CHAPTER I
INTRODUCTION

1.1 Background

Radio Detection and Ranging (RADAR) is a system or device that uses electromagnetic waves in radio frequency to detect the distance, direction, speed, and characteristics of the subject, whether the subject is moving or stationary. The development of non-contact human respiration detection by utilizing a radar system has been growing and becoming a concern for the last few years. This technology is widely used in the medical [1][2][3][4], military [1][5], and post-disaster victim rescue fields [1][6][7][8][9]. In principle, a radar system used to detect human respiration will detect small-displacement movement on the scale of a millimeter (mm) or centimeter (cm) that occurs on the chest or abdominal wall during breathing activity. Detection of human respiration using a radar system applies the concept of the Doppler effect, which arises when radar waves are detected on the chest or abdominal wall during breathing activities [7].

Detection of human respiration in post-disaster rescue is used to find victims who are still alive under the rubble. Several methods such as thermal cameras and cameras have been used in previous studies to detect post-disaster victims [10] [11]. Utilizing sniffer dogs to find victims through smell is one of the standard operating procedures frequently employed for post-disaster victim rescue [6]. However, this technique has the disadvantage that it cannot determine how far and how many victims are searched. Furthermore, sniffer dogs are more likely to detect the presence of a dead victim than a surviving victim. Therefore, another technique is needed that can detect living victims and their locations by detecting human respiration. However, these tools have shortcomings in detecting the target distance. Therefore, radar is one of the tools that can overcome these problems.

Radar technology was chosen because of the ability of electromagnetic waves to penetrate building debris and reflect signals that hit targets that are blocked by the debris. Many researchers have developed the ability of radar technology to detect human respiration, which has been demonstrated in previous studies to detect the presence of victims who are behind rubble. Post-disaster victim search and evacuation is a priority activity in disaster recovery. Therefore, this development was carried out to help search for survivors during a disaster. The elaboration of the through-the-wall concept with small displacement encourages the development of a victim detection method that is behind the wall and has been investigated in previous research.

Several radar systems were reviewed for the purpose of detecting human respiration behind the wall, such as Doppler radar [2][12][13][14][15][16], Ultra-Wideband (UWB) [17][18][19][20], Continuous Wave (CW) [21], and Frequency Modulated Continuous Wave (FMCW) [22][23][8]. Doppler radar has been used due to its accuracy in measuring small displacements, but this radar cannot detect range information. In previouse researched, the UWB radar system was used in the detection of human respiration behind the wall due to its good coverage resolution and good penetration through the wall. CW radar system has been studied previously in for the development of a method for detecting human respiration behind the wall. However, this CW radar system has a weakness in estimating the distance of the detected target. In addition, the FMCW radar system has been widely studied in the development of human respiration detection methods behind the wall. Compared to using UWB and CW radar systems, the FMCW radar system can overcome the limitations of the CW radar system in distance estimation and less complexity architecture than UWB radar system.

In previous studies, FMCW radar systems with operating frequencies in the millimeter wave range such as 24 GHz [8], 77 GHz [24], and 80 GHz [25] for non-contact detection of human respiration have been conducted. The result showed that respiration patterns can be detected by radar which is reflected in the small movement that occurs in the chest or abdominal wall during breathing activities. The respiration pattern is detected from the phase change of the beat signal and the target distance can be estimated from the beat frequency value [7]. Phase detection is performed for each frequency beat component present in the radar signal.

Detection of human respiration using radar systems in post-disaster conditions has problems in detection. One of the problems is the wall or obstacle covering the target. The effect of the wall or obstacle reflection generates reflection that can dominate the reflected signal received by the radar and block the reflected signal coming from the target. The reflected signal coming from walls is called clutter or unwanted signals. In addition, reflection from other objects under the rubble also causes clutter. The blocking wall can affect the radar signal in the form of attenuation and phase shift, each of which can cause a decrease in SCR and a change in the position of the detected target. Therefore, it is necessary to reduce clutter to avoid errors in detection. Some previous research discussed clutter reduction using Mean Subtraction (MS) [26], Singular Value Decomposition (SVD) [27] [26], Factor Analysis (FA) [28], Principle Component Analysis (PCA) [29] [27], Linear Trend Subtraction [26] [30] and Independent Component Analysis (ICA) [28] [31]. Methods and has been proven to reduce clutter caused by static clutter. Some of these methods were reviewed on the UWB radar system discussed in previous research. In this thesis, previously researched methods are used as a comparison of the proposed method. The comparison methods in this research are the SVD and LTS methods. These two methods are methods that can reduce clutter from walls and static objects, but have a high level of computational complexity.

A. A. Pramudita in his research uses the two-step FFT, ROI, and weighting process methods where the three methods are used to determine the target distance, respiration rate, and clutter reduction [8]. In [26], researchers conducted clutter reduction using Mean Subtraction (MS) and comparison that method with Singular Value Decomposition (SVD) and Linear Trend Subtraction (LTS) methods used to reduce clutter originating from the movement body using UWB radar. Rubble that becomes an obstacle in the detection progress dominates the reflected signal obtained, so it is difficult to obtain the reflected signal originating from the target. If the phase detection process is directly applied to the beat signal, the reflected results cannot describe the respiration pattern from the target. In addition, the clutter from wall reflections, and other reflections from other objects under the rubble also caused clutter. Therefore, a method is needed to overcome the previously described problems.

The contribution of this thesis involves developing the presence of a clutter reduction method from the reflection of the surface rubble and multiple reflections under rubble to obtain accurate detection results of the victims under the rubble. The elimination of obstacle reflections involves knowing the obstacle's response. Meanwhile, the weighting process elaborated with a cross-correlation to reduce the clutter from the multiple reflections under the rubble. Then, the proposed method is compared with the SVD and LTS methods to see the success of the proposed method by calculating the increase in SCR obtained. The use of the SVD and LTS methods in this thesis is because, in some previous studies, those methods performed effectively compared to other methods used to reduce clutter from the rubble wall. However, this thesis uses the SVD and LTS methods to reduce clutter from other reflections underneath the rubble. Moreover, the respiration rate and the position of the detected target derive from the maximal value of the signal acquired.

1.2 Problem Formulation

The use of radar to detect the presence of humans (targets) under the rubble of buildings during natural disasters has implemented. However, the condition of the surface wall covering the target (human) and other objects around the target cause unwanted reflected signals, known as clutter. Clutter can cause errors in detection. Therefore, it is necessary to reduce clutter. The method used in previous research uses the SVD and LTS methods to reduce clutter originating from walls arranged flat and static. However, this method has a high level of computational complexity. Therefore, it is necessary to use a method that can reduce clutter originating from irregular wall arrangement and some other clutter under the ruins and has lower computational complexity.

1.3 Objective

This thesis aims to develop a method for reducing the presence of clutter presenting from the surface and multiple reflections under the rubble. Interference generated by obstacles and multiple reflections under rubble will cause detection errors. Therefore, it is necessary to eliminate the wall effect and reduce multiple reflections clutter under the rubble to increase the SCR value and determine the position as well as the respiration rate of the target.

1.4 Scope of Work

Based on the problem formulation, there are scopes of the problem in this thesis:

1. The detected target was instructed to lie down under a concrete brick.
2. The detected target is a male above 20 years old.
3. Collecting data was carried out using laboratory experiment.
4. Detection is performed at a depth 0f 50 cm and 60 cm from the surface of the wall to the floor.
5. The concrete bricks used were 20 cm thick and were used as an obstacle model in this laboratory experiment.
6. The signal processing was done using Matlab software.
7. Wood is uncalculated as clutter.

8. The arrangement condition of bricks is flatly and irregularly.

1.5 Methodology

The process steps in completing this thesis are the following details:

1. Literature Study
   The purpose of this step is to collect study literature from papers, journals, previous research as well as books related to radar, specifications of the radar system to be used, detection methods through walls, methods used to reduce clutter, and determine the literature used as references in this thesis. Another goal is to support the process of working on this thesis.

2. Experiment
   The implementation of an FMCW radar system in a human respiration detection experiment behind a wall is studied. The aim is to establish the effects of walls and multiple reflections from other objects under the rubble on detection and to find out how to reduce these influences to obtain better results.

3. Data Processing
   After collecting the experimental data, signal processing is performed to separate the wall region from the target region. Subsequently, the reflected signal coming from the wall is eliminated. It is necessary to avoid errors in detecting the respiration of the target. Once collected, the signal will show the difference between the target signal and the clutter from reflections of other objects under the rubble. In order to obtain clearer results, it is necessary to reduce the clutter produced by the reflections of other objects under the rubble.

4. Analysis
   The analysis is performed after data processing is complete. In this thesis, the analysis step is performed before and after clutter reduction. Whether clutter affects detection is observed, and the results obtained after reducing clutter are better than when clutter reduction.

5. Conclusion
   After obtaining the results of the analysis, conclusions were obtained.

1.6 Thesis Structure

The systematics for writing this thesis is as follows:

1. Chapter 1 INTRODUCTION This chapter contains the background, problems, objectives, research methods, and systematic writing.
2. Chapter 2 BASIC THEORY This chapter contains an explanation of the theory, tools, and equipment used.
3. Chapter 3 RESEARCH METHODOLOGY This chapter contains the workflow and system design flow.
4. Chapter 4 RESULTS AND ANALYSIS This chapter contains the steps of test results, and an analysis of the test results obtained.
5. Chapter 5 CONCLUSION This chapter contains the conclusions and suggestions of this thesis.