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

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Structure

Introduction
Background

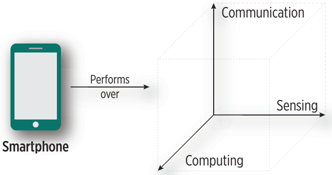


Figure: The advances in the communication, computing and sensing dimensions of mobile devices contribute to their acceptance by society.

Background

- Smart devices, such as the smartphone, become popular after the advances on many of its components.
- The sensing dimension enables *context-awareness* in mobile device, for new interaction ways with users and enhanced operation.
- Battery advances are slower than those of other smartphone components [1], growing 5-10% yearly [2, 3].
- The energy constraint is critical when continuous access to sensors is needed, as in **mobile sensing applications**.

Introduction
Motivation

Motivation

- For the sensing dimension, scientific efforts have been done for achieving the energy efficiency of the GPS location provider.
- The understanding of mobility could augment the location-awareness of the smartphone for many purposes, such as energy savings and the development of Mobility Based Services (MBS).
- As a high level of abstraction, mobility can be characterized as a sequence of frequently visited places (stay points).

Problem statement

- The understanding of mobility is possible at different spatial-temporal scales:

Fine-grain mobility patterns identification

- They refer to the transportation mode employed by user when moving between stay points.
- Given a set of values $\mathcal{V} = \{v_{acc\ 1}, v_{acc\ 2}, \ldots, v_{acc\ n}\}$ obtained from accelerometer in the time interval $[t_1, t_2]$, identify fine-grain mobility information:

$$\textbf{FineGrainMobilityIdentifier}(\mathcal{V}) \rightarrow p_S \in \{\text{static, walking, biking, vehicle}\}$$

with each $v_{acc\ i} \in \mathcal{V}$ composed as $\langle acc_x, acc_y, acc_z, t \rangle$.

Coarse-grain mobility patterns identification

- They refer to motion at a large spatial scale related to user visiting stay points.
- Given a set of values $\mathcal{V} = \left\{v_{gps\ 1}, v_{gps\ 2}, \ldots, v_{gps\ n}\right\}$ obtained from GPS location provider in time interval $[t_1, t_2]$, identify coarse-grain mobility information:

$$\textbf{CoarseGrainMobilityIdentifier}(\mathcal{V}) \rightarrow p_S \in \{\text{new stay point, arrival, departure}\}$$

with each $v_{gps\ i} \in \mathcal{V}$ composed associated $\langle lat, lon, t \rangle$.

Hypothesis

Hypothesis

- The energy consumption of continuous and extended location tracking could be reduced by means of a cognitive dynamic system that learns an expanded spatial-time model from mobility events detected from sensors data and that employs such model in a cognitive controller for dynamically adapting GPS sampling rate through sampling policies tailored to current mobility state.

Objectives

Main objective

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

Particular objectives

- To detect mobility patterns from context information obtained from an inertial sensor (accelerometer) and location provider (GPS).
- To generate an accurate representation of detected patterns for summarizing user mobility.
- To dynamically adapt GPS sampling rate by means of a cognitive controller that employs the learned mobility representation and accuracy requirements for implementing power-aware sampling policies.
- To ease the development of mobile sensing applications that require user location tracking, i.e., LBSs and MBSs, isolating the complexity of sensors access and the associated efficient energy management.

Contributions

Contributions

- An on-device mobility patterns detector that works with streams of raw data collected by smartphone's sensors (GPS and accelerometer).
- An on-device mobility analyzer that incrementally builds a model of user mobility from the detected mobility patterns.
- A cognitive controller inspired on CDSs that, based on the mobility information learned, dynamically adapts GPS sampling rate through power-aware policies.
- A middleware with the previous modules embedded for easing the development of LBSs and MBSs for the Android mobile platform.

Methodology

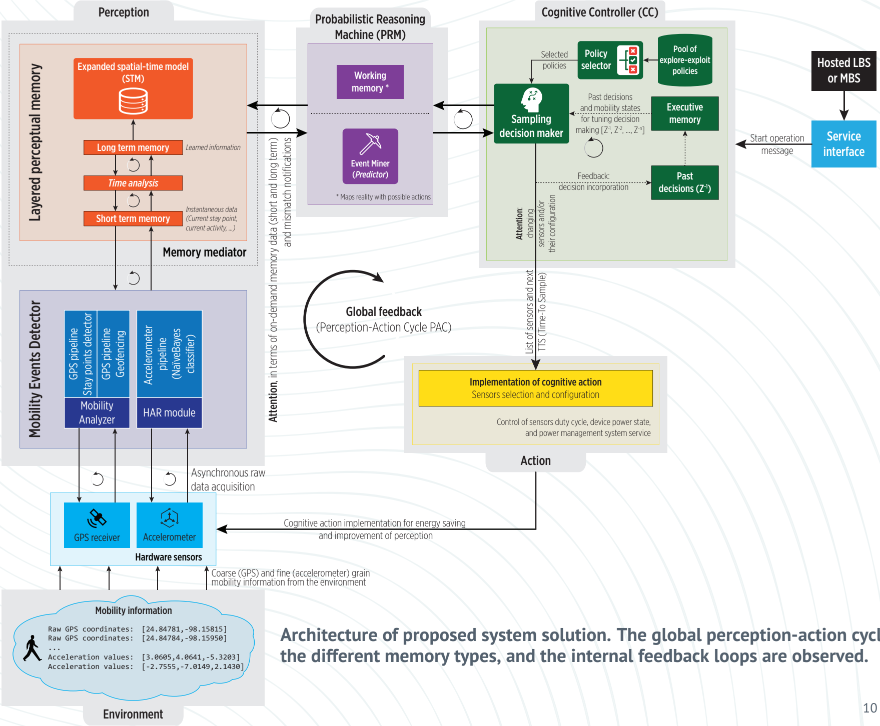
Steps

1. Revision of state of the art power-aware sensing techniques.
2. Formal definition and selection of mobility patterns to be identified.
3. Research on algorithms for detecting mobility patterns.
4. Design of the *Mobility Events Detector*.
5. Design of adaptive policies for energy efficient usage of sensors.
6. Design of the Cognitive Controller.
7. Development of a middleware involving the *Mobility Events Detector* and the Cognitive Controller for the Android platform.
8. Experimentation in terms of spatial-time accuracy and energy efficiency.

Methodology

				2017							2018			
#	Activity	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	I Integration of components													
1	Incorporation of the HAR module in the CC	●	●											
2	Incorporation of the accuracy requirement in the CC		●	●										
	II On-device implementation													
3	Implementation of sigmoid-driven sampling				●									
4	Watchdog mechanisms for Geofencing and Sampling Decision Maker modules				●									
5	Refinement of the list of candidate stay points employed by the Geofencing module				●	●								
	III Experimentation													
6	Experiments with larger and heterogeneous mobility						●	●	●					
7	Completion of evaluation framework					●	●	●						
8	Comparison with other solutions									●	●			
	IV Research work activities													
9	Thesis writing-review								●	●	●	●	●	
10	Thesis defense													●

Table: Schedule of research work pending activities for the last year of the doctoral program.



Architecture of proposed system solution. The global perception-action cycle, the different memory types, and the internal feedback loops are observed.

References I

[1] Mikkel Kjaergaard.
Location-based services on mobile phones: Minimizing power consumption.
IEEE Pervasive Computing, 11:67–73, 2012.

[2] Xiao Ma, Yong Cui, and Ivan Stojmenovic.
Energy efficiency on location based applications in mobile cloud computing: A survey.
In *Procedia Computer Science*, volume 10, pages 577–584, 2012.

[3] Eric C. Evarts.
Lithium batteries: To the limits of lithium.
Nature, 526(7575):S93–S95, oct 2015.

Detailed schedule

Work: ● Done, ● In progress, ○ To be done		2014	2015			2016		
		3rd	1st	2nd	3rd	1st	2nd	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)

Detailed schedule

Work: ● Done, • In progress, ○ To be done

		2016			2017			2018
		1st	2nd	3rd	1st	2nd	3rd	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							○

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

Detailed 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