# Chapter 6
# Human-Centred Acoustic Detection for Smartphone Application in Healthcare

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## ABSTRACT

*In acoustic sensing techniques, acoustic sensors use the main functionality, namely recording and playing the sound, to explore related research and achieve various applications along with novel user experiences. Acoustic sensing is developed in the research, where human-centred research is a vital branch. Human-based research is crucial to healthcare with excellent privacy protection and long-term support. This chapter presents a comprehensive illustration of human-centred acoustic sensing focusing on two innovative dimensions: vertical direction and horizontal direction, to illustrate and analyse the latest developments. In addition, smartphone-based applications and deep learning approaches are systematically described. This chapter also analyses existing technology, predicts its development trend and provides constructive suggestions for future research.*

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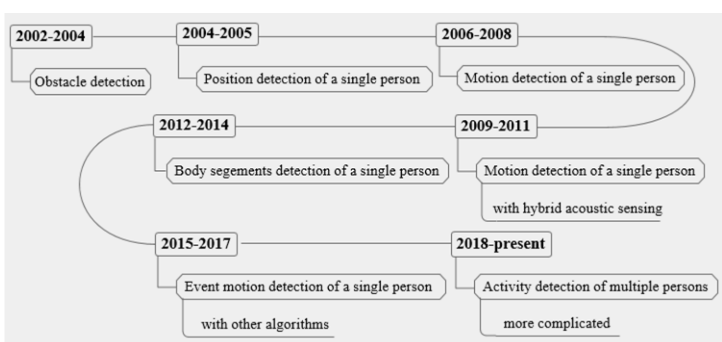
## INTRODUCTION

Among the various sensing technologies, such as those based on sound, light, and electromagnetism, sound-based sensing has a unique position, particularly with the rapid development and widespread use of smartphones. On the one hand, it can preserve users' privacy without taking images or videos; on the other hand, it can use inherent sound components in the smartphone, such as speakers and microphones, to simplify the system operation. Among the widespread applications based on acoustic sensing, human-centred application, mainly via smartphones, is emerging as a vital direction, partly because of the need for assisted living by those living alone or living with difficulties, and easy access to mobile phones for healthcare aid. Because of their widespread use, smartphones have become a potential tool for people's daily life to support broad applications such as home care (Hori et al., 2004) and clinical monitoring (Qi et al., 2014b). Related research has been increased significantly recently to facilitate healthcare, such as Parkinson's patient analysis (Pepa et al., 2015), diagnosis of physical abnormalities (Rodriguez et al., 2015), hazard warning systems (Unni & Pati, 2018), AI-enabled healthcare system (Song et al., 2021) and intelligent COVID-19 diagnosis (Chen et al., 2022).

Looking back on the history of acoustic sensing, approximately seven stages, namely, obstacle detection, position detection of a single person, motion detection of a single person, motion detection with hybrid sensing, body segments detection, event motion detection, and detection of activities for multiple persons, are illustrated in Figure 1. As early as 2002, researchers started exploring the possibility of utilising an ultrasonic sensor for obstacle detection (Huang et al., 2002; Zeng, 2002). Owing to the limitations of sound components and sampling rate, currently at 44.1kHz, high-frequency ultrasound sensing techniques cannot be applied to smartphones. On the other hand, the frequency cannot be too low, which would interfere with the human voice. Usually, the frequency band between 17kHz and 22kHz is widely used for smartphone applications. In addition, due to the varying quality of the sound components in different smartphones, new challenges are raised in using traditional sound detection techniques.

*Figure 1. Development of human-centred acoustic detection*




In this chapter, we discuss from the vertical and horizontal directions to introduce human-centred acoustic sensing and analyse the latest development and healthcare application comprehensively. The vertical analysis contains an in-depth discussion of technological development and fundamentals in this field. The horizontal analysis provides a systematically parallel comparison and summary. An extended

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