Smart usage of context information for the analysis, design and generation of power-aware policies for mobile sensing apps

Doctoral seminar 2016

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Agenda

Background
Motivation

- The popularity of mobile devices is a result of advances in their computation, sensing, and communication dimensions [1].
  - The sensing facilities improve interaction with user, turning them into *omni-sensors* able to *know* about its surrounding environment.

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  - **Context** is the set of environmental states and settings that either determines an application's behavior or in which an application event occurs and is interesting to the user [2].
- However, battery is not evolving at the same pace than the advances in other smartphone's characteristics [3], growing only 5-10% each year [4, 5].
  - The energy constraint becomes critical when continuous access to sensors is needed, which is a core requirement of **mobile sensing applications**.

Background
Stages of mobile sensing applications

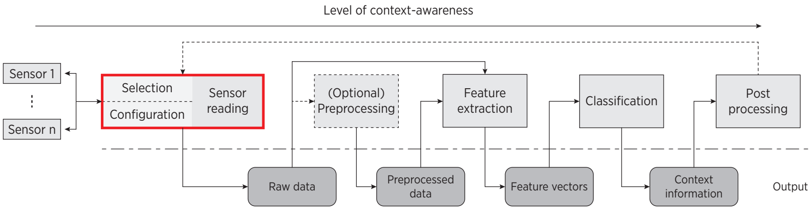

Figure: Stages of mobile sensing applications

There is a tradeoff between the accuracy of context information retrieved and the associated energy consumption [6, 7]. How to face it?

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- An intelligent policy is a special rule that defines how sensors should be selected and configured to reduce energy consumption and achieve the mobile sensing app's requirements. It is intelligent in terms of self-adaptness to changes detected in context information across time.
- This research work is aimed at employing GPS and inertial sensors data (accelerometer) for inferring context information in terms of mobility patterns. This context information will then be exploited to adapt sensors' operation and produce power savings.

Problem definition
Problem statement

Problem 1: Mobility pattern identification

Given a set $V = \{v_1, v_2, \ldots, v_n\}$ of data values read from sensor S in the time interval $T \in [t_1, t_2]$, identify the current mobility pattern p_S that represents the activity of user.

$$\mathrm{PatternIdentifier}(V) \longrightarrow p_S \in \mathbf{Patterns} \quad (1)$$

Where **Patterns** is a set of patterns that represent a user’s mobility context situation, specifically the set `{no movement, walking, running, vehicle transportation, arriving stay point, leaving stay point}` .

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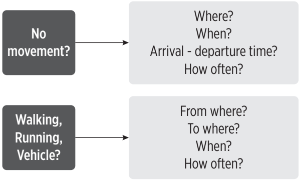


Figure: Context information related to mobility patterns

Problem definition
Problem statement

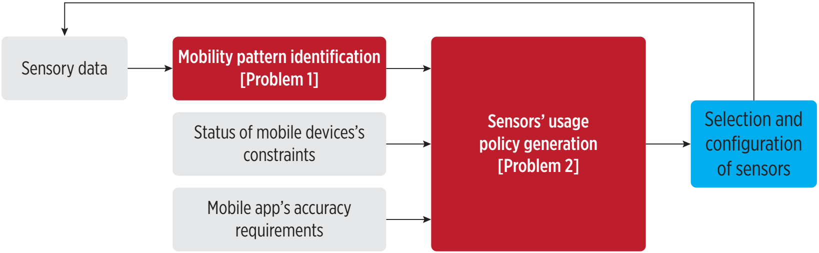
Problem 2: Policy generation

Given the set of detected mobility patterns $\mathcal{P} = \{p_{S_1}, p_{S_2}, \ldots, p_{S_n}\}$ in data from sensors $\mathcal{S} = \{S_1, S_2, \ldots, S_n\}$, accuracy required a, and physical constraints status c of a mobile device, find a policy that select the proper set of sensors $\mathcal{S}_{new}$ and its associated configuration $\mathcal{S}_{new_{conf}}$ while meeting application requirements.

$$\text{PolicyGeneration}(\mathcal{P}, a, c) \longrightarrow \mathcal{S}_{new}, \mathcal{S}_{new_{conf}} \tag{2}$$

The $\mathcal{S}_{new_{conf}}$ configuration is referred to as the *adaptive duty cycle* of associated sensors.

Problem definition
Interaction between problems



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- To identify mobility patterns from context information obtained from an inertial sensor (accelerometer) and location providers (GPS).
- To generate an accurate representation of mobility patterns, which in conjunction with accuracy mobile app requirements and mobile device constraints, allows to generate power-aware GPS sensing policies.

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To reduce energy consumption in the mobile sensing apps, which perform continuous sensor readings, through self-adapting power-aware policies generated from context information obtained from sensors data.

Particular objectives

- To identify mobility patterns from context information obtained from an inertial sensor (accelerometer) and location providers (GPS).
- To generate an accurate representation of mobility patterns, which in conjunction with accuracy mobile app requirements and mobile device constraints, allows to generate power-aware GPS sensing policies.
- To reduce energy consumption in location-based mobile sensing apps through a middleware that implements policies fed with mobility patterns learned from sensors data.

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Expected contributions

- A mechanism for detecting mobility patterns from the data read by sensors of mobile devices (GPS and accelerometer).

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Expected contributions

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- A mechanism for generating policies for accessing sensors. The produced policies will allow to perform an intelligent usage of smartphone's sensing facilities in continuous sensor sampling, reducing the energy consumption.
- A middleware implementing the previous power-aware mechanisms for easing the development of location based services.

Problem definition
Problem's scenario

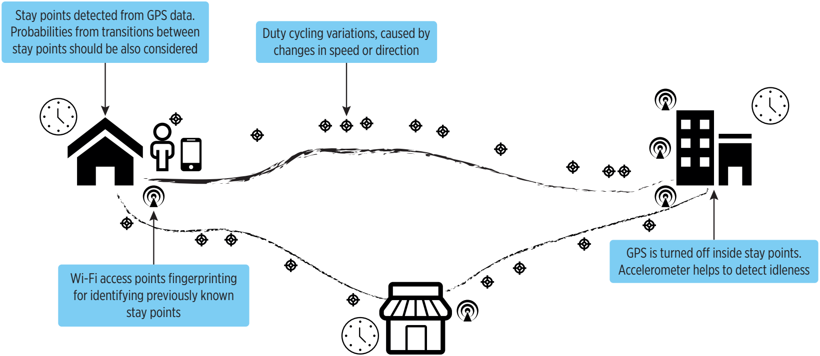

Figure: Basic problem's scenario

Related work
Previous work

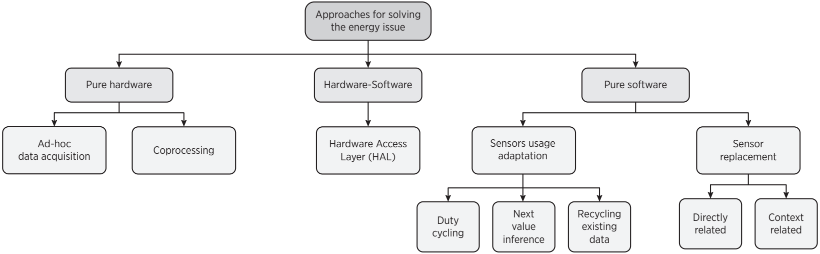

Figure: Taxonomy of related work solutions

Methodology

Methodology steps

1. Familiarization with state-of-art power-aware sensing related techniques
2. Formal definition and selection of mobility patterns to be identified
3. Research on pattern recognition algorithms focused on mobility patterns identification
4. Design of the Pattern Identification Element (PIE)
5. Research on (and proposition of) adaptive policies for energy efficient usage of sensors
6. Design of the Policy Generation Element (PGE)
7. Development of a middleware involving the PIE and PGE for the Android platform
8. Experimentation in terms of accuracy and energy efficiency

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Characteristics

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Overview

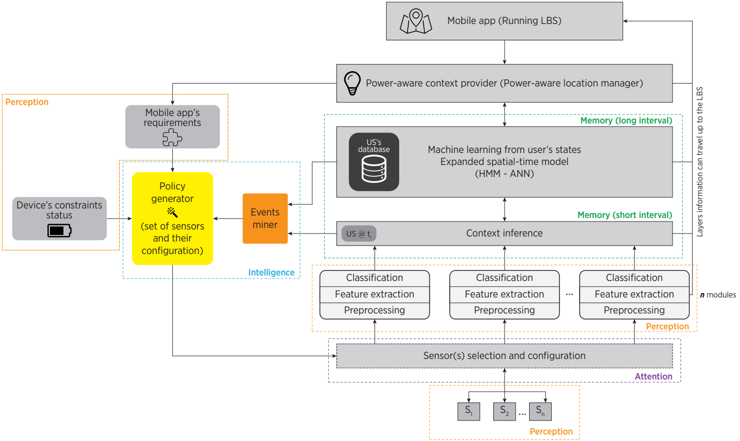

Figure: Overview of current solution

Proposed solution
Operation

- Overall problem divided into:
  - Detection of stay points (The anchor points that user visits frequently).

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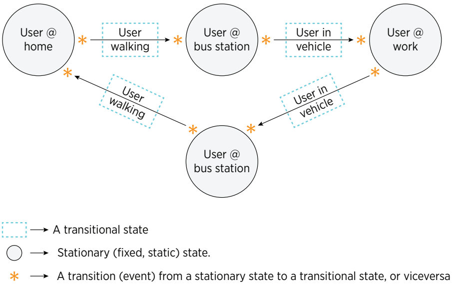

Figure: Information modeled by the expanded spatial-time model

Schedule

	Work: ● Done, ● In progress, ○ To be done	2014 3rd	2015 1st	2015 2nd	2015 3rd	2016 1st	2016 2nd	2016 3rd
	STEP I							
1	State-of-art reading	●	●					
2	State-of-art works categorization		●	●				
3	Documentation of information found (committee request)			●				
	STEP II							
4	Development of a mobile app for accelerometer and location data collection			●	●			
5	Analysis of data				●			
6	Formal definition of mobility pattern				●			
7	Selection of mobility patterns				●	●		
	STEP III							
8	Research on classification algorithms for mobility patterns				●	●		
9	Definition of metrics for evaluating algorithms					●		
10	Implementation of algorithms in mobile platform					●	●	
11	Selection of best algorithms according to metrics						●	
	STEP IV							
12	Definition and modeling of parameters needed by the PIE				●	●	●	●
13	Building of the PIE				●	●	●	●

Table: Schedule of activities (each column represents a four months period)

Schedule

Work: ● Done, ● In progress, ○ To be done		2016 1st	2016 2nd	2016 3rd	2017 1st	2017 2nd	2017 3rd	2018 1st
	Step V							
14	Formal definition of policy			●				
15	Research and evaluation of techniques for generation and adaption of policies			●	●			
16	Design and execution of experiments applied to use cases			●	●			
17	Selection of policies				●			
	Step VI							
18	Definition and modeling of PGE parameters					●		
19	Building of the PGE					●		
	Step VII							
20	Analysis of components into software abstractions					●		
21	Research on Android API for specialized components					●		
22	Development of middleware					●		
	Step VIII							
23	Definition of experiments aimed at accuracy and energy consumption metrics						○	
24	Development of experimental sample mobile apps						○	
25	Experiments execution						○	○
26	Final results analysis							○

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Schedule

		2014	2015			2016			2017			2018	
Work: ● Done, ● In progress, ○ To be done		3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd
	REQUIRED TASKS												
A	Related courses	●	●	●									
B	Research articles submission				●		●					○	
C	Predoctoral exam preparation									○			
D	Thesis writing	●			●			●			○	○	○

Table: Schedule of required activities

Conclusions

As conclusions, in the current talk it has been provided:

- The antecedents and motivation of the current research.

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- The antecedents and motivation of the current research.
- A methodology based on the usage of context information for reducing energy consumption in location-based mobile apps.
- The main blocks of a middleware with an event-driven design and Cognitive Dynamic Systems fundamentals.
- The detailed work plan for addressing each of the methodology steps, including performed and pending activities.

Thank you for your attention!

We make our world significant by the courage of our questions and by the depth of our answers.

Carl Sagan

Cinvestav

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