Chapter 2
Context-Aware Smartphone Services

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ABSTRACT

Combining the functions of mobile phones and PDAs, smartphones can be considered versatile devices and offer a wide range of possible uses. The technological evolution of smartphones, combined with their increasing diffusion, gives mobile network providers the opportunity to come up with more advanced and innovative services. Among these are the context-aware ones, highly customizable services tailored to the user’s preferences and needs and relying on the real-time knowledge of the smartphone’s surroundings, without requiring complex configuration on the user’s part. Examples of context-aware services are profile changes as a result of context changes, proximity-based advertising or media content tagging, etc.

The contribution of this chapter is to propose a survey of several methods to extract context information, by employing a smartphone, based on Digital Signal Processing and Pattern Recognition approaches, aimed at answering to the following questions about the user’s surroundings: what, who, where, when, why and how. It represents a fundamental part of the overall process needed to provide a complete context-aware service.

INTRODUCTION

Context-aware smartphone applications should answer the following questions about the device’s surroundings (Dey, 2000): What, Who, Where, When, Why and How. As a consequence, in order to provide context-aware services, a description of the smartphone’s environment must be obtained by acquiring and combining context data from different sources, both external (e.g., cell IDs, GPS...
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coordinates, nearby Wi-Fi and Bluetooth devices) and internal (e.g., idle/active status, battery power, accelerometer measurements).

Several applications explicitly developed for smartphones will be surveyed in this chapter. In more detail, an overview of the context sources and sensors available to smartphones and the possible information they can provide is proposed in Section “Smartphones: an Overview”.

The general logical model of a context-aware service composed of i) Context Data Acquisition, ii) Context Analysis and iii) Service Integration is introduced in Section “Context-Aware Services”. A set of possible context-aware services such as Audio Environment Recognition, Speaker Count, Indoor and Outdoor Positioning, User Activity Recognition is listed in the following Sections. Further details concerning the aforementioned Context Analysis phase for specific context-aware services, which have been designed and implemented for smartphone terminals, are introduced as well.

In the specific case of this chapter, all context-aware services are based on sophisticated Digital Signal Processing approaches that have been specially designed and implemented for smartphones. The presented methods have been designed based on the principles set out by the corresponding related literature in the field, while additionally all the described solutions concern specific proposals and implementations performed by the authors.

Specifically, Audio Signal Processing-based services are introduced in Section “Audio Signal Processing based Context-Aware Services”. In more detail, Environment Recognition (Pertunen, 2009) and Speaker Count (Iyer, 2006) services are described. Concerning Environment Recognition, both the architecture and the signal processing approach designed and implemented to identify the audio surrounding of the terminal (by distinguishing among street, overcrowded rooms, quiet environment, etc.) will be presented. Speaker Count services will be introduced as well. In detail, determining the number of speakers participating in a conversation is an important area of research as it has applications in telephone monitoring systems, meeting transcriptions etc. In this case the service is based on the audio signal recorded by the smartphone device. The speech processing methodologies and the algorithms employed to perform the Speaker Count process will also be introduced.

An overview of services based on the processing of signals received by smartphones’ network interfaces such as GPS receiver, Wi-Fi, Bluetooth, etc. is proposed in Section “Network Interface Signal Processing based Context-Aware Services: Positioning”. In particular, Indoor Positioning methods (Wang et al., 2003) have been taken into account. In this case the information required to carry out the positioning process is obtained from multiple sources such as the Wi-Fi interface (in the case of Indoor Positioning) and the GPS receiver (in the case of Outdoor Positioning). In particular, the methods suitable for smartphone implementation will be illustrated with particular emphasis on the Indoor Positioning approaches that have been implemented and tested directly on smartphones.

Finally, possible User Activity Recognition services (Ryder, 2009) that can be provided, starting from raw data acquired directly from the measurements carried out by the smartphone’s accelerometer, are introduced in Section “Accelerometer Signal Processing based Context-Aware Services”. In this case, additional technical details on the methods for the classification of activities such as walking, running, etc. will be described.

In all Sections where specific context-aware services will be introduced, the design and the implementation aspects of each service will also be detailed, based on the practical expertise, the employed test-beds and the results obtained during specific experimental campaigns that we have conducted. The chapter moreover will focus on the computational load and the energy consumption that is required to provide specific context-aware services in order to take into account the limited