CHAPTER I
PRELIMINARY

1.1 Background of the problem

As stated by the Higeia JOURNAL OF PUBLIC HEALTH RESEARCH AND DEVELOPMENT [1] the data taken from 2019 showed that Indonesia is still classified as a country with high health issues, with total of people with disability reaching 1,033,698 inhabitants, which include 81,554 of them have a speech impairment, and 145,961 of them have hearing impairments, which lead them to a dependency to use a hand sign language as a main communication platform. Another journal by Puguh Setyo Nugroho et al. [2] showed that when performing Training for Hand sign language training for health workers the survey showed that 72.2% of the training participants needed intense training to understand the hand sign language, and 67.1% of the participants agree that they need a hand sign language translator in a health care unit, even the journal stated that 91,3% of the issue regarding the service in healthcare for people with hearing, and speech impairment involved in the communication aspect, which mean that it is necessary to develop an automatic hand sign language recognition device especially in a healthcare unit.

The advancement of hand gesture recognition technology is a new method for enhancing two-way communication, particularly for individuals who use sign language as their primary way of interaction. Former Automatic hand sign language recognition methods, relying primarily on computer vision and depth image have significantly improved. Techniques such as those reviewed by Oudah et al. [3] and Suarez and Murphy [4] have demonstrated reliable hand gesture identification using image-based approaches. However, these methods face limitations in low-light or visually obstructed environments and are sensitive to background interference, which restricts their practicality in real-time and dynamic settings.

Recently, a new study on radar-based approaches to overcome these limitations. Frequency Modulated Continuous Wave (FMCW) radar gives an alternative for hand gesture recognition, as it can capture micro-Doppler signatures

that reveal detailed motion characteristics of the hand, even in visually compromised environments. Research by Kim and Toomajian [5] demonstrated the effectiveness of CNN-based models in interpreting these micro-Doppler signatures, Showing radar's potential in gesture recognition. Similarly, Leem et al. [6] developed a method for detecting mid-air gestures using radio sensors, which proves radar's applicability in non-visual and less structured environments.

While the current radar systems provide accurate gesture recognition, they are still limited by computational complexity and environmental variability. High-resolution radar imaging frameworks, as presented by Schüßler et al. [7] and Ortiz-Jiménez et al. [8] , show the capability of radar to detect precise hand movements. Yet, there are still difficulties in balancing resolution, response time, and device cost. Moreover, existing systems lack the adaptability required to handle diverse gesture languages, making it difficult to extend these applications effectively to the broader goal of sign language recognition.

This research wants to improve the problem by developing an FMCW radar-based hand sign recognition system capable of interpreting a set of hand gestures for sign language with the application to be used in a health care unit. Using a machine learning model in order to analyze radar-generated hand gesture data, this paper aims to build a system that can recognize sign language accurately and in real-time. This system have a potential, especially to improve the accessibility for the deaf and hard-of-hearing communities. The preferred solution of using FMCW radar with machine learning gives several advantages, including Privacy issues, real-time response capabilities, and reduced sensitivity to lighting.

1.2 Formulation of the problem

To develop an effective and practical automatic hand sign recognition system for two-way communication, several key challenges must be addressed:

1. How can an FMCW radar-based system be designed to recognize hand gestures accuracy up to 80% in real-time, specifically for sign language?

2. What machine learning approach is most suitable for processing and classifying radar-based hand gesture data, ensuring reliability and adaptability across varied environments

3. How can this system be optimized for accessible between users, particularly those who rely on sign language, especially in a health care unit

1.3 Objectives

The objective of this research is to develop a reliable and efficient automatic hand sign recognition system that facilitates two-way communication in a health care unit between the health worker, and the person with hearing, and speech impairments, using machine learning and FMCW radar. Specifically, this research aims to create a robust model capable of accurately interpreting and classifying hand gestures used in sign language, even in challenging environmental conditions, such as low-light or cluttered backgrounds. By leveraging FMCW radar's ability to capture detailed motion characteristics, this study seeks to overcome the limitations of traditional vision-based methods, providing an accessible, real-time solution that bridges communication for individuals who rely on sign language. Ultimately, the goal is to enable seamless interaction between sign language users and those unfamiliar with it, fostering inclusivity and enhancing accessibility in diverse settings.

1.4 Benefit Of Research Results

This research enhances accessibility for sign language users by providing a real-time, radar-based hand sign recognition system that enables seamless communication with non-signers, even in challenging environments.

1.5 Limitation of problem

1. The system is designed to recognize only standardized hand signs from a *SIBI (Sistem Isyarat Bahasa Indonesia*), Focusing on the Alphabet (A-Z).

2. Testing and validation are conducted primarily in indoor settings with minimal external interference; therefore, the system's performance in outdoor or highly complex environments may not be fully reliable.

3. The system is optimized for close-range (10-30 cm) interactions typical of personal communication, and its effectiveness may decrease at greater distances.

1.6 Research method

The research method that will be used in this research will include the following :

1) Literature Review

   This method will be used to understand the basic theory of FMCW radar and its technology that is relevant to the purpose of hand sign language recognition and understand how the radar can acquire the data through signal processing, furthermore, the literature review will also include the basic theory of Convolutional neural network algorithm which will be used to classify the desired hand sign language.

2) Empirical Measurement

   In this method the empirical measurement from the FMCW radar will be taken to acquire the dataset for several hand sign recognition inputs from the subject, the measurement will be taken place inside a room, with an input range of a maximum 30 cm from the radar, this data acquisition will be required in the further analysis.

3) System design

   Based on the previous literature review and system design, the method on how can the hand sign language be detected using FMCW radar and Convolutional Neural network (CNN) will be made, this phase will

choose what are the best algorithm and signal processing method in order to get the best result.

4) Simulation

This simulation phase will be used to train the dataset that are already taken in the empirical measurement, and then the dataset will be trained using CNN and validate the result with real-life situations, in this simulation phase some adjustments in the configuration and the algorithm will also possible, so that the hand sign recognition accuracy will increase.

5) Implementation

This phase will include the assembly of the hardware, which will include the integration of the FMCW radar with the Data capture adapter (DCA), the mini PC, and the display, some adjustments are still possible in this phase in order to increase the accuracy of the hand sign recognition,

6) Dissemination of Results

Dissemination of the results will be done by combining the result in a final project report book and journal publication, the result of this research will hopefully be helpful in the development automatic hand sign recognition method using FMCW radar, and hopefully be useful, especially in the medical field, the purpose of the publication is to spread the knowledge and opening the opportunity for further research.

1.7 User Projection

The primary users projected to benefit from this research are members of the deaf and hard-of-hearing communities, who will gain an accessible tool for two-way communication with non-sign language users especially for health care applications. Additionally, educational institutions and assistive technology

developers may use this system to enhance learning resources and develop further accessibility solutions