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THE USE OF SMARTHPONES IN THE 21ST CENTURY

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ABSTRACT

Smartphone devices are nowadays common affordable devices not only for communication purposes but also for determining the user's position, for sending emails, managing digital agendas and to allow internet access. Starting from last decade, they become interesting instruments also for engineering and biomedical applications, thanks to their high diffusion. In 2018, 66% of individuals in 52 key countries owned a smartphone, with an increment of about 3% in only one year. This fact permitted the rapid development of apps for different goals, starting from precise positioning both in outdoor and indoor scenarios, to the 3D reconstruction of the environment using images up to driving evaluation purposes or healthcare and biomedical engineering applications. This chapter resumes the main research fields where smartphone devices are considered, providing the main references. It also introduces and briefly describes the contributions contained in this book, guiding the reader through the logical structure of the book in order to point out new possible studies and future perspectives in different reserch fields.

Keywords: Smartphones; sensors; mobile applications; state of the art; future perspectives

INTRODUCTION

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Smartphones are mobile devices that perform many of the functions of a computer, typically having a touchscreen interface, Internet access, and an operating system capable of running downloaded apps [1].

They are similar to notebook computers with their own operating system, processor, internal memory, and high-quality camera lenses [2]. The diffusion of smartphones and other mobile devices is increasing the number of contacts between brands and consumers, by giving consumers new opportunities to connect to media content wherever they are, at any time in the day. This diffusion is greater in the high-tech than in the less economically developed countries (LEDC).

As wrote in [3], in 2018, 66% of individuals in 52 key countries (which includes all Europe countries, US, Central and South America, and some Asian countries such as China , Japan, South Korea and Thailand) owned a smartphone, up from 63% in 2017 and 58% in 2016, according to Zenith's *Mobile Advertising Forecasts 2017*, published on October 16, 2017. The rapid expansion of smartphone ownership across the world, which has transformed the way that advertisers communicate with consumers, is slowing down as penetration reaches 80%-90% in the most advanced markets. The number of smartphone owners have been increased by 7% in 2018, compared to 10% growth in 2017, 14% in 2016 and 21% in 2015.

Western Europe and Asia Pacific continue to lead the world in smartphone ownership. The ROI agency Zenith [3] predicts that five markets will have smartphone penetration above 90% in 2018: the Netherlands (94%), Taiwan (93%), Hong Kong (92%), Norway and Ireland (each at 91%). 11 markets will have penetration levels between 80% and 90%, all of them in Western Europe and Asia Pacific with the exception of Israel, where penetration will be 86%.

As reported in [2], the latest annual Mobility Report from Ericsson indicated that nowadays, there are 84 million new mobile subscriptions, reaching a total of 3.9 billion of smartphone subscriptions. It is estimated that mobile subscriptions are growing at around 3 percent year-on-year globally. Thus, the forecast for 2022 is to have 6.8 billion of smartphone subscriptions.

This happens because smartphones and other mobile devices allow to increase the number of interactions between companies and customers, by giving consumers new opportunities to connect to media content wherever they are, at any time in the day. In addition, the continuous improvement of smartphone electronics and the development of new apps have inspired researchers and scientists for using smartphones not only for phone calls.

Today, smartphones are equipped with many sensors, such as the built-in camera, GPS/GNSS receivers and antennas, accelerometers, gyroscopes, magnetometers, proximity sensors, and barometer.

Exploiting the characteristics of these sensors, smartphones can be used for many activities such as colorimetric detection [4], for sharing the information on real time, as well as quantification [5], monitoring [6], solving medical problems (e.g., freezing of gait in Parkinson's disease [7], glucose monitor [8], to detect enzymes [9], to preventive health care [10][11], pain management [12]), applications related to food [13] or for engineering activities [14]. In these cases, the application fields start from hydraulic (e.g., for analyzing the quality of the water [15] or to detect its salinity [16]) to chemistry (e.g., detection and discrimination of explosives [17]), environmental (e.g., aluminum and chromium determination in natural water [18]), and positioning purposes (e.g., precise [19] or collaborative positioning [20], mapping [21], location base services [22], augmented reality [23][24] or 3D reconstruction [25]) up to search and rescue activities [26].

It is neither possible to cover all research fields where smartphones are used nor to describe all possible applications where smart devices are used.

This book wants to highlight a selection of restricted contributions in the emerging research fields where smartphones can be used for innovative approaches.

The first chapter aims to demonstrate the use of a smartphone as a real-time data capture device, which can be connected to either a local server or a cloud platform to perform analytics on both externally and internally captured data.

The second and third ones are focused on positioning applications and performances for outdoor and indoor scenarios, respectively.

The second one focuses the attention on GNSS receivers installed inside smartphones: after a brief description about GNSS positioning, it introduces the use of GNSS in smartphones, including the latest developments, providing also some examples of positioning perfomances, obtained exploiting raw GNSS measurements.

The third chapter shows certain recent results on the usage of UWB sensors with smartphones in order to improve the estimation of users' positions in indoor environments. In addition, an example of a mobile mapping system for GNSS-denied environment is also shown, considering the combination of UWB devices and smartphone devices.

The fourth chapter wants to show the performance of different IMU mass-market platforms present in mobile devices, considering different positioning modes (static and kinematic) and estimating the noise through classical tests available in the literature. This is very interesting especially for indoor positioning or outdoor applications, where the quality of GNSS signals is not good or available, due to interference, spoofing, signal blockage.

The next chapter shows an interesting application of smartphone-based systems for driving evaluation: the authors consider an integrated framework for different Intelligent Transportation System purposes. This is interesting because autonomous driving is becoming a reality and it is no longer a futuristic dream. Thus, smartphones and mobile devices could be all we need to operate our car and probably future smartphone app would substitute key fobs.

Particularly interesting is the 3D reconstruction of the environment, not only for driving purposes: the sixth chapter deals with the state-of-the-art in the use of smartphones for 3D models reconstruction and close range photogrammetry, focusing the attention on camera sensors and the calibration procedures, that are mandatory steps of an accurate final solution.

The last chapter is an innovative contribution related to the Network Centric Therapy, an example of the Internet of Things for the domain of healthcare and biomedical engineering. This is one of the newest and most important applications where smartphones and mobile devices can be used and considered: this work takes up what is described in chapter 4 and it extends the utility of wearable and wireless systems comprised of inertial sensors, such as the accelerometer and gyroscope.

With these selected contributions, this work wants to highlight the recent innovations and applications related to smartphone technology, and it can provide some interesting insights for future research activities.

Then, this book is meant for academic researchers, engineers and for others who want to find out more about smartphone emerging technologies and future applications.

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