

Proposal and Experiment
- Estimate reconstruction accuracy assuming spatiotemporal correlation of the original data.
- Did an field experiment of mobile environmental sensing in Shibuya, and evaluated the proposal method with the data randomized by the negative survey technique.

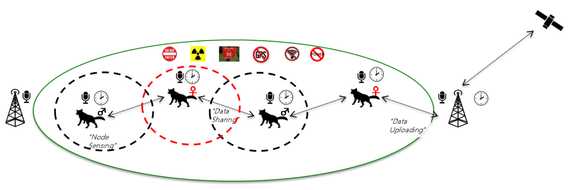






Spatio-Temporal Information Correction Mechanism for Wildlife Wearable Sensors

- Field surveys are meaningful for researchers for bringing much natural information in detail, but there are various obstacles during them.
- Forested area in Japan is approximately 70% of whole is the out of communication range.
- Realize effective inter-animal communication using animal wearable devices, the data-collecting system through animals with wearable sensors as carrier pigeons do.



location Privacy Preservation Considering Time-Varying Population Density

Goal
- We evaluate the effectiveness of the prior information derived from population density as an adversary's knowledge to the existing location privacy preservation methods.

Approach
- We integrate a prior probability derived from population density into a probability distribution used to estimate user locations by the adversary.

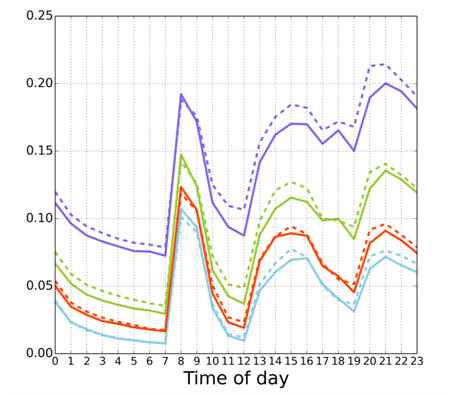
Evaluation
- We confirm the location privacy preservation level for existing privacy preservation methods is depressed, that is to say, the population density enhances the adversary's performance to infer the user locations.

- Existing metric :

$$LP(u,t) = \sum_{r \in R} \hat{p}_{u,t}(r) ||r - a_u(t)||$$

- Proposed metric : Population Density

$$LP(u,t) = \sum_{r \in R} \eta \cdot \hat{p}_{u,t}(r) pd_t(r) ||r - a_u(t)||$$



Offloading Mobile Applications to "The Edge"

Modern mobile applications have become computationally intensive as recent developments in machine learning and computer vision have instigated a new consumer trend for virtual applications. Most of the heavy lifting is traditionally offloaded to cloud servers; however, network latency hinders user experience, making real-time rendering implausible for sophisticated applications. Although mobile devices are capable of performing necessary real-time calculations, mobile devices typically cannot sustain heavy workloads. Edge servers become useful in these scenarios as they are powerful and close enough to users to support real-time applications. Computer vision applications are currently being investigated.