



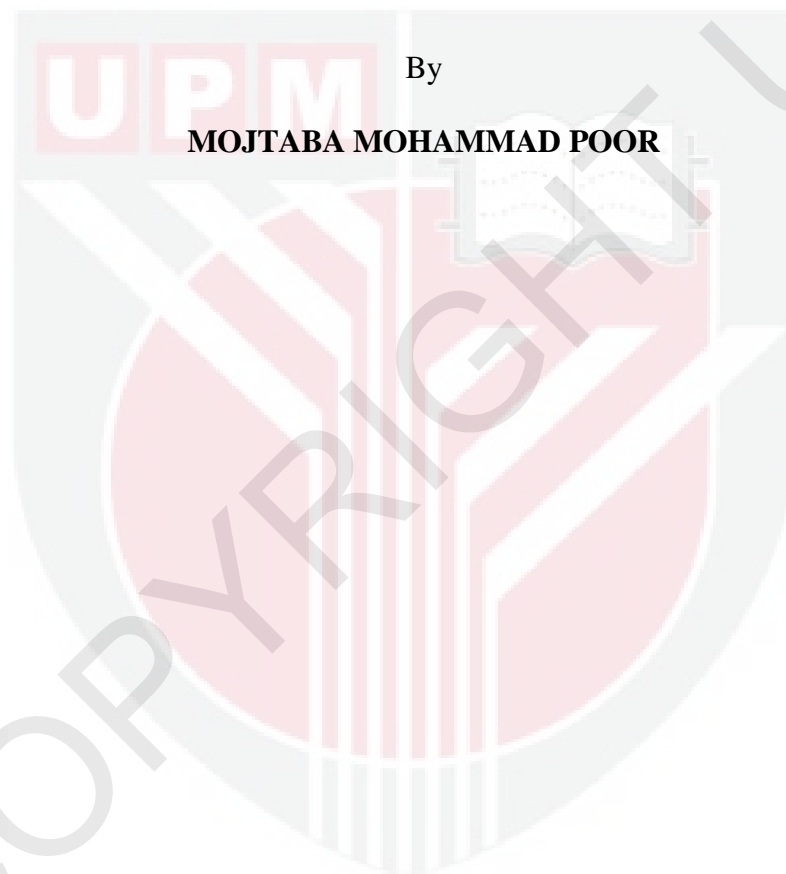
UNIVERSITI PUTRA MALAYSIA

***CIRCULAR SYNTHETIC APERTURE RADAR SYSTEMS
FOR ON-THE-GROUND OBJECT DETECTION***

MOJTABA MOHAMMAD POOR

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GROUND OBJECT DETECTION**



By

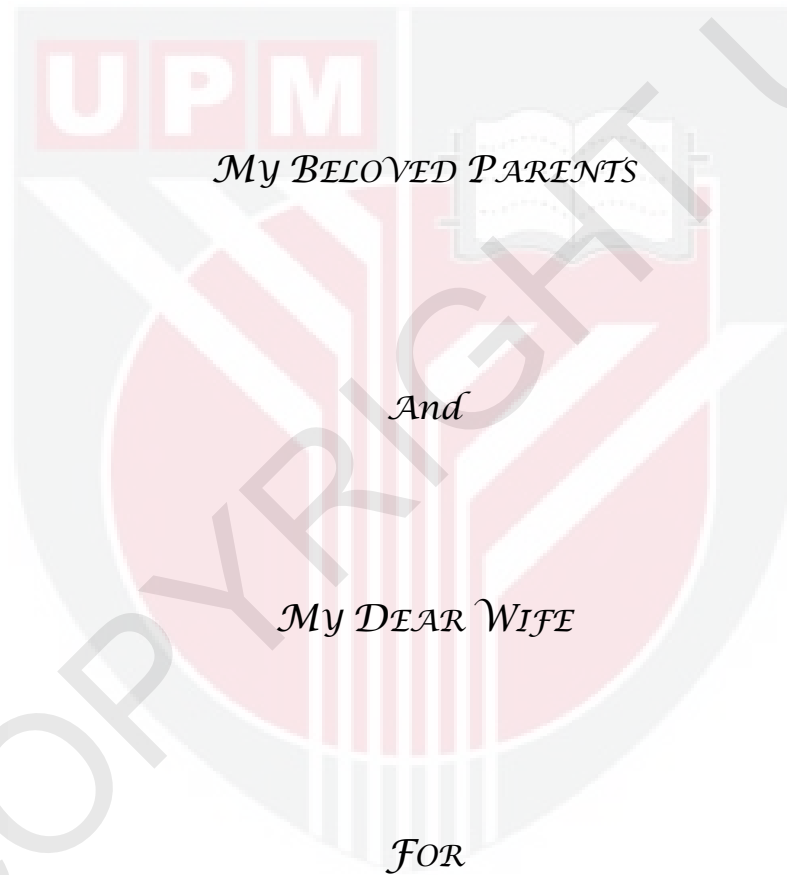
MOJTABA MOHAMMAD POOR

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of
the Requirement for the Degree of Doctor of Philosophy**

June 2012

DEDICATION

This thesis is dedicated to



THEIR ENDLESS PATIENCE AND LOVE

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

CIRCULAR SYNTHETIC APERTURE RADAR SYSTEMS FOR ON-THE-GROUND OBJECT DETECTION

BY

MOJTABA MOHAMMAD POOR

June 2012

Chairman: Assoc. Prof. Raja Syamsul Azmir Raja Abdullah, PhD

Faculty: Engineering

Detecting on-the-ground object is a subject of interest for some applications. An example of application is detection of airport's runway Foreign Object Debris (FOD), which is an important issue in the aviation safety. In this way, radar imaging has several inherent advantages over other techniques, including larger coverage area, robustness in bad weather conditions, and ability to operate unabated for twenty-four hours. Currently existing FOD-detection systems are using very high carrier frequencies at millimetre-wave, and are prone to be affected by different weather conditions. Moreover, their usage is limited to free-space applications due to their inability in penetrating into solid materials. Furthermore, two radar technologies are possible to be investigated for such applications, namely Synthetic Aperture Radar (SAR) and bistatic radar. SAR concept is applicable in this regard with some modification, especially in terms of movement trajectory.

In this thesis, a circular monostatic and a circular bistatic system of low-carrier frequency synthetic aperture radar are proposed which can be used for such applications. In both proposed systems, wideband Linear Frequency Modulated (LFM) pulses are generated and employed. The advantages of using LFMs include their higher signal-to-noise ratio and lower hardware complexity. Both proposed systems were analyzed theoretically, modelled and verified through field experiments. Two new processing algorithms for each of the systems were also developed to be used in the system.

The ability of the proposed circular monostatic system is shown through detecting one or more metallic cylinders as small as 1cm diameter and 1.5~2.5 cm height at 7-10 m ranges and different angles. The output of the system is a radar image of the area where the position of the objects is highlighted in it. Similar action is repeated for the bistatic proposed system by detecting cylinders as small as 2 cm diameter and 2.5 cm height at 5-7 m ranges. The ability of the system is verified because the system produces a radar image of the area by highlighted points at the position of the objects.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**SISTEM RADAR APERTUR TIRUAN MEMBULAT UNTUK PENGESANAN
OBJEK ATAS TANAH**

Oleh

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Mengesan objek atas tanah merupakan suatu keperluan bagi sesetengah aplikasi. Contoh aplikasi tersebut ialah pengesanan Serpihan Objek Asing (FOD) di atas landasan kapal terbang, yang merupakan isu penting dalam keselamatan penerbangan. Di dalam hal ini, pengimejan radar mempunyai beberapa kelebihan ketara berbanding teknik-teknik lain, termasuk kawasan liputan yang lebih luas, ketahanan di dalam cuaca buruk, dan kebolehan beroperasi secara berterusan selama dua puluh empat jam. Sistem pengesanan FOD sedia ada pada masa kini menggunakan frekuensi pembawa sangat tinggi pada gelombang milimeter, dan sangat terdedah kepada kesan perubahan cuaca. Tambahan pula, kegunaan sistem tersebut adalah terhad untuk aplikasi-aplikasi ruang bebas disebabkan ketidakupayaan untuk menembusi bahan pepejal. Tambahan pula, dua teknologi

radar yang boleh dikaji bagi aplikasi-aplikasi tersebut, dinamakan Radar Apertur Tiruan (SAR) dan radar dwistatik. Konsep SAR boleh diaplikasi bagi tujuan ini dengan beberapa pengubahsuaian, terutamanya dari segi trajektori pergerakan.

Di dalam tesis ini, suatu sistem monostatik membulat dan dwistatik membulat SAR berfrekuensi rendah dicadangkan dimana boleh digunakan untuk aplikasi-aplikasi tersebut. Di dalam kedua-dua sistem yang dicadangkan, denyut-denyut Frekuensi Linear Termodulat (LFM) jalur lebar dijana dan digunakan. Kelebihan penggunaan LFM termasuklah ia mempunyai nisbah hingar kepada isyarat yang lebih tinggi dan perkakasan yang lebih ringkas. Kedua-dua sistem yang dicadangkan telah dianalisa secara teori, dimodelkan dan disahkan melalui eksperimen lapangan. Dua algoritma pemrosesan baru bagi setiap sistem juga telah dibangunkan untuk digunakan di dalam sistem.

Kebolehan sistem monostatik membulat yang dicadangkan ditunjukkan melalui pengesanan satu atau lebih silinder logam berdiameter sekecil 1 sentimeter dan setinggi 1.5~2.5 sentimeter pada julat jarak 7–10 meter dan pada sudut-sudut berbeza. Hasil keluaran sistem merupakan suatu imej radar kawasan dimana kedudukan objek diserlahkan di dalamnya. Tindakan yang sama diulang untuk sistem dwistatik yang dicadangkan dengan mengesan silinder berdiameter sekecil 2 sentimeter dan setinggi 2.5 sentimeter pada julat jarak 5-7 meter. Kebolehan sistem adalah disahkan kerana sistem menghasilkan suatu imej radar kawasan tersebut dengan menyerlahkan titik-titik pada kedudukan objek.

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My heartfelt thanks to all of you, again, with our nice memory that I never could forget them.

APPROVAL

I certify that a Thesis Examination Committee has met on 25 JUN 2012.. to conduct the final examination of MOJTABA MOHAMMAD POOR on his Doctor of Philosophy thesis “Circular Synthetic Aperture Radar Systems For On-The-Ground Object Detection” in accordance with the Universities and University Colleges ACT 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106]Experimental 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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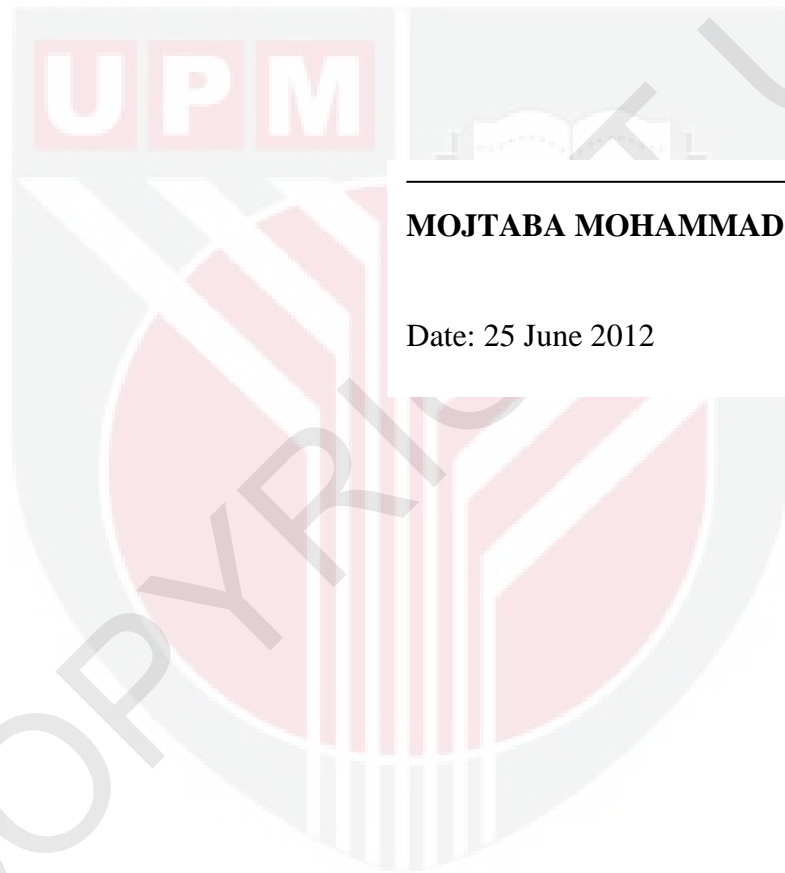
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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.



MOJTABA MOHAMMAD POOR

Date: 25 June 2012

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