The Modelling and Simulation of Passive Bistatic Radar

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Contents

Abstract

Passive radar systems use illuminations by transmitters of opportunity, such as digital audio broadcasts (DAB), to detect and track targets. In bistatic radar systems, the transmitting and receiving antennas are separate and widely spaced. In an era of strong demand for enhanced surveillance, proponents of passive bistatic radar (PBR) technology assert that it offers many benefits, in particular the use of already existing transmitters. PBR systems suffer from high system complexity however. This presents challenges for PBR designers and researchers, as testing ideas experimentally is prohibitively expensive.

Direct signal interference (DSI) is a major problem in all passive radar systems and occurs when the direct signals transmitted by the illuminators are stronger than the target return signals. This can lead to a large reduction in the dynamic range that is available for target detection. DAB networks are particularly problematic because there are often a large number of illuminators present that are transmitting virtually identical signals at the same frequency.

This thesis describes the development of a realistic model/simulator for a general PBR system that can be used to develop radar algorithms, DSI mitigation techniques and optimise the design of radar systems. The simulator can be applied to multi-transmitter/multi-receiver systems, which allows researchers to test ideas without building equipment.

In this thesis, a brief introduction is given to PBR, including its history, challenges and an overview of radar modelling and simulation. A rudimentary PBR model is then described and verified by comparison of a simulated radar signal produced by the model with that of an off-the-air radar signal.

The rudimentary model is made more realistic by the addition of more sophisticated propagation effects, namely, diffraction, multipath and depolarisation. Further enhancements are made with the development of radar cross section and antenna gain components. The model is then used to simulate a number of realistic scenarios involving typical aircraft flight paths around the University of Bath in the UK.

Finally, the model is applied to the testing of a DSI mitigation technique, namely, shielding by topography, using the Bath region as a test case. The success of the simulation results suggests that the technique can be used in the Adelaide area of South Australia.

The simulator serves as a virtual multi-static environment for developing applications such as a tracker. A tracker would need to function in a variety of situations, and its operation would be affected by factors such as terrain and DSI. A detailed knowledge of the propagation environment would be necessary for the development of such a tracker, and the simulator can provide this knowledge.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Yik Ling Lim and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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ADC	Analog-to-digital converter
AOA	Angle of arrival
ARD	Amplitude range-Doppler
CBD	Central business district
CFAR	Constant false alarm rate
COFDM	Coded orthogonal frequency division multiplexing
CW	Continuous wave
DAB	Digital audio broadcast
DR	Dynamic range
DSI	Direct signal interference
DTED	Detailed terrain elevation data
DTV-T	Digital television – terrestrial
DVB	Digital video broadcast
FM	Frequency modulation
GPS	Global positioning system
GSM	Global system for mobile
LOS	Line-of-sight
NEC	Numerical electromagnetics code
PBR	Passive bistatic radar
PE	Parabolic equation
RC	Radar channel
RCS	Radar cross section
SIR	Signal to interference ratio
UHF	Ultra high frequency
UK	United Kingdom
VHF	Very high frequency