Chapter 12
Intelligent Tracking and Positioning of Targets Using Passive Sensing Systems

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ABSTRACT

Target localization and tracking has always been a hot topic in all eras of communication studies. Conventional system used radars for the purpose of locating and/or tracking an object using the classical methods of signal processing. Radars are generally classified as active and passive, where the former uses both transmitter and receivers simultaneously to perform the localization task. On the other hand, passive radars use existing illuminators of opportunity such as wi-fi or GSM signals to perform the aforementioned tasks. Although they perform detection using classical correlation methods and CFAR, recently machine learning has been used in various application of passive sensing to elevate the system performance. The latest developed models for intelligent RF passive sensing system for both outdoor and indoor scenarios are discussed in this chapter, which will give insight to the readers about their designing.

INTRODUCTION

Wireless communication systems are extensively used in both indoor and outdoor scenarios. The radio frequency (RF) signals transmitted from majority of these system can be used by passive receivers as non-cooperative opportunistic signals for tracking moving objects around them. RF signals, e.g., frequency modulation (FM), satellite signals, global system for mobile communication (GSM) and digital television (DTV) signals can be used in outdoor environments for passive listening. On the other side, Wi-Fi
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is a suitable option for the indoor environment because most of the buildings these days possess Wi-Fi systems that are used to connect users with the internet. Different security and surveillance applications can be designed for the buildings' premises by using Wi-Fi-based passive sensing system. As the passive RF system has no dedicated transmitters, they are considered covert and power effective in nature.

The prominent application of passive sensing system is determining the motion profile of target objects in the surroundings. By using advance techniques and complex algorithms, such systems are now able to provide more information about the motion of objects rather than just detecting them. However, there is always a big question i.e., “can we bypass the complex conventional techniques in implementing such systems?” This question can be answered by drawing attention to the emerging field of machine learning and deep learning.

Over the last decade, many researchers analyzed and developed different kinds of intelligent tracking techniques for moving bodies based on RF passive sensing systems. The classical RF passive sensing system has two or more receiving channels. One is the reference channel which provides unaltered echoes of the transmitted signals and other is the surveillance channel which provides the echoes of the transmitted signals from the area of interest (AOI). As the number of surveillance channels increases, the resolution of tracking gets better. Furthermore, the adaptive filtering techniques such as least mean square (LMS), extensive cancellation algorithm (ECA) etc. are used for obtaining the output which is free from the variation of transmitted signals. Therefore, this resultant time series signal only has information related to the changes happening in the AOI as demonstrated by (Iqbal et al., 2018).

(Chen et al., 2015; Colone et al., 2012) have used complex mathematical techniques to develop the algorithms which help in determining the nature of motions in AOI. However, the recent use of deep learning framework by (Iqbal et al., 2018; Khan et al., 2017b; Wang et al., 2017) in this field proved its success in both accuracy and efficiency. This chapter is about the design and analysis of the RF passive system based on machine learning and deep learning frameworks in outdoor and indoor scenarios. The rest of the chapter is organized as follows. History, origin and evolution of the passive sensing system is discussed in the next section, whereas general working of passive RF sensing system is elaborated in RF passive sensing system section. Afterword, design of outdoor and indoor passive sensing system is discussed in passive sensing system for outdoor scenarios section and passive sensing system for indoor scenarios section respectively. At the end, prominent applications of passive sensing system based on machine learning/deep learning are discussed in application of passive RF sensing system.

BACKGROUND

The concept of passive radars is not new. Back in 1935, Robert Watson Watt demonstrated the working of the radar by detecting a Handley Page Heyford bomber from a distance of 12 km using the BBC shortwave transmitter at Daventry as mentioned in (Chodos et al., 2006). During World War 2, the project named “Klein Heidelberg” was initiated by the Germans as described in (Griffiths & Willis, 2010) for long-range air surveillance. Six of these bi-static radars were deployed along the Belgian, Dutch and French side of the English Channel and North Sea. These radars didn’t have any dedicated transmitters and worked by using the reflections from the Chain Home (British coastal radar system).

In 1955, unique type of passive radars named as “AN/FPS-23 Fluttar Radars” were deployed on the North America Distant Early Warning (DEW) line for detecting the penetration in the territory by low-flying bombers. According to (Skolnik, 2007), they detect the presence of aircraft/bomber by extracting