vCityMap: Crowdsensing Towards Visible Cities

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Visualization of City

- Sound
- Roads with respect to maintenance
- View (Google Maps, Google Earth)
- …
- …

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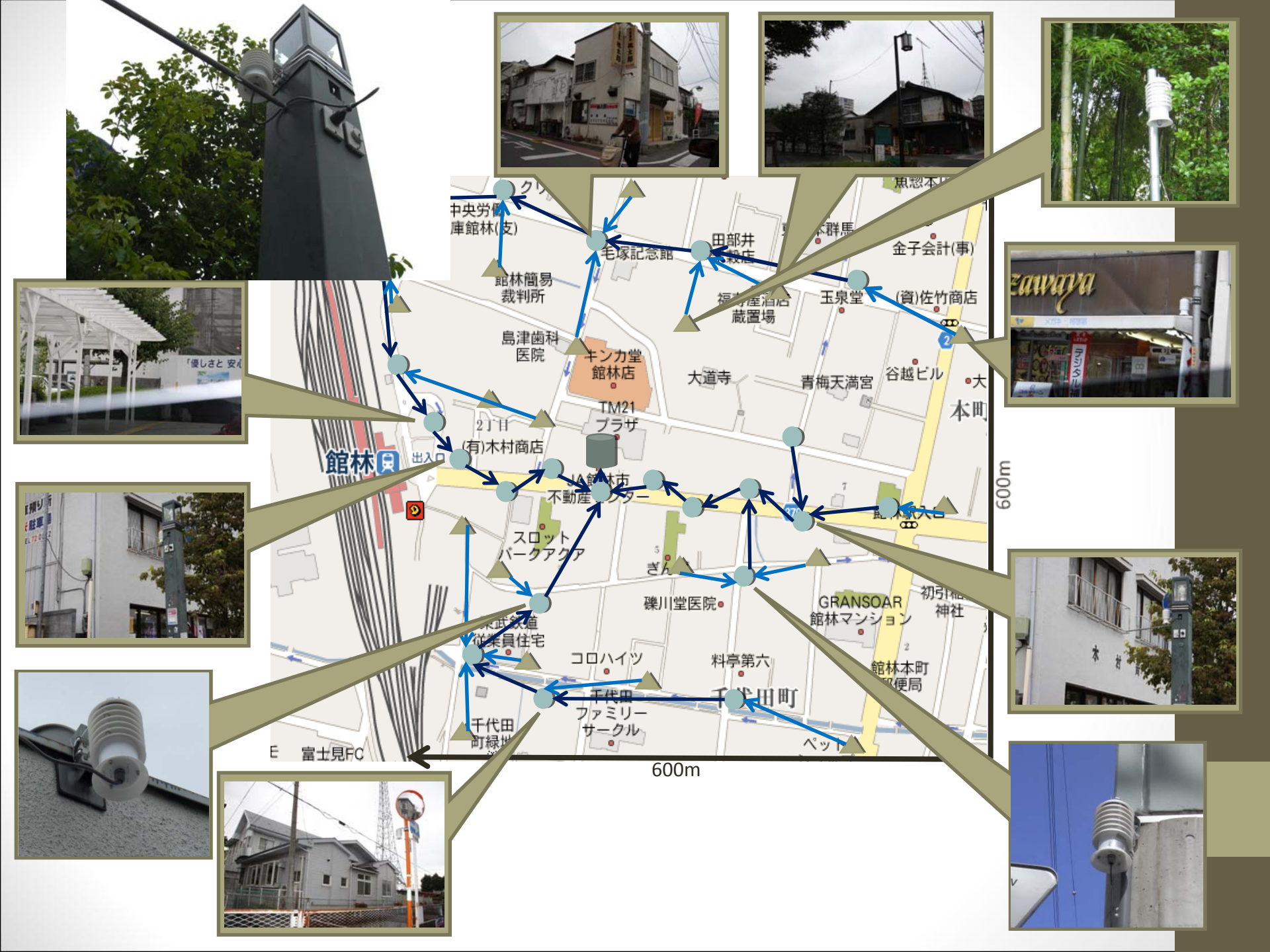
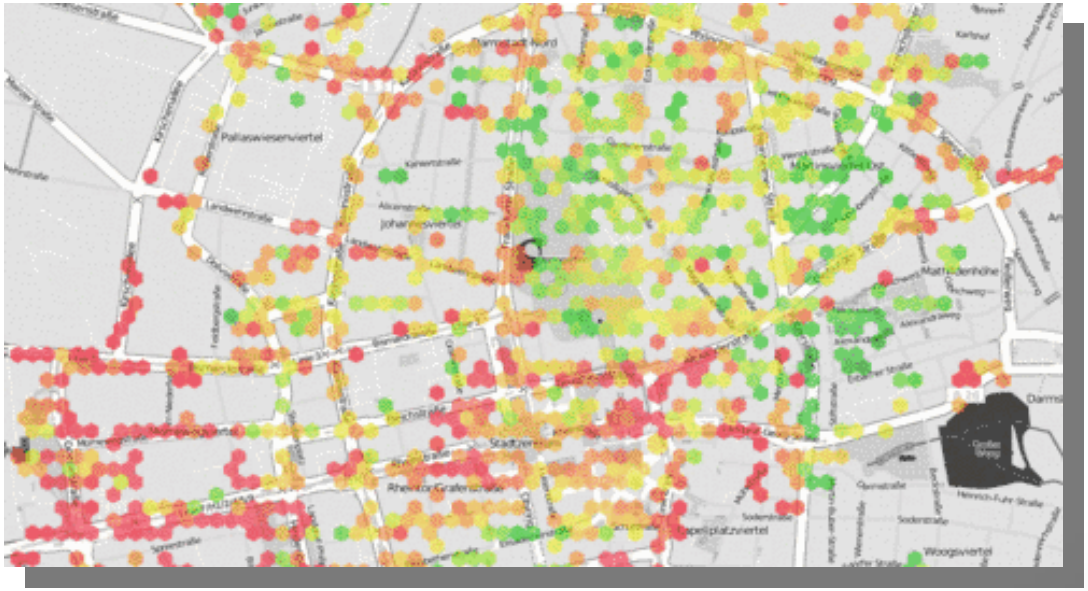

館林
出入口
TM21
プラザ
スロット
パークアクア
キンカ堂
館林店
(有)木村商店
島津歯科
医院
館林簡易
裁判所
宅塚記念館
田部井
玉泉堂
(資)佐竹商店
金子会計(事)
大道寺
青梅天満宮
谷越ビル
本町
礫川堂医院
GRANSOAR
館林マンション
コロハイツ
料亭第六
千代田
ファミリー
サークル
千代田町
館林本町
郵便局
富士見FC
600m
600m

Crowdsensing

- or Participatory Sensing for data with non-real-time property

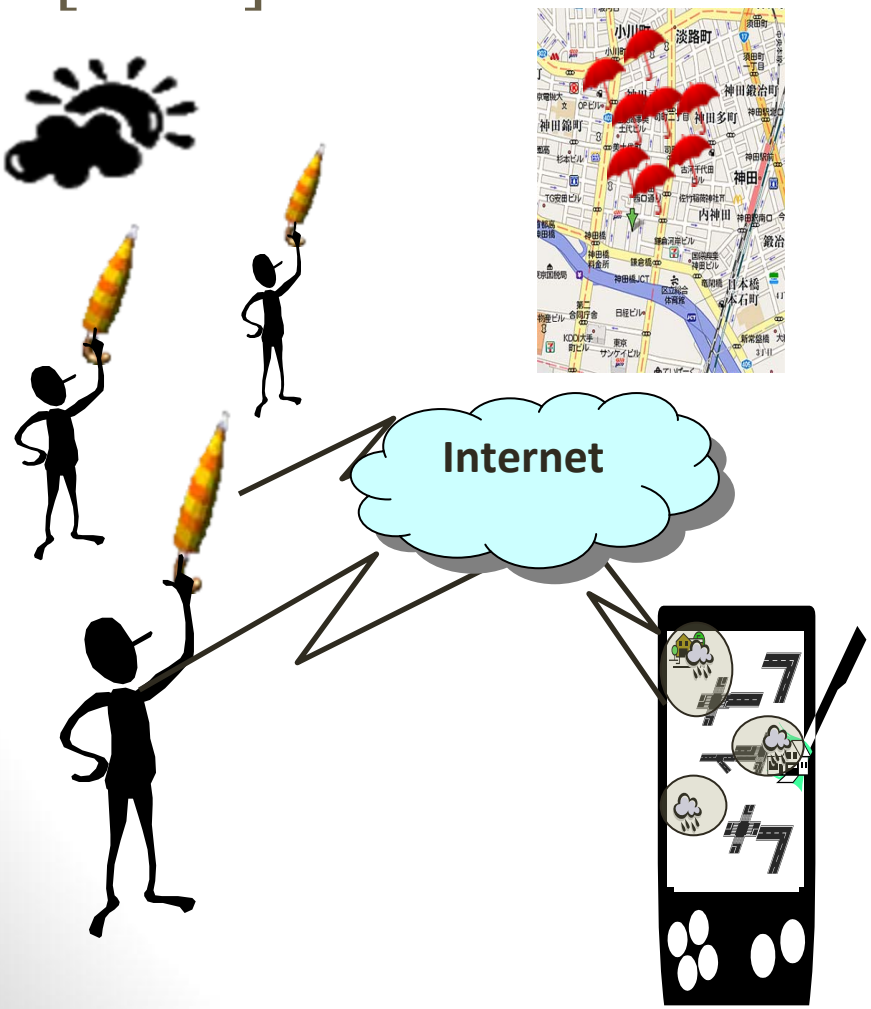
Sensor Data Collection in Wide-Area by People

(Example□Noisemap - Discussing Scalability in Participatory Sensing □Meurisch, 2013□

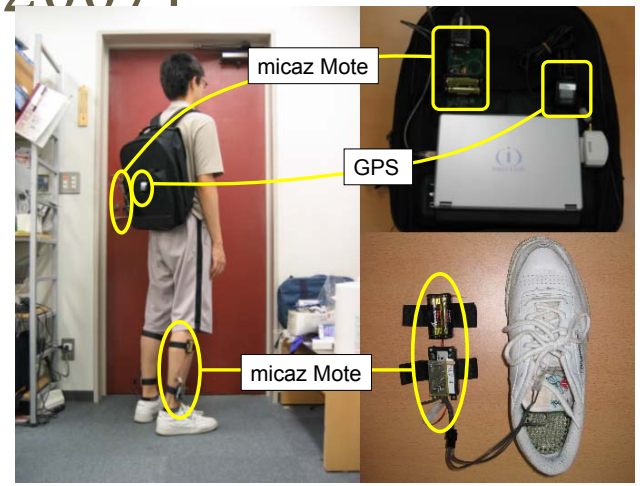


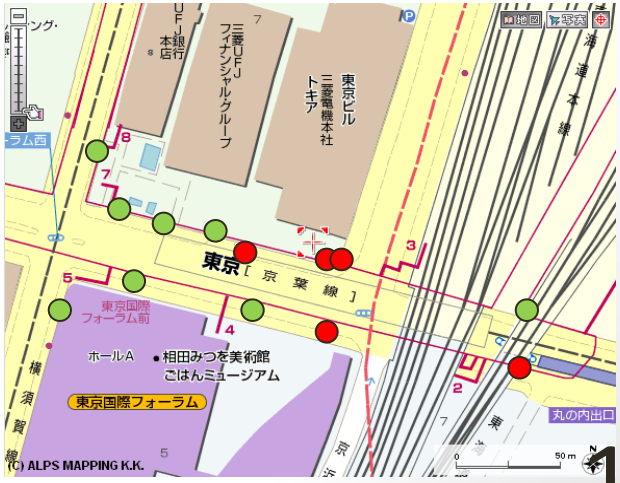
Our Previous Gadgets

Umbrella Human Probes [2005]

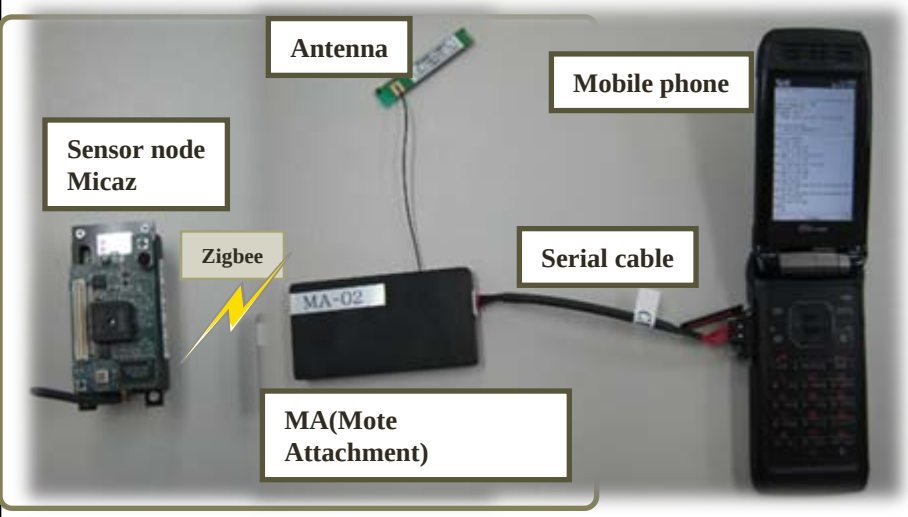


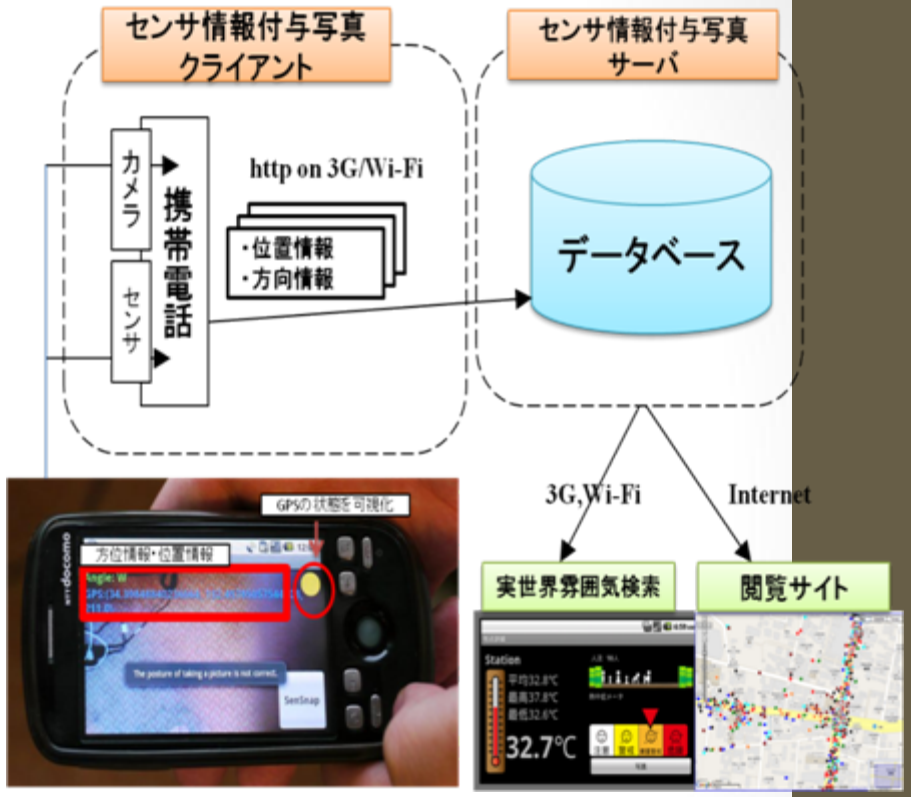
Shoes Human Probes [2007]





Additional Dedicated Hardware ?





Dedicated Hardware

Software

Sensors are embedded into Phones.

Visualization of City

- Sound
- Roads with respect to maintenance
- View (Google Maps, Google Earth)
- …
- …

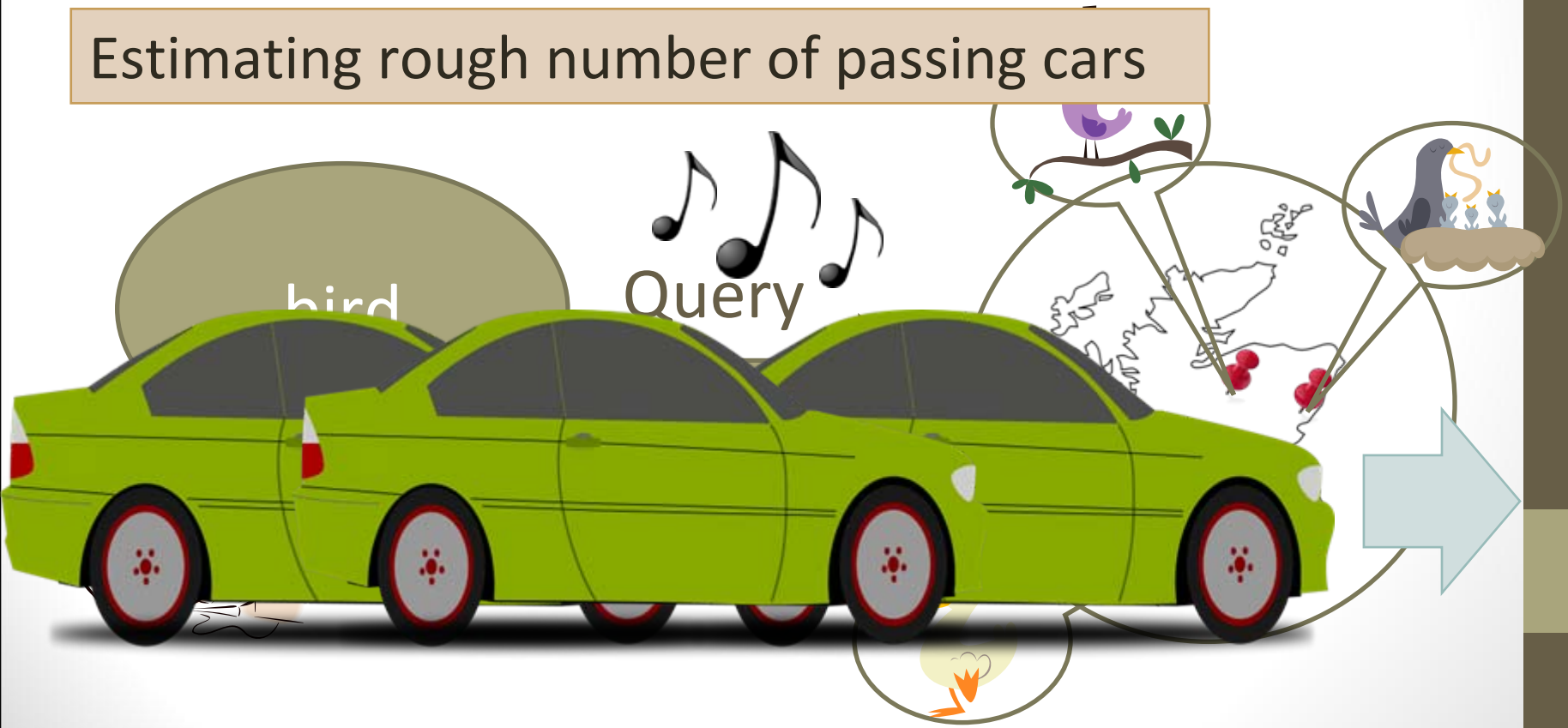
Why Sound ?

- Sound represents the atmosphere of Place
- Less concern about privacy
- Analyzable

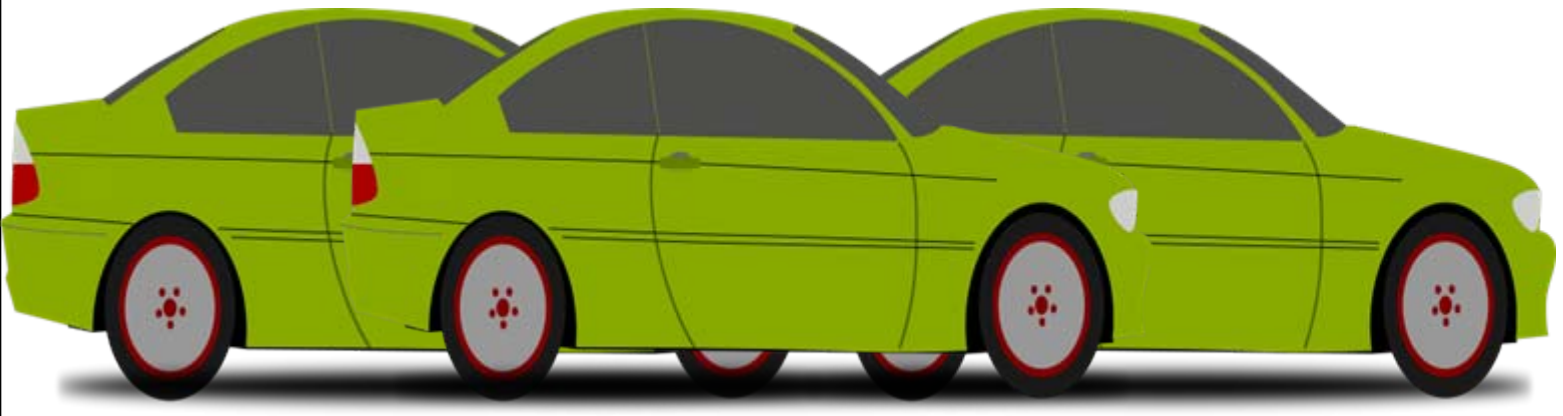
First Goal

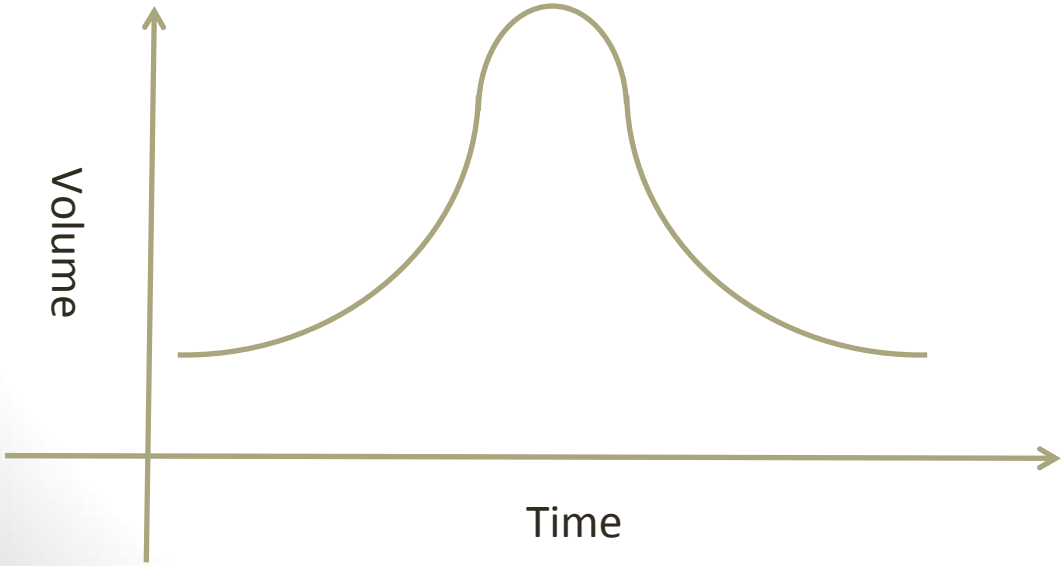
- Classification of sound for queries
  - what kind of sound
  - Which area has a particular kind of sound ?

Estimating rough number of passing cars



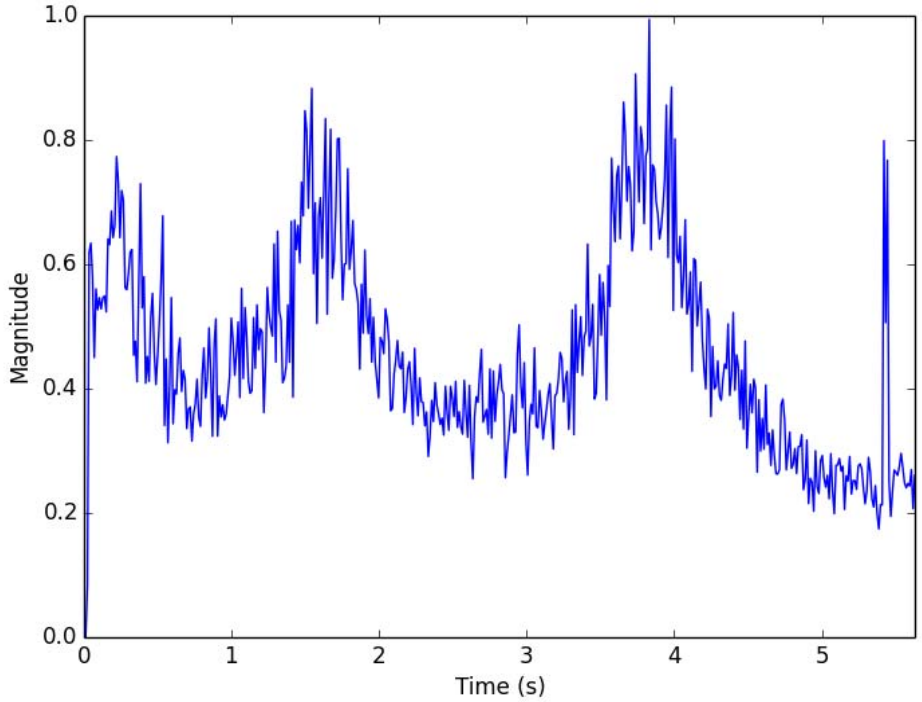
Classification Method





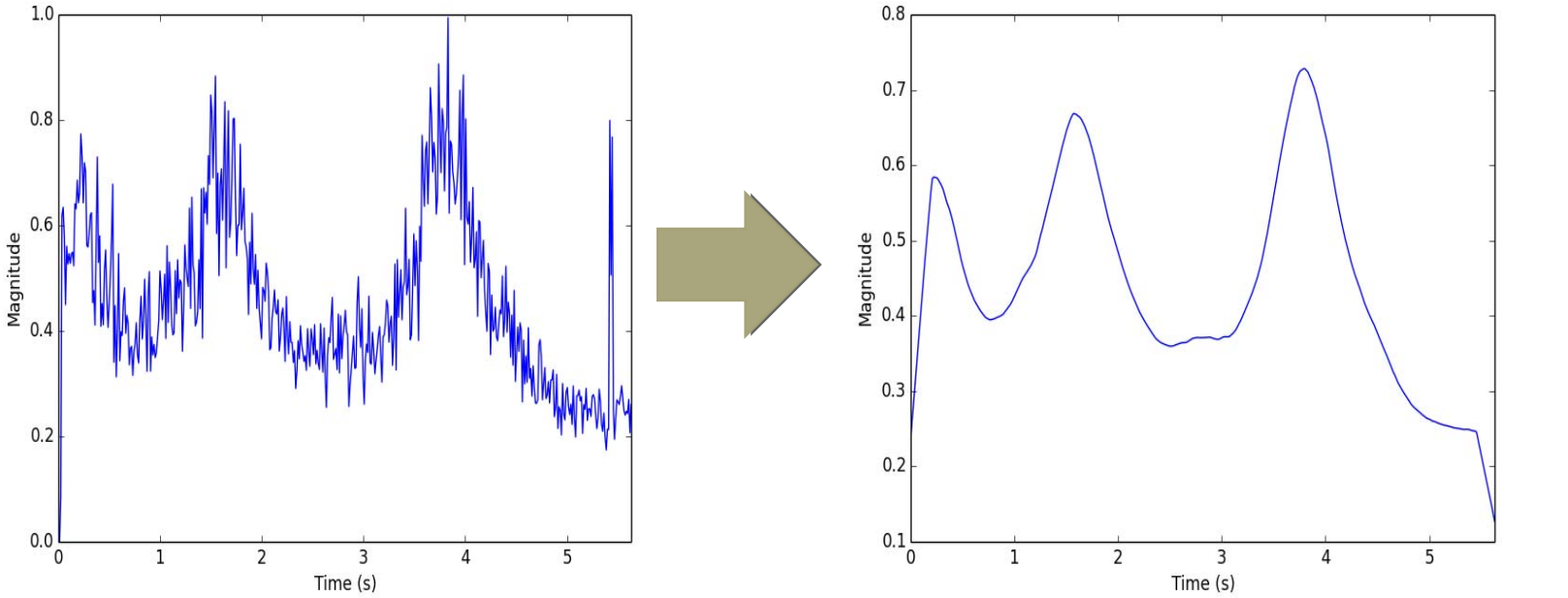
Preprocessing

- Applying short-time Fourier Transform to the originally acquired signal
- Calculate the mean of spectral power of 2-3 kHz



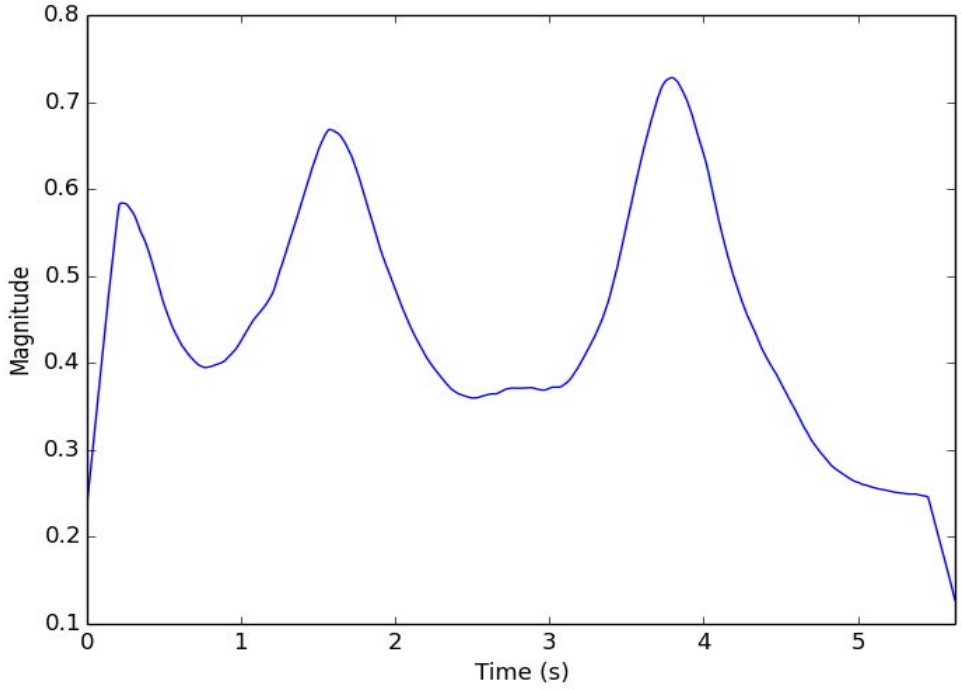
Filtering

- Applying moving average and median filter to subband mean time series
- Filtering impulse noise by median filter
- Smoothing signal transition by moving average filter



Determination

- Filtered Signal S_i $(i = 1, 2, \ldots, N)$
- Differential Signal $\Delta S_j = S_j - S_{j-1}$ $(j = 1, 2, \ldots, N-1)$



Preliminary Experiment

Format	Wave 16-bit LPCM
Sampling rate	44.1 kHz
Recording time	5□10 sec
Channels	Mono

- 100 sound files were collected with and without passing-by cars.
- Car sound
  - A recorder is on a sidewalk
  - 2-lane road
- Non-car sound
  - Inside a train
  - On campuses
  - On streets where pedestrians were walking

Experimental Result

	Car	Non-Car
Correct	45	48
Error	5	2
Accuracy	90%	96%

Correct	Error	Mean Error per file	Accuracy
38	12	1.08	76%

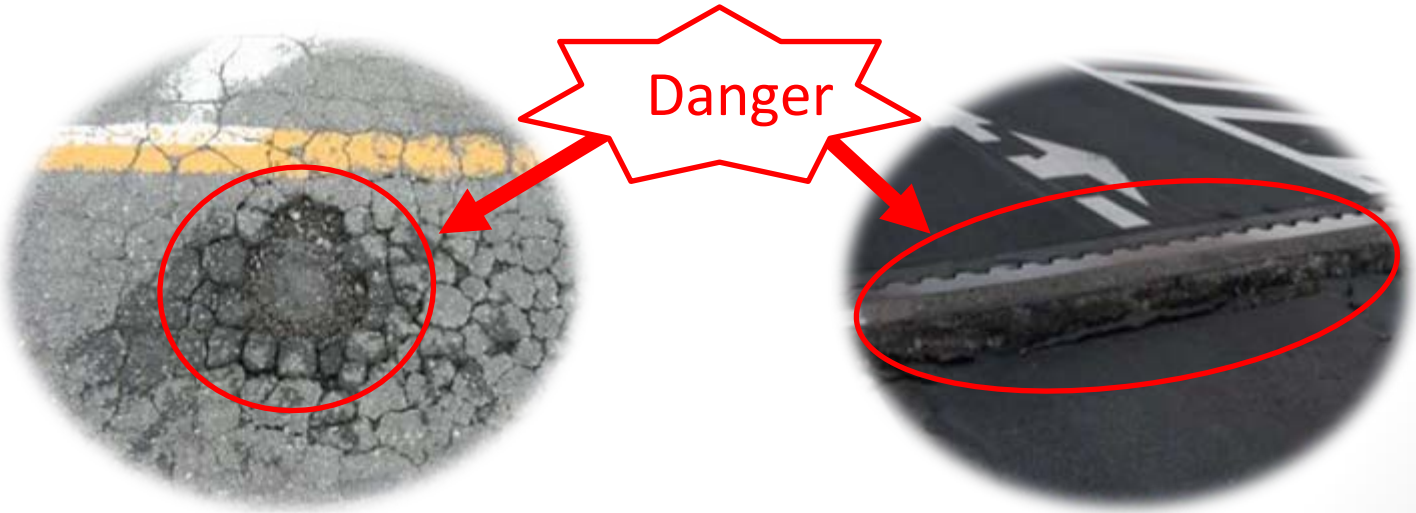
Visualization of City

- Sound
- Roads with respect to maintenance
- View (Google Maps, Google Earth)
- …
- …

Road Surface

- Long-Term Maintenance of Social Infrastructure
  - Roads, Cycling Roads

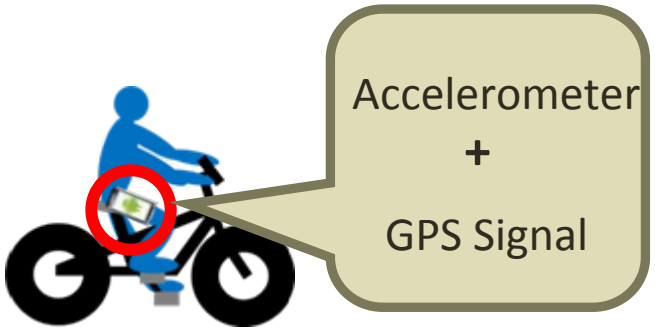
Needs Early Detection of Anomaly.

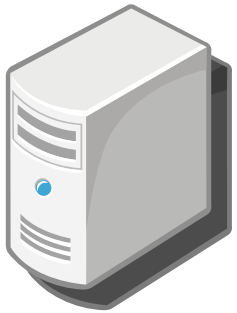


Our Approach

- YKOB（Your Kinetic Observation Bike）
  - ✓ Investigation by Participatory Bike Riders
  - ✓ Android Phones

Collection & Transmission → **Analysis** → **Visualization**





УКОВ

Collection of Data

Extraction of Road-Surface Signal

Detection of Anomaly

Classification of Anomaly

YKOB

Collection of Data

Extraction of Road-Surface Signal

Detection of Anomaly

Classification of Anomaly

- Smartphone in a pocket of bike rider

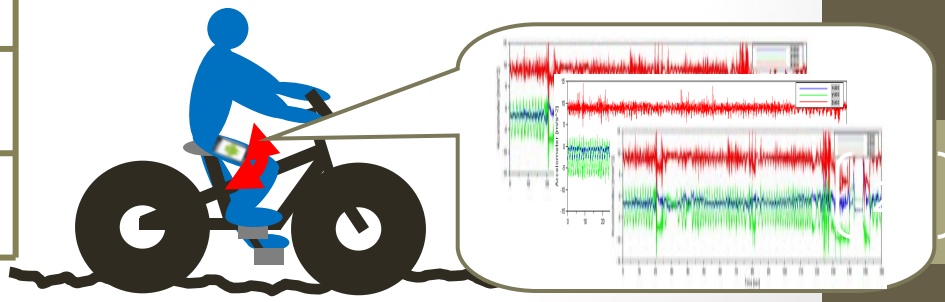
Collection of Data

- Installation
  - Pocket of pants
- Format

Time	Latitude	Longitude	X_{acc}	Y_{acc}	Z_{acc}

- Conditions

Sampling Frequency	50 Hz
Assumed Speed	12~14 km/h
Type of Bike	City Bike



YKOB

Collection of Data

Extraction of Road-Surface Signal

- Collected signal contains signals other than source from road surface
- Extract only road-surface signal

Detection of Anomaly

Classification of Anomaly

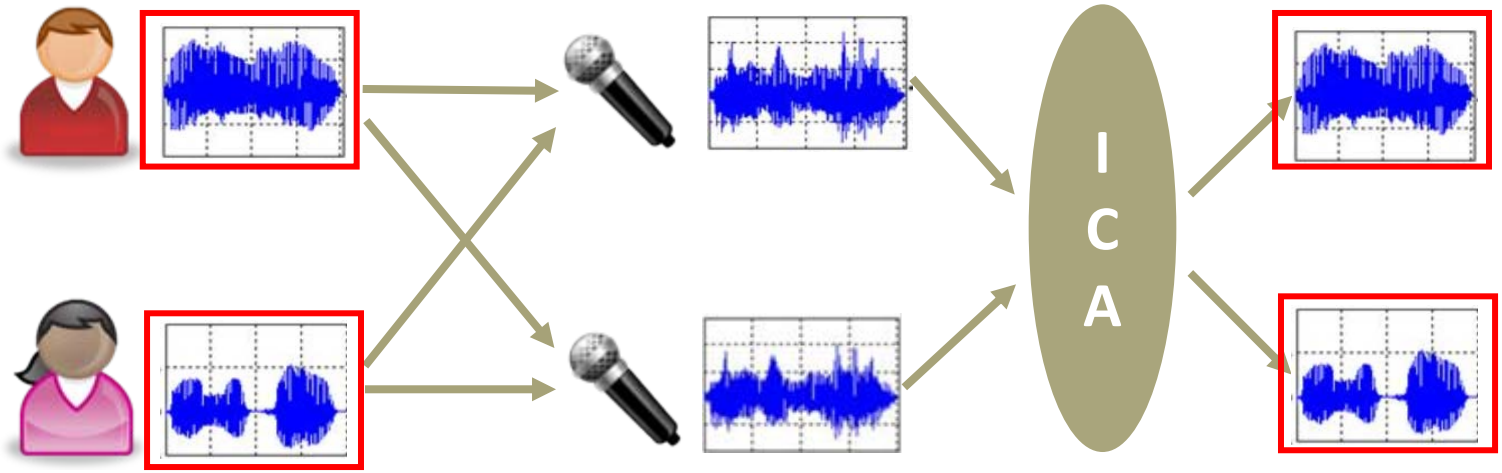
Extraction of Road-Surface Signal (□/□)

- Mixture of Pedaling and Road-Surface Signals

Separation based on ICA

- Independent Component Analysis (ICA)

  Separate Independent Signals from Observed Signals



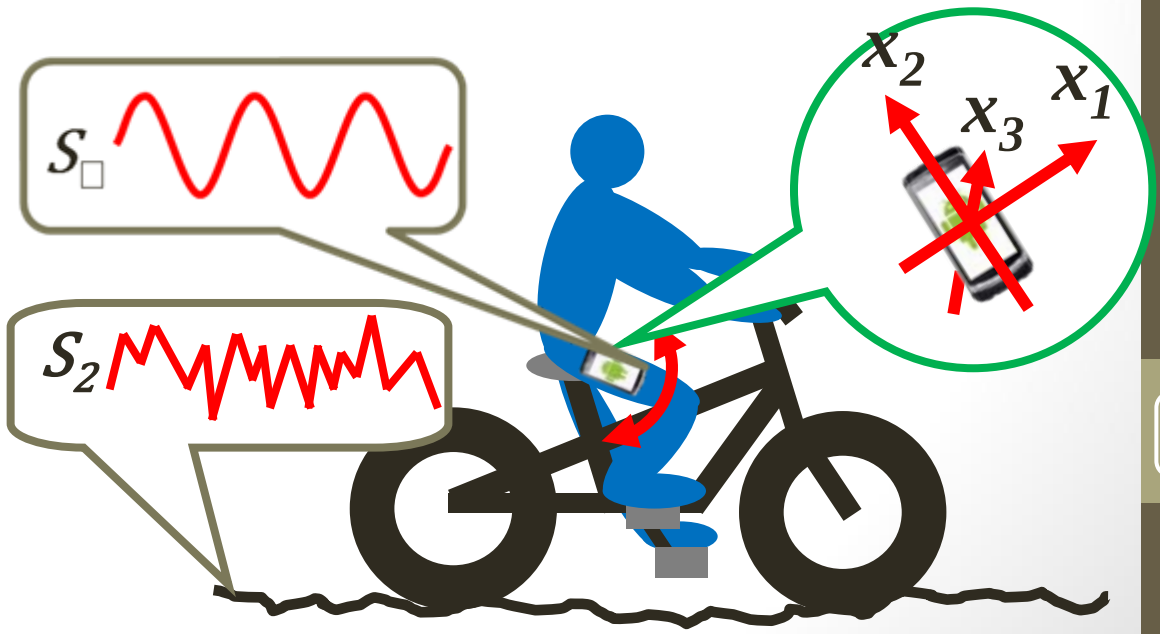
Extraction of Road-Surface Signal(□/□)

- Applying ICT to the raw signal

- Independent Signals $S = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}$ $(s_1: Peddaling, s_2: Road\ Surface)$
- Observed Signals $x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ $(x_1: x\ acceleration, x_2: y\ accel., x_3: z\ accel.)$
- Mixing Matrix A

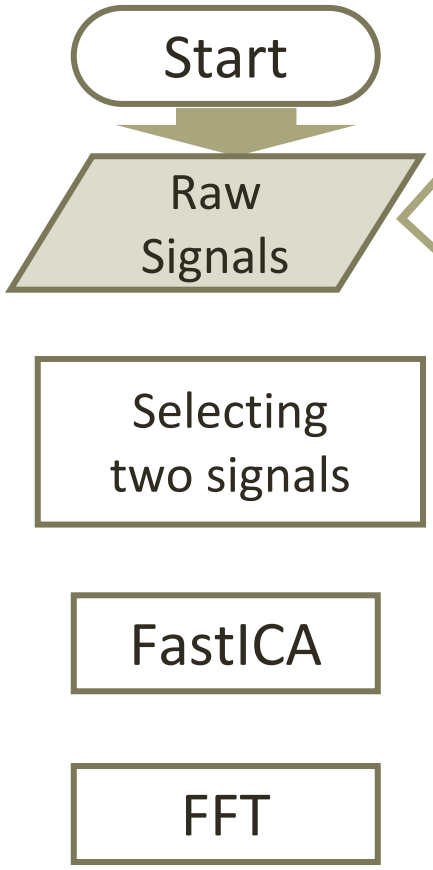
$$x = As$$

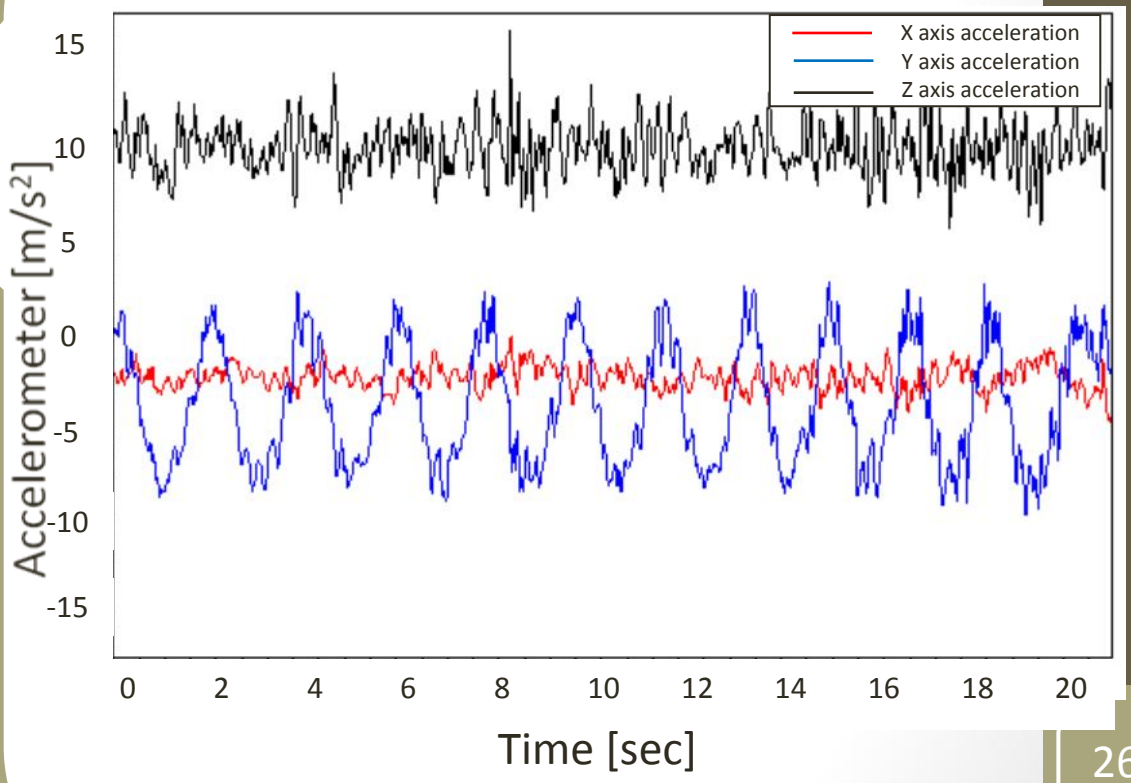
$$\hat{s} = \hat{A}^{-1}x$$



Extraction of Road-Surface Signal(3/5)

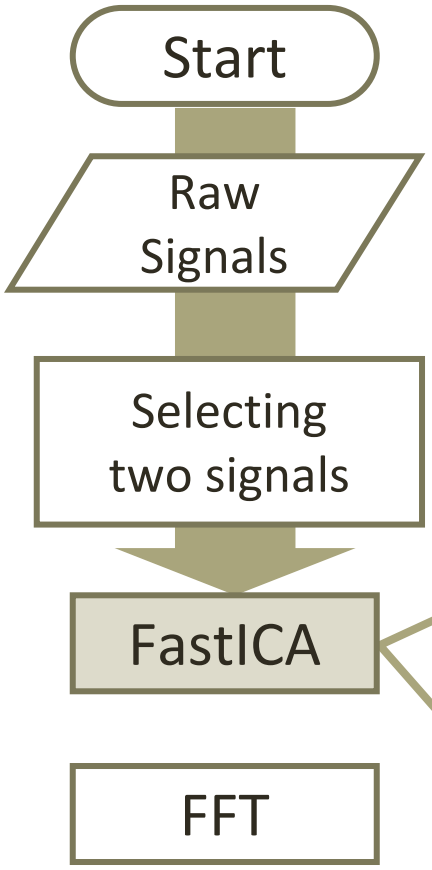
- Obtaining Acceleration Signal

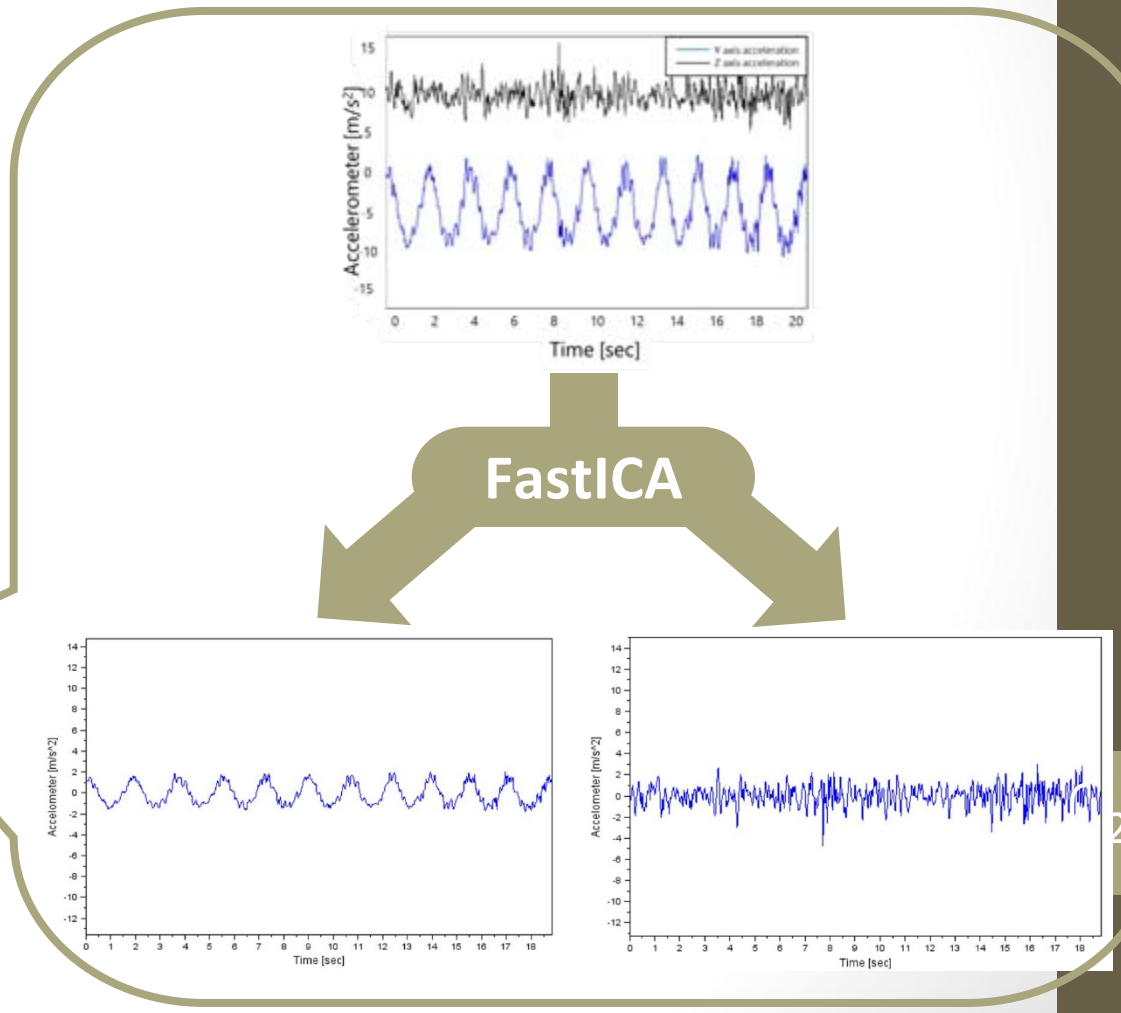




Extraction of Road-Surface Signal (4/5)

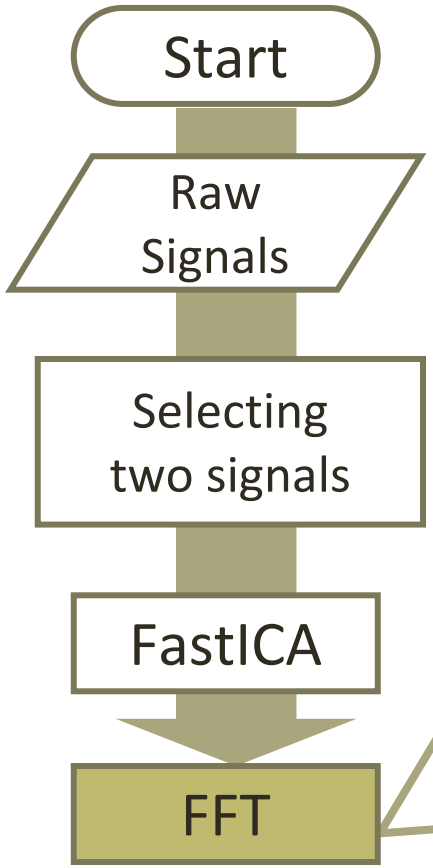
- Separation of signals using FastICA

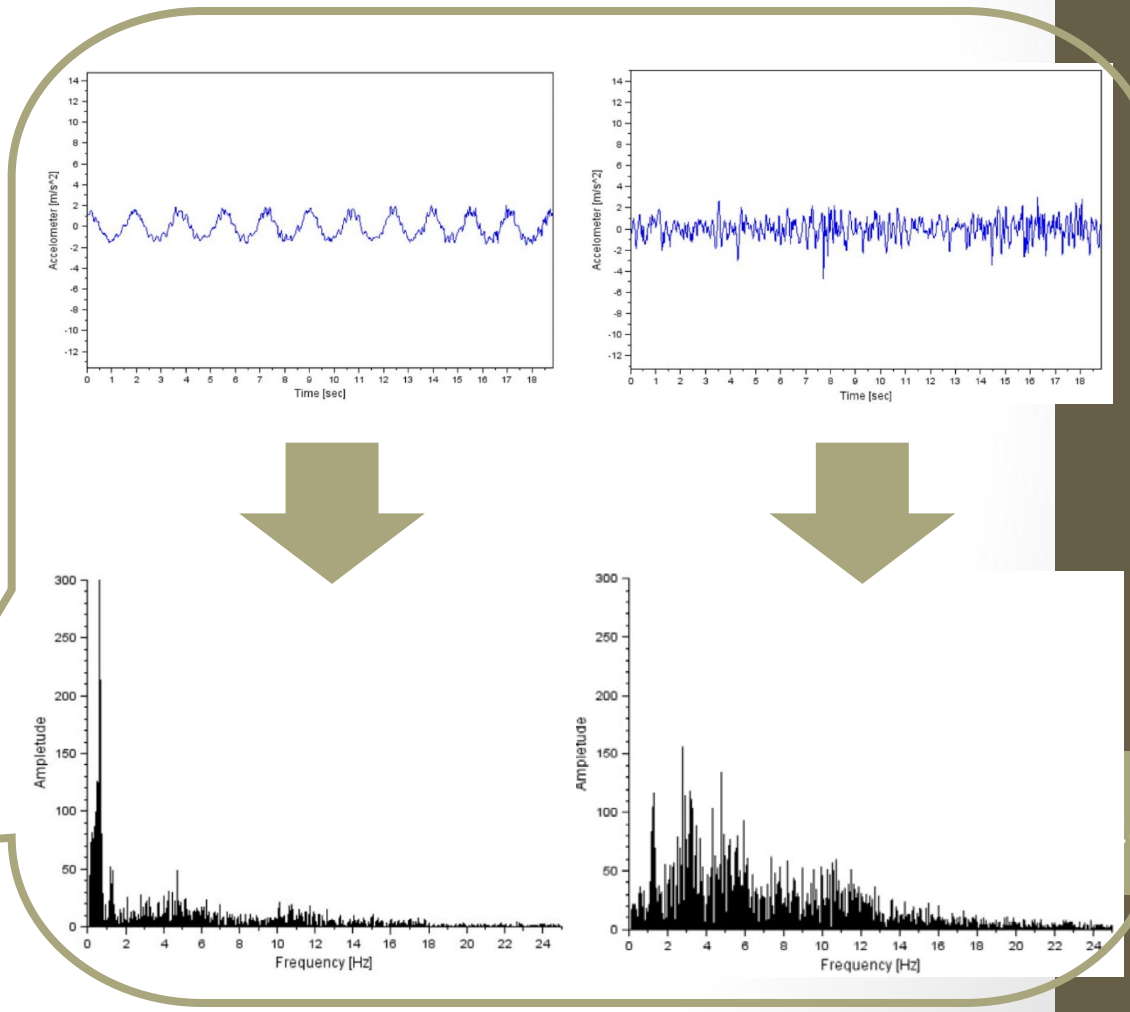




Extraction of Road-Surface Signal (5/5)

- Extraction of Periodicity using FFT





YKOB

Collection of Data

Extraction of Road-Surface Signal

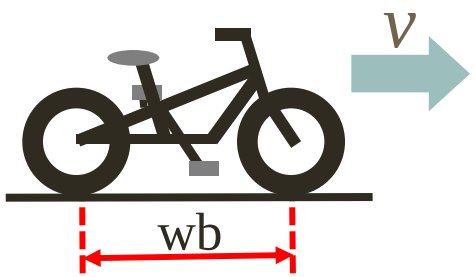
Detection of Anomaly

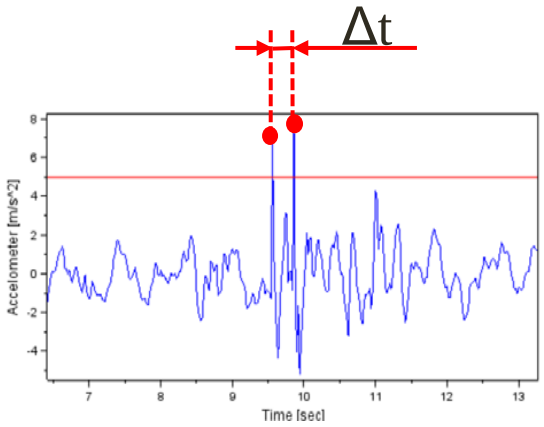
- Algorithm of Detecting Anomaly Location

Classification of Anomaly

Detection of Anomaly

- Use two peak values corresponding to the front and the rear wheel





$\Delta t = 0.30$ [s]

$v = 13.4$ [km/h]

wb = **1102 [mm]**

$d = \Delta t * v$ = **1102 [mm]**

- Threshold

  Δt < 0.4 s (based on experiments)

Detection of Anomaly□□/3□

Detection of Anomaly（3/3）

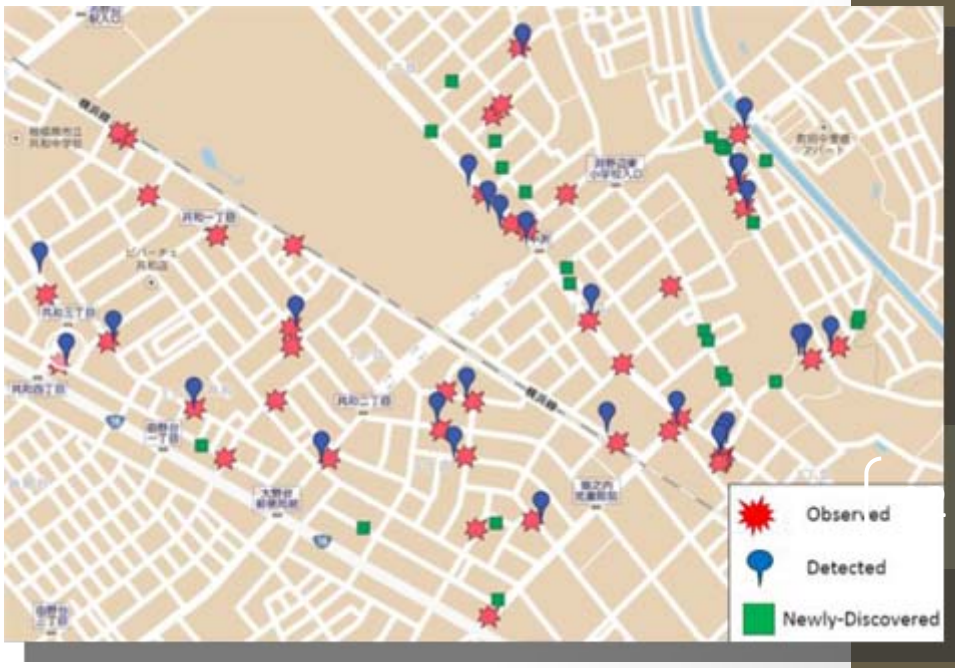
- Results

N_o : # of observed anomaly （42 locations）

N_d : # of correctly detected anomaly （28 locations）

N_n : # of incorrectly detected anomaly （26 locations）

	Definition	Ratio
Correct	$\frac{N_d}{N_o}$	0.67
Incorrect	$\frac{N_n}{N_d + N_n}$	0.48



vCityMap Sagamihara

- OpenStreetMap
- Collector
  - Android Application Downloadable from the Web
- Visualizer
  - JavaScript

- Participants
  - Began in July 2014
  - 9 participants
  - Facebook Community

vCityMap

rcl.it.aoyama.ac.jp/vcitymap/

Apps | プレゼンタイマーOnline | Grammarly | Inst… | IP address chang… | コンピュータアーキテク… | 各種申請用紙・関… | Internet Program…

vCityMap-Sagamihara

vCityMap

- HOME
- MAP
- APPLICATION
- LINKS

お問い合わせ

ご不明な点がございましたら、下記メールアドレスまでお問い合わせください。

vcity-info@rcl-aoyama.jp

はじめに

vCityMap-Sagamihara は、相模原市およびその周辺の環境の変化を地図とむすびつけて記録に残していこうという試みです。具体的には、スマートフォンを保持している方から、場所・時刻付きのデータをアップロードしていただき、サーバ で管理します。あらゆる種類の状態取得に挑戦しますが、2014年はまず、

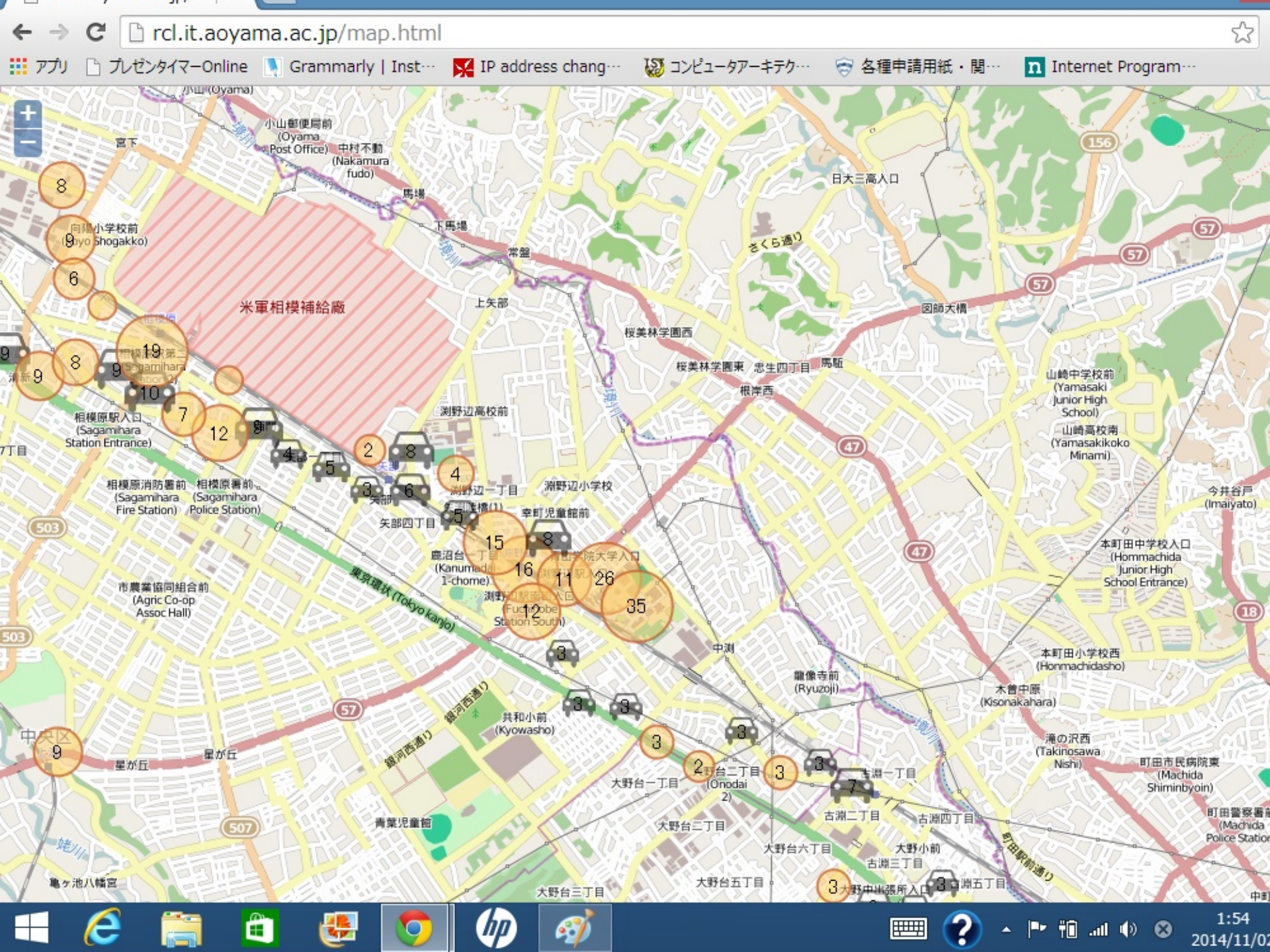
(1) 環境音

(2) 自転車走行に伴う路面の状態

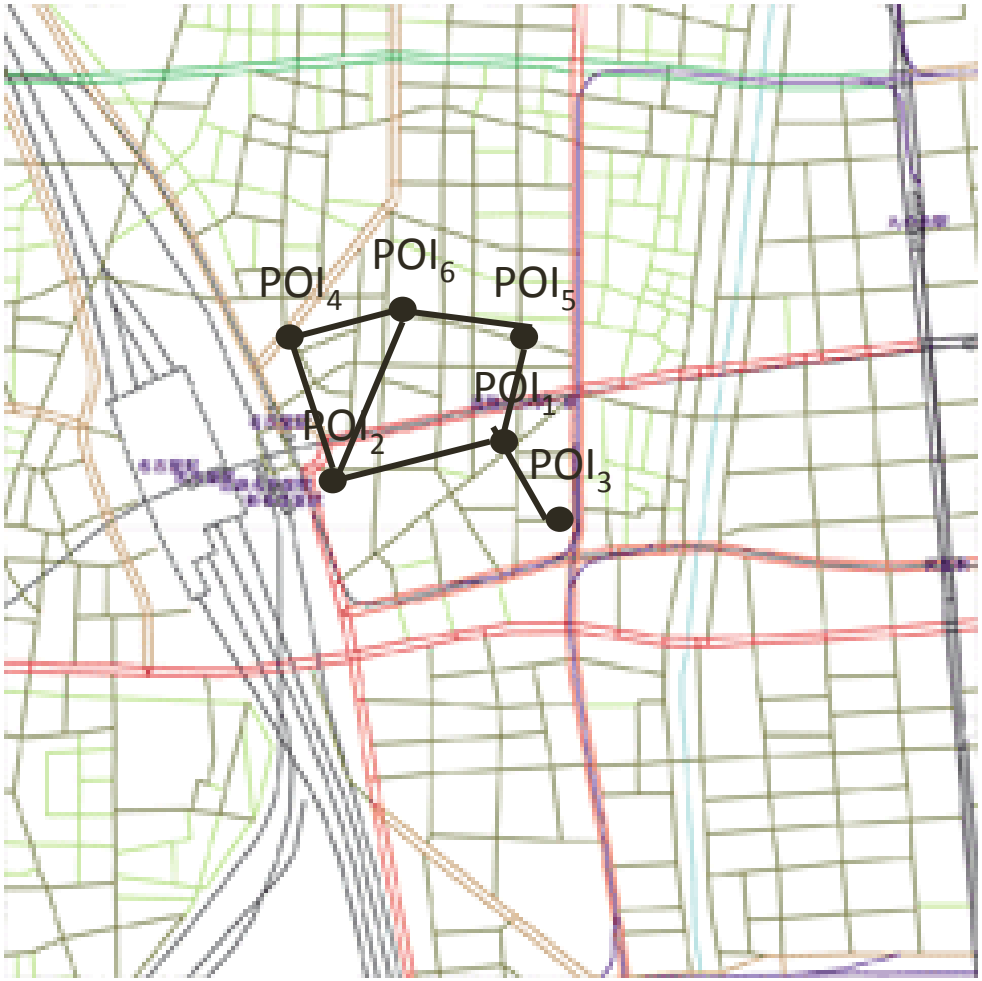
の2つに取り組む予定です。

情報収集にご協力お願いいたします。

MAP


rcl.it.aoyama.ac.jp/map.html
アプリ
プレゼンタイマーOnline
Grammarly | Inst…
IP address chang…
コンピュータアーキテク…
各種申請用紙・関…
Internet Program…
米軍相模補給廠
相模原駅入口 (Sagamihara Station Entrance)
相模原消防署前 (Sagamihara Fire Station)
相模原署前 (Sagamihara Police Station)
市農業協同組合前 (Agric Co-op Assoc Hall)
東京環状 (Tokyo kanjo)
共和小前 (Kyowasho)
青葉児童館
亀ヶ池八幡宮
渕野辺高校前
渕野辺小学校
渕野辺一丁目
矢部四丁目
辛町児童館前
鹿沼台一丁目 (Kanumadai 1-chome)
渕野辺駅南口 (Fuchinobe Station South)
中渕
龍像寺前 (Ryuzoji)
大野台一丁目
大野台二丁目 (Onodai 2)
大野台三丁目
大野台五丁目
大野台六丁目
大野小前
古淵一丁目
古淵二丁目
古淵三丁目
古淵四丁目
古淵五丁目
大野中出張所入口
日大三高入口
桜美林学園西
桜美林学園東
忠生四丁目
根岸西
図師大橋
さくら通り
山崎中学校前 (Yamasaki Junior High School)
山崎高校南 (Yamasakikoko Minami)
本町田中学校入口 (Hommachida Junior High School Entrance)
本町田小学校西 (Honmachidasho)
木曽中原 (Kisonakahara)
滝の沢西 (Takinosawa Nishi)
町田市民病院東 (Machida Shiminbyoin)
町田警察署前 (Machida Police Station)
今井谷戸 (Imaiyato)
小山郵便局前 (Oyama Post Office)
中村不動 (Nakamura fudo)
向陽小学校前 (Koyo Shogakko)
馬場
下馬場
常盤
上矢部
星が丘
中央区
銀河西通り
境川
姥川
鶴見川
相模川
57
47
503
507
156
18

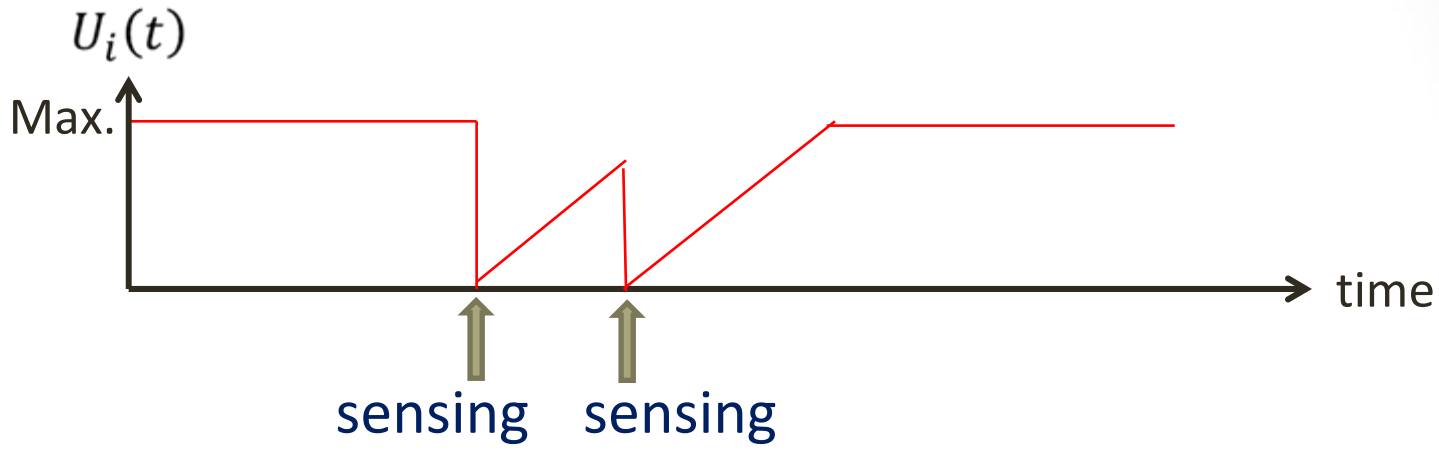
Point of Interest (POI)



Consumers determine POIs

Utility Function

Sensing data at a POI *i* are independent of other POIs



$$U(t) = \max\left(U_{min}, \min\left(U_{max}, a(t - t_{prev})\right)\right)$$

$U(t)$ = Utility at POI i at time t
U_{min} = Minimum utility
U_{max} = Maximum utility
a = Constant
t = Current time
t_{prev} = Latest sensing time at POI i

Summary

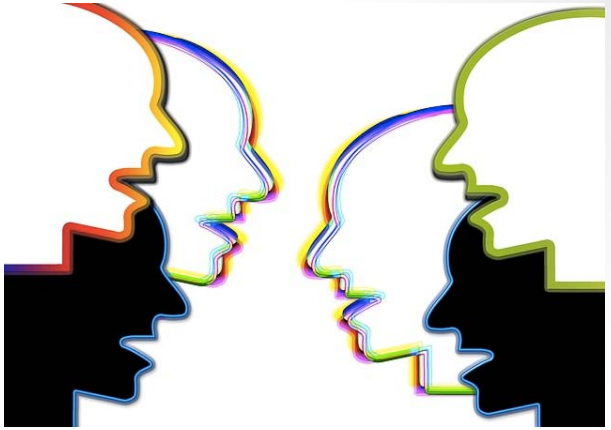
- We have created a crowdsensing kit.
- Starting from
  - Sound Maps
  - Road-Surface Status Maps

- Future Plans
  - Community in Android-phone users
  - Decision of POIs
  - Machine Learning for classification

Sensor-Data Efficiency Index

- $\mu = C / (U + C)$
  - C: Consumed Data
  - U: Unconsumed Data
- Low μ means energy inefficiency
  - "Hey, don't produce that many data!"
- Not Consumed by One Person

Discussion



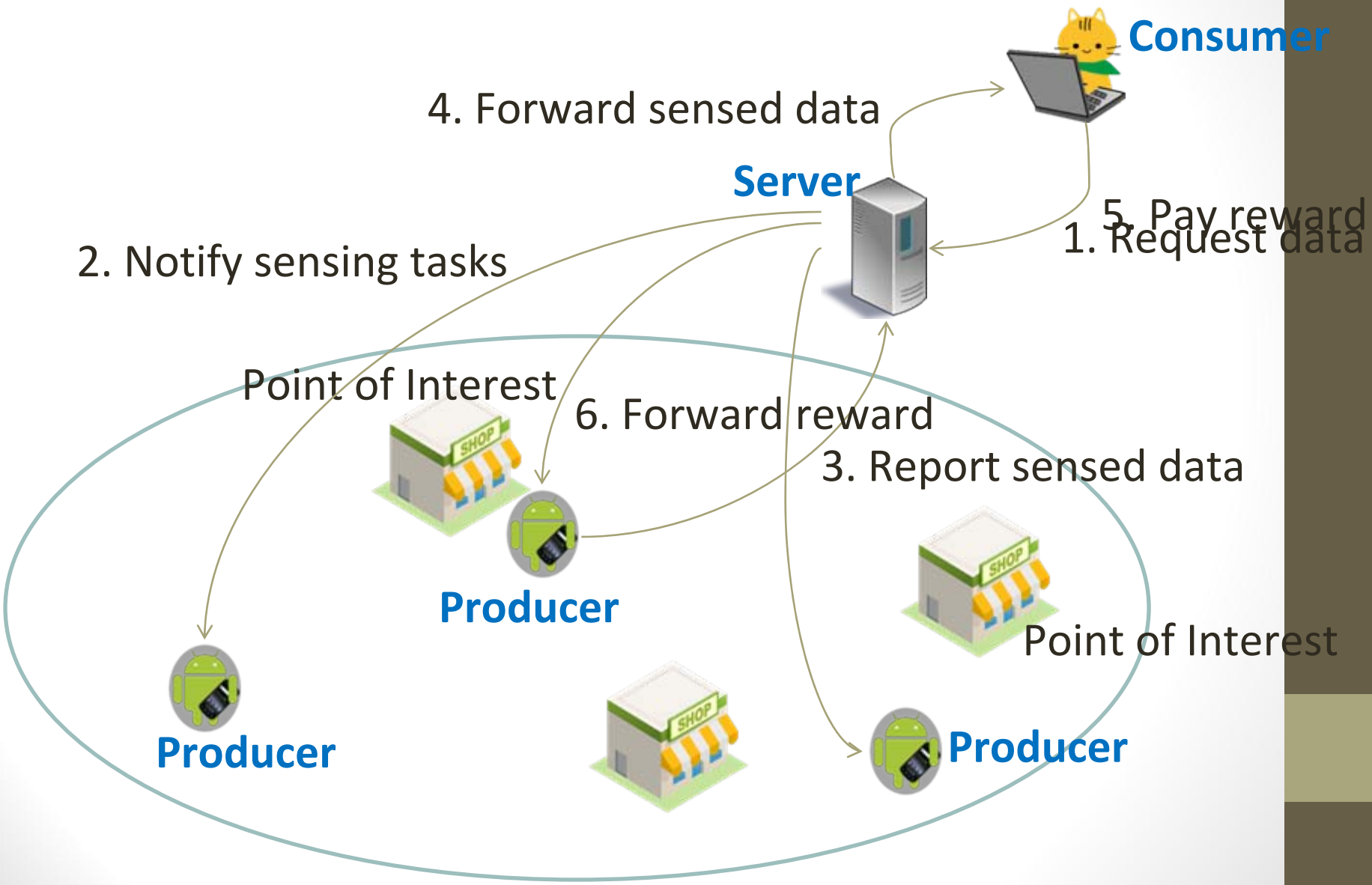
- Thresholds are optimized?
  - Use machine learning technique

- Avoid detection error
  - Use features in frequency domain

Transmission of Data

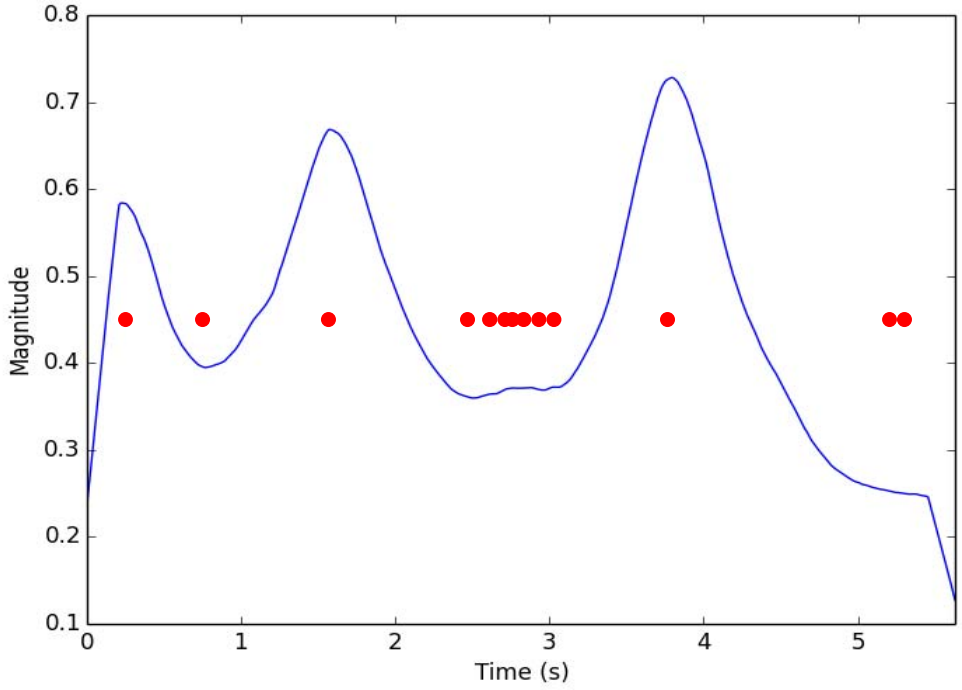
- # of packets affects energy consumption
- Wait until the maximum packet size and send

SenseUtil System: Server, Consumer & Producer



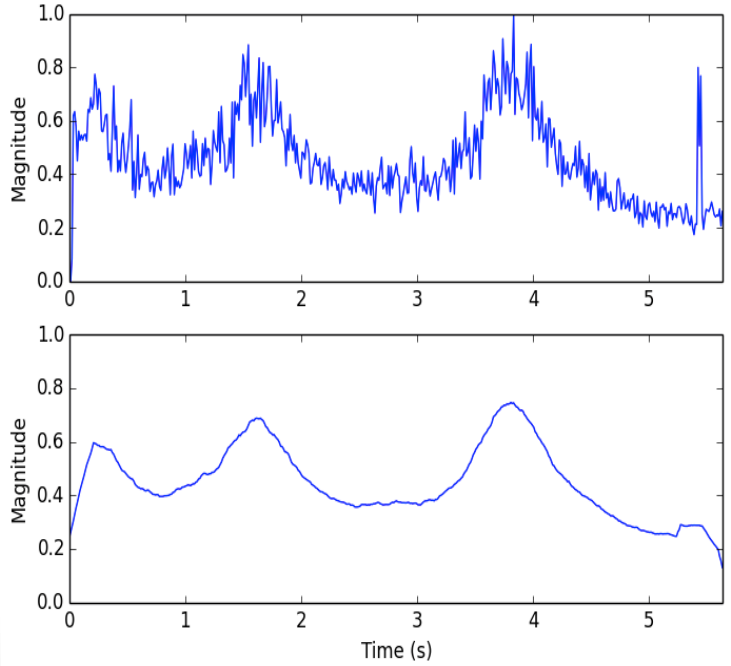
Determination

- Filtered Signal S_i $(i = 1, 2, \ldots, N)$
- Differential Signal $\Delta S_j = S_j - S_{j-1}$ $(j = 1, 2, \ldots, N-1)$

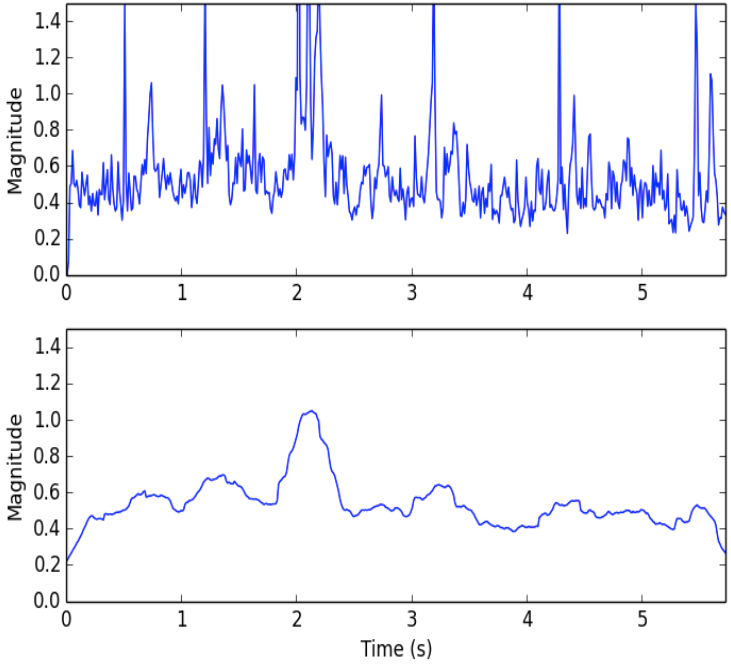


Filtering

- Non-car sound may still be contained in candidate arches



In a case where 3 cars pass



In a case of other environmental sound