UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE DEVELOPMENT OF SOUND TRACKING FEATURES ALGORITHMS FOR ROBOT HEAD MOVEMENT CONTROL

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

by

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DECLARATION

I hereby, declared this report entitled "Robot Head Movement Control with Sound Tracking Features Using Sound Detection" is the results of my own research except as cited in references.

.

Signature : ………………………………………….

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Date : **26TH DECEMBER 2018**

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honors. The member of the supervisory is as follow:

……………………………

(Dr. Aliza Binti Che Amran)

ABSTRAK

Time Different of Arrival (TDoA) ialah antara satu langkah untuk penentuan arah sumber suara. Ia boleh digunakan untuk menentukan arah sumber suara dating dari 8 arah di hadapan muka robot. Kawasan hadapan muka robot akan dibahagikan kepada lapan bahagian yang dikenali sebagai “zone”. “Zone-zone” tersebut menunjukan bahawa robot akan menghadap ke “zone” yang sepatutnya setelah perbezaan masa antara mikrofon modul telah dikenali. Perbezaan masa antara modul-modul untuk bunyi tiba di mikrofon modul telah digunakan sebagai satu pembolehubah untuk mengenalpasti arah sumber suara dalam projek ini. Oleh itu, perbezaan masa tersebut telah dikirakan menggunakan “Trilateration Principle”. Projek ini ialah combinasi daripada elektronik dan mekanikal. Untuk bahagian yang digunakan dalam elektronik, papan Arduino dan mikrofon modul telah diaplikasikan dalam projek ini. Untuk bahagian mekanikal pula, 2 biji servo motor digunakan untuk melakukan mekanisme leher untuk robot tersebut. 2 biji servo motor tersebut akan menjalankan putaran mengoleng kepala dan putaran menangguk kepala masing-masing untuk menghadap muka robot ke arah sumber suara.

ABSTRACT

Time Different of Arrival (TDoA) is a method of sound localization. It is using to localize the sound source in omnidirectional in front of robot face. The area in front robot head will be divided into eight quarter zones. Each zone indicate that the robot can face to eight directions after determined the time different for the sound reach microphones from same source. The time different of arrival to the sound sensor is calculate by using Trilateration Principle. This project is a combination of electronic and mechanical design. For the electrical part, an Arduino Board and microphone sensor are used in this project. For the mechanical part, 2 servo motor are used to perform neck mechanism. The robot will be facing its head to the sound source with the servo motor neck mechanism that control yaw and pitch rotation respectively.

DEDICATION

To my beloved parents, I acknowledge my sincere indebtedness and gratitude to them for their love, dream and sacrifice throughout my life. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my dreams.

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Chapter 1

INTRODUCTION

1.1 Background

Sense is playing a central role for social and activity in daily life. Humans have five basic senses such as touch, sight, hearing, smell and taste. Human senses will be associated by sensing organs and information will be send to brain to help us understand and perceive the world around us. Hearing and sight enable us response to environment spontaneously. This project is about a humanoid robot that able to track sound and facing to the orientation of the sound source. Microphone is act as auditory sense to the robot and the neck mechanism movement of the humanoid robot is helping the robot head face to the orientation of the sound source. In this project, only auditory sense will be emphasized since the visual of the robot may not suitable in some condition with insufficient of light or if the subject is located outside range of the visual sensors. [6] [13] Hence, the aural sense of a robot is decisive to help the robot to localize the sound source. When we are communicating, we should be able to know the direction of talker and facing the talker to show the respect to the talker. Same as the humanoid robot, auditory sensors allow humanoid robots listen to talk and surrounding sound and perform as the ears of the human being. Microphones could be as sound sensor and will be used in this project. However, it is difficult for the robot with humanoid head working in a real environment. It is because using a pair of microphones on a robot is a difficult task to match capabilities of humans.

The arrangement of the microphone position will affect the accuracy of localization. A good array of microphone will increase the accuracy in determine the sound source. To getting a high accuracy of arrangement of microphone, we are not limiting to use only 2 microphones in humanoid robot to improve the accuracy of localization. [12] (Due to human have a pair of ears to heard)

Sound source localization (SSL) is a mechanism used to tracking the sound source. There are several types of mathematical derivation or algorithms to calculate the actual position of sound source from the reading get from microphone, such as DOA (Direction of Arrival), TDOA (Time Difference of Arrival) and ILD (Inter-aural Level Differences). Time Difference (or Time Delay) of arrival (TDOA) is the most popular method among these three methods. [6] Estimate are obtained from the time different between microphone pair. After that, these reading will be used for localization the sound source.

1.2 Problem statement

In this project, most accurate Sound Source Localization (SSL) arrangement of the array of microphones and number of microphones is required to be carried out. Secondly, the robot head will be able to turn its head after "heard" sound from environment. The neck mechanism of the robot head will be in 2 degrees of freedom, pitch and yaw rotations. The movement will be carried out by servo motor. Lastly, the robot will be able to function at real-time environment, such as multiple sound source. The robot will face to the nearest sound source.

1.3 Scope

To achieve the purpose of the project, there are several scopes had been marked. The scope of this project involves using only microphone as a sound sensor to collect the data. After that, Arduino will act as a controller of the robot head to analysis the data collected from microphone to get the position of sound source by algorithms. Finally, servo motor will be used as a part of neck mechanism to face the robot head toward the sound source. The servo motor will control the yaw and pitch rotation of the robot head. Roll rotation will not be carried out due to that movement is not a familiar movement to the human and unlikely to be used. In this project, the sense like touch, sight, smell and taste will not be carried out. Moreover, the SSL system will work only for sound source locate in front of robot head.

1.4 Objectives of Project

There are three objectives outlined in this project

1) To design a robot's head with neck mechanism.
2) To build a controller to move the robot head to face the sound source.
3) To verify the performance of position control of the robot head.

1.5 Organization

The focus of this project is to design a humanoid robot head that will facing to sound source in real life environment.

In the Chapter 1, it is about the introduction of the overall projects. It consists of background, objectives, scope and finally organization.

Chapter 2 is about the previous research about Sound Localization System (SSL). Main ideas and knowledge about SSL will be gained from here. The most suitable microphone arrays and type neck mechanism will be chosen for this project.

Chapter 3 is the methodology part. In this part, the detail components use in this project will be included. The flow chart of process development of whole project will also be including in this session.

Chapter 4 will be result and discussion part. The data collect from simulation testing and running of hardware. After that, the collected data will be analyses. In this chapter, whether the project achieve the objective will be discussed.

Chapter 5 will be the conclusion and recommendations. It is a conclude about this project and give a solution to solve the problem face along this project.

Chapter 2

METHODOLOGY

2.1 Introduction

In this chapter, previous research about sound localization will be studied. The array of microphones, design of neck mechanism and algorithms or method to locate sound source will be placed great emphasis.

2.2 Neck mechanism for Robot Head

2.2.1 Introduction to Neck Mechanism

In human anatomy, neck is the start from the spinal column to spinal cord. There are about 2 dozen vertebrae in the neck. The vertebrae in the neck is known as the cervical vertebrae. They are the littlest and uppermost vertebrae in the human body. Human neck mechanism is divided to three parts, roll, pitch and yaw. Consider to the neck movement in Figure 1 (b) is not a common movement for robot head even a human, this project will be more focus on movement in Figure 2.1 (a) and (c).

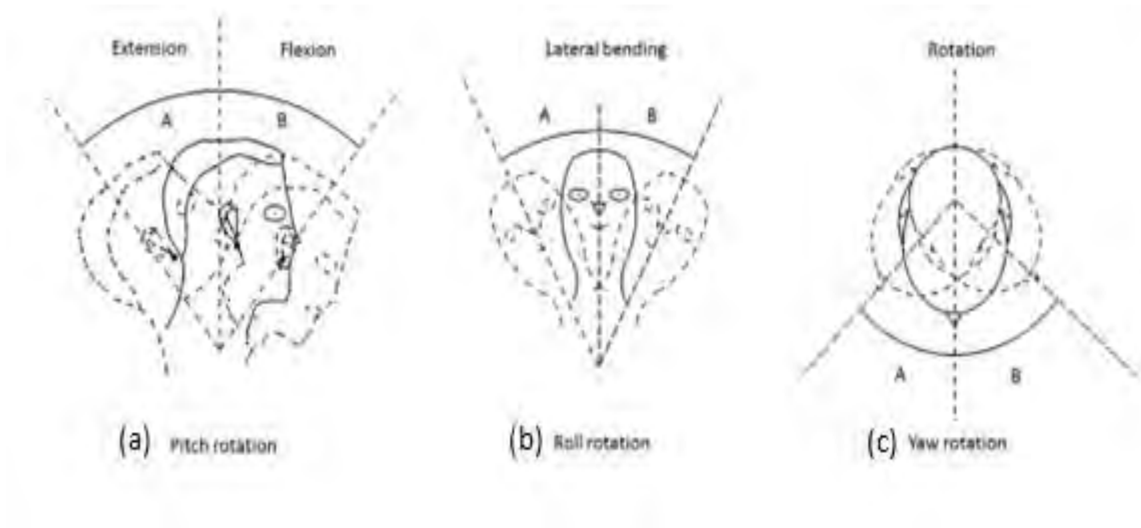

Figure 2.1: Roll, Pitch and Yaw [1]

Roll rotation is tilts to left and right for 45° from the vertical. Pitch rotation is shift forward and backward for 50° and 57.5° respectively. For yaw rotation, it is the looking straight rotation either from left to right or right to left about 70°. Maximum speed for each neck motion is shown in Table 2.1.

Table 2.1: Maximum Speed for Each Degree of Freedom [1]

Neck motion range	Degree range	Maximum speed, Deg/s
Roll	-45° to 45°	360°
Pitch	-57.5° to 50°	430°
Yaw	-70° to 70°	467°

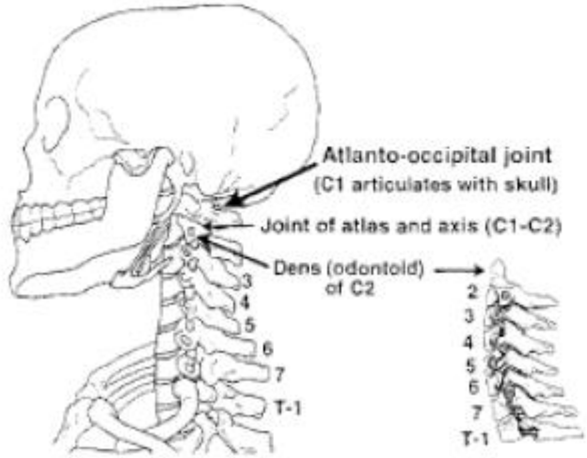

Figure 2.2: Atlanto-Occipital Joint [1]

From the Figure 2.2, the human head is attached to a spherical joint called atlanto-occipital joint. It will make the design process easier with replace the neck mechanism with the joint. In the red point show in the Figure 2.3, that is the central point for three rotational axes intersect.[1]

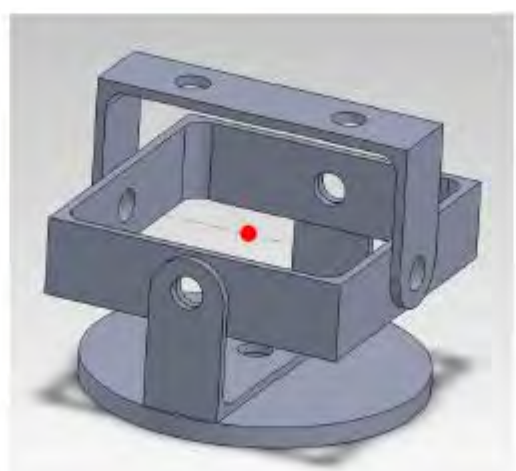

Figure 2.3: Central Point [1]

2.2.2 Designation of Neck Mechanism

There are many designs for neck mechanism reported in the literature. However, only three type of neck mechanism will be considered as shown in Table 2 and only one design will be chosen and will be used to develop the project experimental setup.

2.2.2.1 Neck Mechanism Using Servo Motor

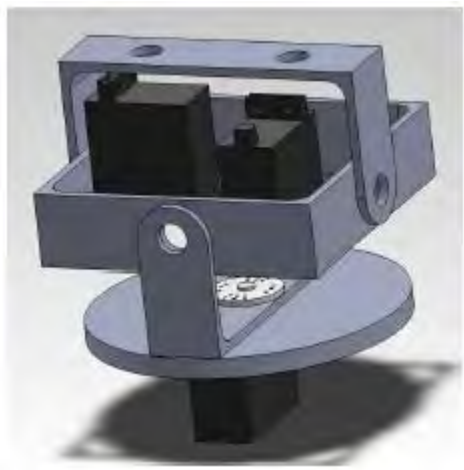

Figure 2.4: Initial Neck Mechanism Using Servo Motor [1]

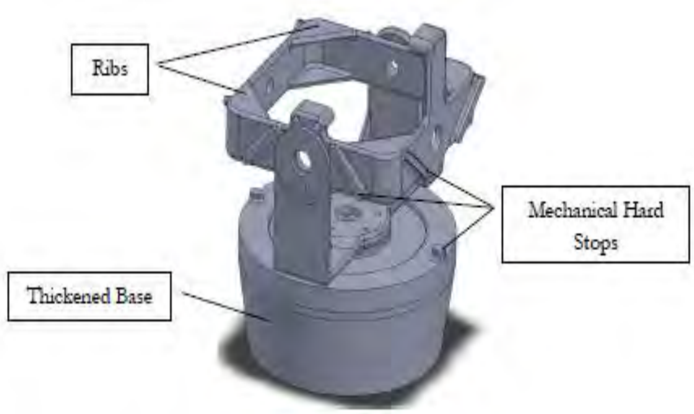

Figure 2.5: Position of Mechanical Hard Stop, Ribs and Thickened Base [1]

Figure 2.6: Final Design of Neck Mechanism Using Servo Motor [1]

Firstly, the position and size of servo motor should be considered at all to avoid collision. The position of servo motor as shown in Figure 4 would not collide with neck shell. Secondly, there are some design that can make the neck mechanism more practical. Mechanical hard stop can be added to prevent the rotation out of their desire range. Moreover, ribs can be used to intensify the rotation and the base will be thickened to ensure there was stable during the neck mechanism was operate. There is a final design with suitable servo motor in Figure 6.

2.2.2.2 Neck mechanism using actuators mechanism

There are two main type neck mechanism using actuators mechanism, serial mechanism and parallel mechanism. The actuator of serial mechanism is position in serial position whereas the actuator is position in parallel to each other in parallel mechanism. Only mechanical actuator can be used in serial mechanism. It is not suitable for humanoid neck because mechanical actuator will not provide smooth movements. On the opposite site, the parallel mechanism gains more advantage because of the applicable of pneumatic actuator Pneumatic actuator will provide smoother movement compare with serial mechanism. The application of the parallel mechanism commonly is more on flight simulation devices. [2] (Figure 7)

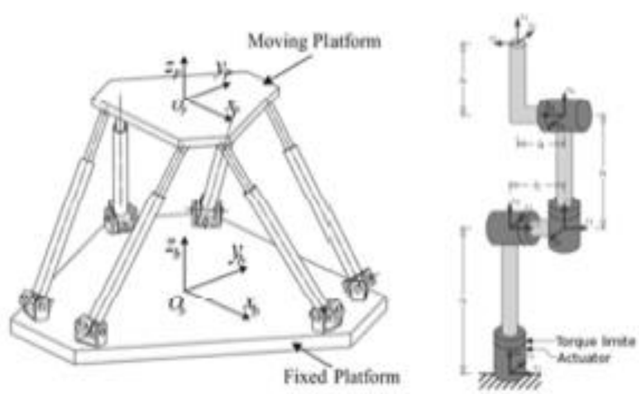

Figure 2.7: Neck Mechanism with Actuator [2]