UNIVERSITI TEKNOLOGI MARA

MULTIPLE-INPUT MULTIPLE-OUTPUT CONCEPT ON FREQUENCY MODULATED CONTINUOUS WAVE RADAR USING BEAT AVERAGING METHOD FOR MARITIME APPLICATION

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ABSTRACT

Finding the ideal performance of a maritime radar can be challenging due to the large sea spikes and the required day-to-night operation for maritime surveillance. The employment of multiple-input multiple-output (MIMO) radar concept in frequency modulated continuous wave (FM-CW) radar is intended to improve the performance of maritime radar due to their advantages, among others, in terms of better accuracy and low output power. Nevertheless, there are minimal number of works that investigate in detail, the MIMO processing method at the receiver side. Furthermore, reports on experimental result on MIMO-FMCW is rarely reported. Existing method requires complex processing due to multiple signals used in MIMO and Fast Fourier Transform (FFT) computation in the MIMO FM-CW processing at the receiver. Therefore, the objective of this thesis is to propose an alternative post-processing scheme for the MIMO FM-CW radar system using beat averaging method to reduce the computational complexity of the radar system, and analyse the performance of the proposed MIMO FMCW radar scheme, through numerical simulations and experimental evaluation. This method uses multiple frequency diverse FM-CW signals in transmission where multiple beat signals produced during target detection was averaged before FFT computation. The proposed method is initially studied in a numerical simulation where several schemes of MIMO radar was evaluated before it is compared with the performance of the single radar system, and the existing post-processing method of MIMO FM-CW radar. The performance evaluation was studied in terms of probability of ranging errors and computational complexity before the results were further validated through experiment. The results of the study have showed an improvement of probability of range error when using MIMO FM-CW radar system compared to conventional FM-CW radar system. In addition, the proposed scheme using beat averaging method also outperforms the existing MIMO-FMCW using spectrum averaging, by approximately 2 dB in signal-to-noise ratio to achieve similar performance. The proposed scheme also comes with a lower computational complexity compared to the spectrum averaging method. Therefore, the proposed scheme is considered a good alternative processing scheme to implement a MIMO concept in FM-CW systems, providing an advancement towards the realisation of the said system.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

The technology for Radio Detection and Ranging, or simply identified as ‘radars’, can been developed in many kinds of ways. Among the classification of the radar system can be based on the radar’s platform, where the radar can be classified as either ground based, ship based, airborne or space borne [1], [2]. Radar studies are also categorised according to its function and application– whether for surveillance, tracking, imaging, traffic control, military defence, remote sensing or any other uses where the mechanism of the radar differs accordingly. Then, radars are also varied based on its operating frequency and data acquisition method where different frequency bands serve different purposes and it can be used whether for range, azimuth, speed or any other target parameter.

Due to the daily operation required in maritime setting such as for security surveillance and vessels traffic control, one of the popular studies regarding radars are related for maritime application. One of the most prevalent types of radar used in maritime setting is the frequency modulated continuous wave (FM-CW) radar, in which the signal is transmitted in the form of continuous sinusoidal wave radio energy modulated in frequency within a determined measurement time. The radar principally operates by processing the change in frequency of the backscattered signal from the transmitted signal, where the frequency shift of the received signal from the referenced signal, is where the target’s range and velocity can be calculated. This type of radar is widely adopted in maritime radars due to its potential in day-to-night operation of which it produces relatively low power output.

Multiple-input-multiple-output (MIMO) technology has been discussed in recent signal processing studies where the utilisation of multiple orthogonal signals was found to yield increased degree of freedom that improves target detection capability and provides better localisation accuracy from the conventional radars. Therefore, the implementation of MIMO may produce an enhanced radar technology in FM-CW radars used in maritime application where one of the main challenges was the high-cluttered environment in maritime background. The advantage of MIMO radars,