RADAR CROSS SECTION (RCS): STUDY ON THE PHYSICAL ACTIVITY MOVEMENTS' SIGNAL OF HAMSTER WITH RADAR

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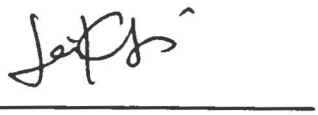

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ABSTRACT

This study is about measurement of the physical activity movements of a 4-months old female hamster by using Lab-Volt Radar Training System in the Instrumentation and Signal Processing Lab, School of Science and Technology, Universiti Malaysia Sabah. The main objective of this study is to determine the possible of hamster's movement's estimation by the means of Lab-Volt radar. It is also used to identify the reflected radar signals of hamster due to different physical activity movements. Fourier analysis is been done for this study in order to increase the signal-to-noise ratio (SNR). Frequency domain graphs are plotted by using the Fourier transform magnitude and the Fourier transform frequency. Two different activity movements of hamster, active movement and sleeping moment, were being observed along the experiment. Average intensity of physical activity signal of active hamster is 0.006044 where average intensity of physical activity signal of sleeping hamster is 0.003864. According to the result, radar signal reflected by the 4-months old female hamster when it is in active state is higher than when it is sleeping. It is because the hamster was moving around and sometimes it took vertical position. However, it is not moving at all while it is sleeping. Referring to the experiment that has been conducted, the radar signals between the hamster and the laboratory rat are different. The results are compared with the laboratory rat's radar signals detected by a bio-radar. The frequency domain graph of active hamster shows a slightly curve shape and the frequency domain graph of sleeping hamster is more flat. The results of the study of hamster's activity movements by using Lab-Volts proved that different radar signals are recorded due to different physical activity movements of hamster. Besides different radar signals are observed due to different living parameters but they shown similarities in the shape of the plotted graphs.

ABSTRAK

Kajian ini adalah tentang pengajian aktiviti dan gerakan fizikal hamster jantina yang berumur 4-bulan dengan menggunakan Lab-Volt Sistem Pelatihan Radar di Makmal Instrumentasi dan Pemprosesan Isyarat, Sekolah Sains dan Teknologi, Universiti Malaysia Sabah. Objektif utama kajian ini adalah menentukan kemungkinan gerakan hamster dengan menggunakan Lab-Volt radar. Selain itu, kajian ini juga bertujuan mengenalpastikan isyarat radar yang dipantulkan daripada hamster pada gerakan aktiviti fizikal yang berbeza iaitu dalam keadaan aktif dan keadaan hibernate. Isyarat radar tersebut menunjukkan isyarat activiti hamster tersebut. Analisis Fourier dilakukan untuk meningkatkan ratio isyarat-kepada-bunyi(SNR). Graf frekuensi domain diplot dengan menggunakan magnitud Transformasi Fourier dan frekuensi Transformasi Fourier. Kesimpulannya, isyarat radar dipantulkan oleh hamster yang sedang bertidur adalah lebih rendah berbanding dengan hamster yang berada dalam keadaan aktif. Purata intensity isyarat aktiviti fizikal hamster aktif adalah 0.006044 manakala where purata intensity isyarat aktiviti fizikal hamster yang sedang tidur adalah 0.003864. Graf frekuensi domain of hamster yang sedang bertidur adalah lebih mendatar berbanding dengan hamster aktif. Ini disebabkan oleh hamster aktif tersebut bergerak di sekitar kotak dan kadang-kadang mengambil kedudukan menegak. Namun, dia tidak bergerak ketika sedang tidur. Kemudian, hasilnya dibandingkan dengan isyarat radar tikus makmal dikesan oleh bio-radar. Daripada graf-graf yang diperolehi, isyarat radar antara hamster dan tikus makmal didapati berbeza pada amplitud isyarat tetapi mempunyai kesamaan pada bentuk graf. Kesimpulannya, isyarat radar yang berlainan didapati akibat aktiviti fizikal hamster dan jenis haiwan yang berlainan digunakan. Isyarat radar hamster yang aktif adalah lebih kuat daripada isyarat radar hamster yang tidur telah didapati dengan menggunakan radar Lab-Volts.

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SYMBOL AND UNIT LIST

$\varphi_{(t)}$	phase noise of Local Oscillator
A_C	reflected signal magnitude from the target body
A_{eff}	effective area of the radar receiving antenna
A_R	reflected signal magnitude from the heart
c	speed of light in vacuum
cm	centimeter
D	number of rows of data
dB	decibel
E	photon energy
E_{eff}	effective emission power
f	frequency
fs	sampling frequency
G	antenna multiplier
GHz	Giga hertz
G_t	gain of the radar transmit antenna
G_T	antenna emission reflective energy by target
h	Plank's constant
Hz	Hertz
J.s	Joule second
m	meter
m^2	meter square
mm	milimeter
ms^{-1}	meter per second
P_t	power transmitted by the radar
P_T	emission power received from the antenna
P_{Tgt}	effective reflective energy by target
P_Y	power received back from the target by the radar
r	distance from radar to target
$R(t)$	backscattered signal from the heart at the antenna
s	seconds
S	standard deviation

sa	total data points chosen
SE	standard error
t	time interval
V	volt
V_{pk}	voltage peak
V_{ppk}	voltage peak-to-peak
V_{rms}	voltage root-mean-square
W	angular frequency
λ	wavelength
σ	radar cross section of the target

CHAPTER 1

PREFACE

1.1 INTRODUCTION

Life-detection system has been improved by using radar. Life-detection system via radar can be used to detect life parameters such as physical activity movement signal with non-human contact. This invention is widely been used to search life-signals under the debris, clothes and brick walls after earthquake or buildings collapse. Moreover, it also can be used by law-enforcement services in order to search criminals that hiding behind various covers. The radar detector radiates electromagnetic microwaves to living objects and receives echo waves reflected by the body surface jiggle caused by their physiological activities. (Wang, 2006; Anishchenkol, 2009; Jang, 2008)

Heartbeat is a vital, involuntary action for living objects and controlled by the automatic nervous system. Human's heartbeat and the surrounding signals are considered as noise in this system. In order to differentiate the noise from the signals wanted, hamster is selected as the specimen in this project. Although hamsters do not hibernate, they do slow down their breathing and heartbeat rate for short periods of time. Normally, average adult human heartbeat is 60 beats per minute where average hamster heartbeat is 450 beats per minute. (Wikipedia, 2009)

Besides, it is developed in the medical field. Electrocardiogram (ECG) is method of graphic tracing of the electric current generated by the heart. Information on the condition and performance of the heart can be detected by monitoring the ECG. However, traditional ECG is not practically been used on the infants at risk of sudden infant death syndrome or burn victims. Due to the imperfectness of ECG, the improvement and development of microwave Doppler radar has drawn more

attention of the medical team these years. Microwave Doppler radar is used for remote monitoring of health signals without human contact. (Wikipedia, 2009; Hampton, 2003)

Microwave Doppler radar has been used for wireless applications now for number of years. Based on the Doppler theory, the chest-wall of living objects can be targeted, and a continuous wave radar-type sensing system will receive reflected signal where the phase of the reflected signal will be modulated by the time-varying position of the chest-wall. The heartbeat and breathing signals can be monitored by phase demodulation. Thus, it will provide a signal proportional to the chest-wall position and thereby provide information about the movement due to the heartbeat and respiration. (Edde, 1995; Lin, 2009)

Microwave Doppler radar can be improved in the field of preserve and protection of endanger species. Malaysia having a continuous canopy of green and marvelling at an abundance of plant and animal species, it is an attraction to anyone who appreciates the natural world. In the Borneo's rain forest is the shelters of the world's rarest and most remarkable animals: the Sumatran Rhinoceros, the Clouded Leopard and Malaysian Tiger, the Sun Bear, the Monitor Lizard, and the *Orang Utan* (man of the forest). In order to protect its natural heritage, natural forest management and conservation of wildlife are established through a network of protected areas.

By using microwave Doppler radar, health signals of the endangered species can be monitored by the scientists and medical doctors without direct contact with the animals or disturb the animals' natural habitats. Hence the work of preservation of the endangered species can be enhanced.

Electromagnetic wave is generated by oscillator via a directional coupler and then it is radiated by the antenna via a circulator. This radar system works with only one antenna and the circulator isolates the transmission from the reception. The echo signal is received by the same antenna then passed through a mixer to pre-processor. After that the mixed echo signals passed through pre-processor to an analog-to-digital converter (ADC). The mixed echo signals included heartbeat,

respiration signals and noises. Finally, these signals are sent for signal processing and analysis. (Edde, 1995; Lin, 2009)

1.2 PROJECT GOALS

The goals for this project are to measure the physical activity movement by using Lab-Volt Radar Training System and to identify the different physical activity movements of hamsters. Besides, it is also a good opportunity to study and monitor physical activity movement of hamsters.

1.3 OBJECTIVES

The objective for this project is

i. to investigate possible of hamster's movement estimation by the means of Lab-Volts radar
ii. to identify the radar signals of hamsters due to different physical activities state
iii. to compare the physical activity signals detected by Lab-Volts radar with the signals (reference signals) detected by bio-radar.

1.4 HYPOTHESIS

i. Different radar signals will be recorded due to different physical activity movement of hamster.
ii. Radar signal of hamster at active movement is stronger than in sleeping state.
iii. Similarities will be observed from the comparison of different radar detection on hamster and laboratory rat.

1.5 LOCATION

This study will be carried out by using Lab-Volt Radar Training System from Lab-Volt (Quebec) Ltd 1999, Canada in Instrumentation and Signal Processing Lab School of Science and Technology, Universiti Malaysia Sabah

CHAPTER 2

LITERATURE REVIEW

2.1 BACKGROUND OF RADAR

2.1.1 Definition

RADAR (*RA*dio *D*etection *A*nd *R*anging) is a method of using electromagnetic waves to remote-sense targets' velocity, position and identifies their characteristic. It can be used to identify the range, altitude, direction and speed of both moving and fixed objects such as motor vehicles, aircrafts, ships and weather formations. A radar system emits microwaves or radio waves via a transmitter. These waves are in phase when emitted and when they contact with an object is re-radiated in all directions. The signal is thus partly reflected back and it has a slight change of wavelength if the target is moving. Usually, the receiver is in the same location as the transmitter. Although the reflected signal are very weak but it can be amplified by using electronic techniques in the receiver and in the antenna configuration. Hence, radar able to detect objects at ranges where other emissions would be too weak to detect. (Edde, 1995; Wikipedia, 2009)

Radar can be classified into three categories which are bistatic radar, monostatic radar and quasi-monostatic radar. Bistatic radar is the transmit-and-receive antennas are at different locations as viewed from the target. For example, ground transmitter and airborne receiver. Then monostatic radar is where the transmitter and receiver are collocated as viewed from the target such as the same antenna is used to transmit and receive. Quasi-monostatic radar is where the transmit and receive antennas are slightly separated but still appear to be at the same location as viewed from the target such as the separate transmit and receive antennas on the same aircraft. (Scribd, 2009)

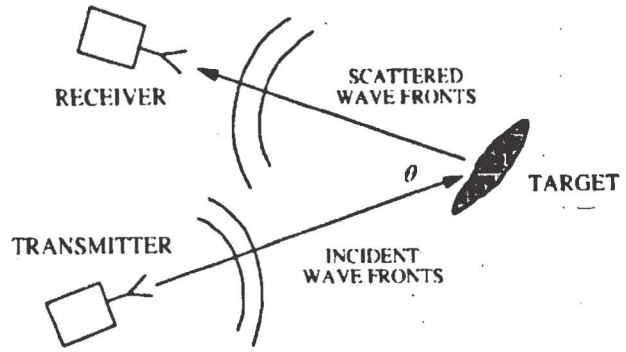

Figure 2.1: Orientation of receiver, transmitter and target. (Scribd, 2009)

The radar antenna emits pulses of microwaves which bounce off any object in their path. A tiny part of the wave's energy will backscatters to the antenna which is usually located at the same site as the transmitter. The time it consumed for the reflected waves to return to the antenna enables computer to detect and calculate the distance of the object from the antenna, its radial velocity and other characteristics. (Edde, 1995)

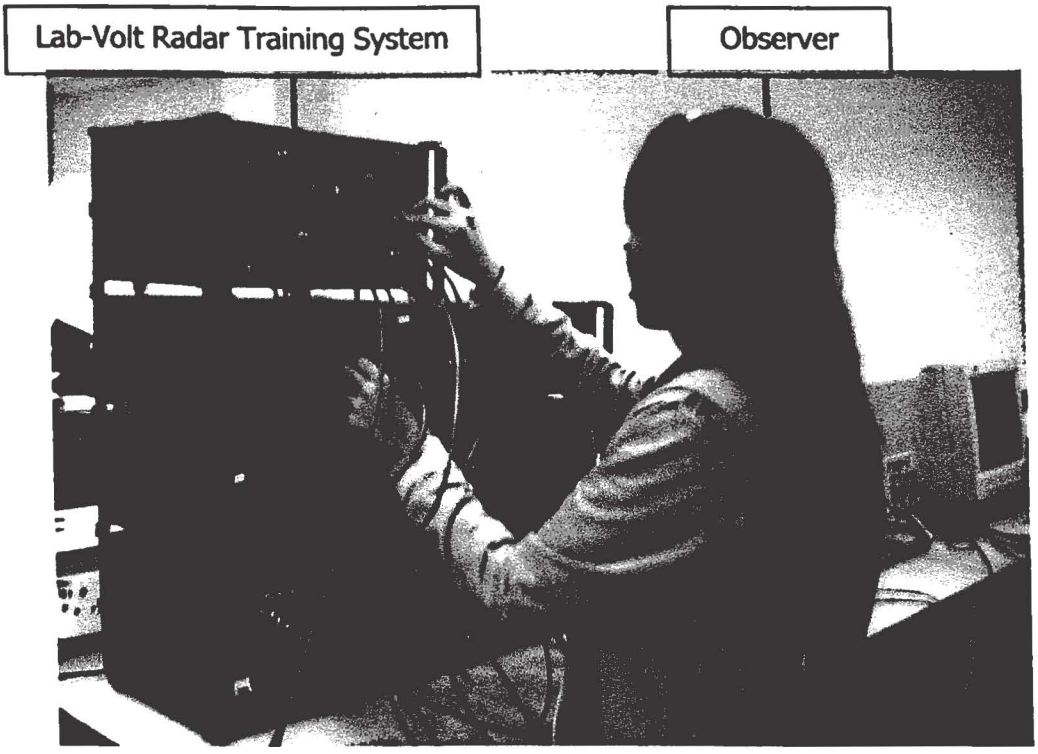

Photo 2.1: Lab-Volt Radar System Set in the Instrumentation and Signal Processing Lab, School of Science and Technology, Universiti Malaysia Sabah.

2.1.2 History of Radar System

The early history of radar is closely connected with warfare but recent year radar have developed for civilian application by radar technology and attracted public attention. The oldest known precursor to modern radar systems evolved in bats millions of years ago, and is known to us today as SONAR (*SO*und *N*avigation *A*nd *R*anging). Bats send a short 'cry' from their noses, receiving the echo with their ears which acts like antenna. Although bat doesn't use electromagnetic waves but the working principle is similar to the modern radar system. (Encyclopedia Britannica, 2009)

First radar business was begun around the 20th Century. Heinrich Hertz in Germany calculated that an electric current swinging rapidly back and forth in a conducting wire, which commonly known as "antenna" nowadays, would radiate electromagnetic waves into the surrounding space. Hertz was the first to demonstrate experimentally the production, reception and scattering of electromagnetic waves in the radio bands. This discovery is then leads directly to radio. In 1904, Christian Hülsmeyer (1881-1957) received a Germen patent for *Telemobiloskop* or Remote Object Viewing Device. The device achieved ranges of 3000, against ships. It was useful to prevent ship collisions but it didn't attract many customers' interest and finally fell into oblivion. (Encyclopedia Britannica, 2009; Wikipedia, 2009)

In 1922, Guglielmo Marconi demonstrated a clear idea that it was possible to detect remote objects by radio signals but he was unable to show the working device. In 1925/26, Breit and Tuve, American physicians, with the British researchers Appleton and Barnett had performed measurements of the Earth's ionosphere by using a pulsed radio transmitter which could be described as radar. In 1935, Sir Robert Alexander Watson-Watt (1892-1973) was a Scottish physicist who successfully demonstrated the detection of an aircraft by a radio device. Besides, bombers could be detected at ranges of 150km and more. (Radar was patented (British patent) in April, 1935)

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