Jurnal Ilmiah Komputer dan Informatika (KOMPUTA)
Edisi. .. Volume. .., Bulan 20.. ISSN : 2089-9033

# DIVIDE & CONQUER AND EUCLIDEAN DISTANCE COMPARISON FOR SPEECH RECOGNITION IN CHESS GAME APPLICATION

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## ABSTRACT

Speech Recognition is a process of identify words associated with some command, regardless of the person's identity. Speech Recognition can be used in an application that produces a command as the final result (Command & control) and an application that allows to replace the role of the keyboard and mouse into sound. Chess is a mind game using some type of pieces on a board with specific rules. Command & control used on the chess game application, with keyboard and mouse for control. The matching process is the crucial part on speech recognition because user's voice signal input will be matched with data in database to execute the corresponding command. Therefore, an efficient methods is needed to perform the matching process with high accuracy. The matching method to be used is Divide and Conquer and Euclidean Distance.

Chess game application using the Speech Recognition with Divide & Conquer and Euclidean Distance matching method, with the aim to determine which algorithm is more accurate to conduct the matching process for database. Fast Fourier Transform algorithm implemented on the game application as a voice signal processor, and Least Mean Square algorithm used to reduces noise.

Based on the overall test result, it can be concluded that Euclidean Distance result is accurately for implemented speech recognition compared to Divide and Conquer result.

**Kata Kunci :** Chess, Fast Fourier Transform, Least Mean Square, Divide and Conquer, Euclidean Distance.

## 1. INTRODUCTION

Chess is a mind game using some type of pieces on a board with specific rules. The game of chess can be enjoyed by anyone for how to play interesting and can be understood by anyone. The game of chess has been much adaptation into areas such as the computer field. On the application of computer games, chess using a command and control in the application, is using a keyboard or mouse to move it. In order for a game of chess on the computer can be enjoyed or used by anyone, if replacing the use of the keyboard and mouse into a voice command, a chess game is more able to facilitate or support a lot of people, even by people's with special needs (physical disabilities), because physical disability is it is often considered a disaster for individuals who experience [1] and make that individual, difficulty in doing something because there are no adequate facilities. The process is also called the voice commands with voice recognition process.

Voice recognition process is a branch of artificial intelligence that allows the computer to be able to receive feedback in the form of the spoken word. Speech Recognition is one of the voice recognition process that does not concern the identity of the person who chants [2]. Speech Recognition can be applied to the application's that produces the final result of the command (Command & Control) and an application that allows to replace the role of the keyboard and mouse into sound. One of the applications that implement it is a game.

In the process of voice recognition, there is a voice signal processing is intended that the computer can recognize the voice input by the user. The process of matching is one of the voice recognition process is very important, because the voice signal entered by the user will be matched with the data in the database. The matching results will be the final result of an action or movement that will be done by computer. Therefore, the process of matching urgently need a method that is very accurate in recognizing the data. The method can be applied to perform matching, such as Divide and Conquer and Euclidean.

Distance Divide and Conquer algorithm is a principled break first large problem into parts to the smallest parts so it is more easily resolved. Problem's that can be solved as in problem 1 or 2 dimensional array looking pair of points that were located nearby also called Closest pair. In Krishna Nugraha research [3], he successfully implemented a Divide and Conquer as voice matching method.

Euclidean distance is a calculation method 2 pieces point in Euclidean space. Euclidean space associated with Pythagoras theorem and is usually

applied to an array based template 1, 2 or 3 dimensions. But also simple when applied to a higher dimension [4]. At Eva Damayanti research [5], she successfully applied the Euclidean distance as voice matching method.

Based on the similarity of the two methods that can be applied to a 1 or 2 dimensional array and has been successfully applied as voice matching algorithm in previous studies, both the algorithms will be applied to a voice recognition application, and will do a comparison. The purpose of the comparison is to measure the accuracy or the accuracy of the calculation and matches in a voice recognition system.

Based things that have been discussed previously will be constructed chess game app that compares the results of the implementation of Divide and Conquer and Euclidean distance as a voice pattern matching. Expected by this research, the algorithm can determine which one will make the process better sound pattern matching on the value of accuracy and determine better methods to be applied to speech recognition to a chess game.

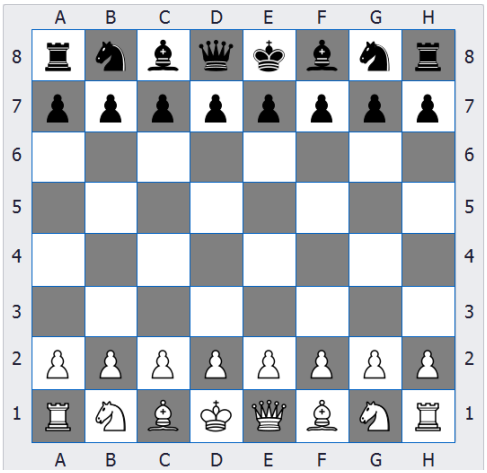
## 2. CONTENTS OF RESEARCH

### 2.1 Chess game

Chess is a mind game played by two people. Chess including strategy game that requires thought to finish. Chess is a person who plays chess, both in game one on one or one against many people (in informal circumstances). Before the match, chess choose chess piece to be played. There are two colors that distinguish chess, which is black and white. Holders of white pawns start the first step, which is followed by the holder of the black pawns in turn until the game is finished.

Before the match, chess pawns choose colors that will be played. Holders of white pawns start the first step, followed by black fruit holder interchangeably. Each step can only move one piece (except for castled in which there are two pieces that move). Pawn is moved to the empty slot, or which has been occupied by an opponent pawn, and then move the pawns means capturing the opponent out of the game. There are exceptions movement, which is to move en-passant.

The goal is to reach a position check-mat, which is a condition that occurs when the king is threatened and can not escape into another compartment.



Picture 1. Board of chess game

### 2.2 Voice

Sounds sometimes referred to as an acoustic wave (acoustic wave is actually a special case of elastic waves in the air or fluid medium) [6].

The sound is something that is unique and has a range that can be heard and can not be heard by humans, has a certain frequency and intensity. Limit the frequency of sound that can be heard by the human ear range between 20Hz (Hertz) to 20kHz (Kilo hertz). Unit for measuring the intensity of the sound is the decibel (dB) is taken from the name of the inventor is Alexander Graham Bell, inventor of the telephone. The units of the sound frequency is Hertz is named after physicist, Heinrich Rudolf Hertz to appreciate the merit for his contribution in the field of electromagnetism.

### 2.3 Speech Recognition

Voice recognition is a process to recognize letters, words or sentences spoken. Voice recognition, better known as Automatic Speech Recognition or Speech Recognition Computer where the use of a machine or computer to recognize a person's voice or identity of the spoken voice. Most speakers spoke in front of the computer or machine, then the computer or machine to recognize a person's voice precisely as spoken. Voice pattern recognition known to the various levels of duties, identification in the form of an acoustic signal levels in the order of sub-word units of phonemes, words, phrases and sentences. The introduction of the vowel sound of the voice recognition is the basis for the wording of the order of several letters, one of which is a vowel, so that if a fundamental principle of the introduction of the vowel sound can be used in further research.

### 2.4 Artificial Intelligence

Some people translate Artificial Intelligence as artificial intelligence, artificial intelligence, artificial intelligence or artificial intelligence. The term Artificial Intelligence deliberately not translated into Indnesia because that term is already very familiar to

the people of Indonesia. as well as the abbreviation AI, already inherent in the various scientific and non-scientific media.

AI definitions are grouped into four categories, namely Thinking Humanly, Acting Humanly, Rationally Thinking and Acting Rationally [7].

### 2.5 Problem analysis

The game of chess is a strategy game that can be played by two people. The game uses a black and white board with pawns as a game. There are 6 types of pawn different with different steps (Pion, Fortress, Riding, Secretary, Queen and King) and 64 boxes consisting of 8 boxes of letters (A, B, C, D, E, F, G, H) and 8 box numbers (1, 2, 3, 4, 5, 6, 7, 8) that all of the box can be passed by all the pieces. The main process in Speech Recognition in this chess game is the process of matching the data dictionary. The process aims to obtain the appropriate voice or appropriate in order to produce the final result of the movement of chess pieces and is a process that is very important because it is the process whereby a voice pattern recognition occurs. Obstacles encountered in the voice pattern recognition process is using the right algorithm to obtain accurate results. In this study, used two algorithms are the same can calculate the distance of a pattern and successfully applied in previous research. The pattern can be applied to a 2 dimensional array to adjust the data dictionary this chess game. The intended use of the two methods is to do a comparison algorithm which is more accurate and more appropriate in this chess game.

### 2.6 Pre-processing

Sound signals to be processed in the processing of the analog voice signal is so in order to recognize by computer, the analog signal must be converted into a digital signal in the form of a sequence of numbers, called analog to digital conversion.




Picture 2. Scheme *analog to digital converter*

Description working concept ADC in this application, as follows:

1. Sampling is continuous signal conversion in the time domain into a discrete signal, through a process of sampling signals at specified intervals. So if x0 (t) is the input signal, the output is x0 (t), where T is the sampling interval.
2. Quantization is a process to round off the value data into a specific number of numbers that have been determined in advance. Coding in this process, each discrete value has been obtained, represented by n-bit binary numbers.

#### 2.6.1 Data Acquisition

This stage is the process of collecting data in the form of a voice signal obtained by recording the sound through a microphone connected to a computer. Sound recording format used is .wav with a sampling frequency of bits/sample, channels and duration of recordings that have been determined in advance.

#### 2.6.2 Windowing

To reduce the blocking caused Frame low number of sampling rate, which led to leakage of spectral (spectral leakage) or aliasing and made discontinue the signal becomes. To reduce the possibility of spectral leakage, it must pass through windowing process.

$$W_i = 0{,}54 - 0{,}46\cos(\tfrac{2\pi i}{N-1}), 0 \le n \le N-1 \qquad (1)$$

Here is a representation of Hamming Window function of the sound signal that has been incorporated .

$$X_i = D_i * W_i \qquad (2)$$

Where : $X_i$: Signal windowing results
$D_i$: initial signal value
$W_i$: windowing value

### 2.7 Fast Fourier Transform algorithm

FFT (Fast Fourier Transform) is the technique of fast calculation of DFT (Discrete Fourier Transform). Discrete Fourier transformation, or so-called Discrete Fourier Transform ( DFT ) is a Fourier transformation model imposed on discrete functions, and the results are also discrete. FFT is a DFT with a quick calculation techniques and utilizing the properties of periodicals (conjugation) of a Fourier transformation.

$$F(x) = \tfrac{1}{N}\textstyle\sum_{n=0}^{N-1} f(n)\,(\cos\left(\tfrac{2\pi nx}{N}\right) - \mathrm{j}\sin\left(\tfrac{2\pi nx}{N}\right)) \qquad (3)$$

Where : $N$: Amount of data
$f(n)$: Discrete values
$\pi$: Phi (3,14)

To see the value of the FFT.

$$|F(x)| = [R^2 + I^2]^{1/2} \qquad (4)$$

Where : $f(x)$: DFT calculation results
$R$: Real numeric
$I$: Imaginary numbers containing J

### 2.8 Least Mean Square algorithm

Adaptive system is a system that is able to adjust and can beadaptasi directly to the condition of their environment. Least Mean Square (LMS) algorithm in the adaptive filter is used to fix the filter coefficients

(weights) expected that his future will produce a very small error.

$$d'(n) = W_n * (n) \quad (5)$$
$$e(n) = d(n) - d'(n) \quad (6)$$
$$W_{n+1} = W_n + \mu * e(n) * (n) \quad (7)$$

Where : $W_{n+1}$ : Update the filter coefficients
$W_n$: Old filter coefficient
$d(n)$: Value FFT signal
μ: Rate convergence
e(n): Error generated
(n): The input signal to the n

With the flow as follows:

1. At the time of n-th , weighting filter Wn known.
2. Early initialization : Wn = 0
3. Calculate output filter : d'(n) = w(n) * x(n)
4. Calculate estimation error: e(n) = d(n) - d'(n)
5. Calculate the weight of the next filter : w(n + 1) = w(n) + μ* e(n)*(n)
6. Continue to : n = n + 1

LMS algorithm does not require a complicated calculation process because it does not require the calculation of the correlation function and matrix inverse calculation. The properties of this simple calculation will be easily applied in the form of a computer program. Because of this simplicity LMS algorithm has become one of the standard and most commonly used in the calculation of the adaptive filter.

### 2.9 Divide and Conquer

Divide and Conquer method is very popular in the world of computer science. Divide and Conquer is an algorithm that principled fragmenting the problems that are too big into small sections so it's easy to solve.

In this intensive search , using a two dimensional array calculations with step by step as follows:

1. Sort the data features of sound from the smallest to the largest.
2. For each element of the reference data in a database, matched with new data using a binary search.
3. Calculate the smallest forecasting error, using formulas and results smallest MSE is the solution or the resulting output.

### 2.10 Euclidean Distance

Euclidean distance is a calculation method 2 pieces point in Euclidean space. Euclidean space associated with Pythagoras theorem and is usually applied to an array -based template 1, 2 or 3 dimensions. In this chess game, using a two dimensional array calculations.

$$d_{ij} = \sqrt{\sum_{k=1}^{n} (x_{ik} - x_{jk})^2} \quad (8)$$

Where : $d$: Distance
$i$: Input values
$j$: Database template values

### 2.11 Analysis database

The database is a collection of information stored in the computer in a systematic way so that it can be checked using a computer program to obtain the information contained therein. The database on this application is called the data dictionary. In this chess game, a data dictionary stores information in the form of chess movement. Shaped 2 dimensional array with three different formations.

| Pion1 | Pion2 | Pion3 | Pion4 | Pion5 | Pion6 | Pion7 | Pion8 | Benteng1 | Benteng2 | Kuda1 | Kuda2 | Mentri1 | Mentri2 | Ratu | Raja |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |

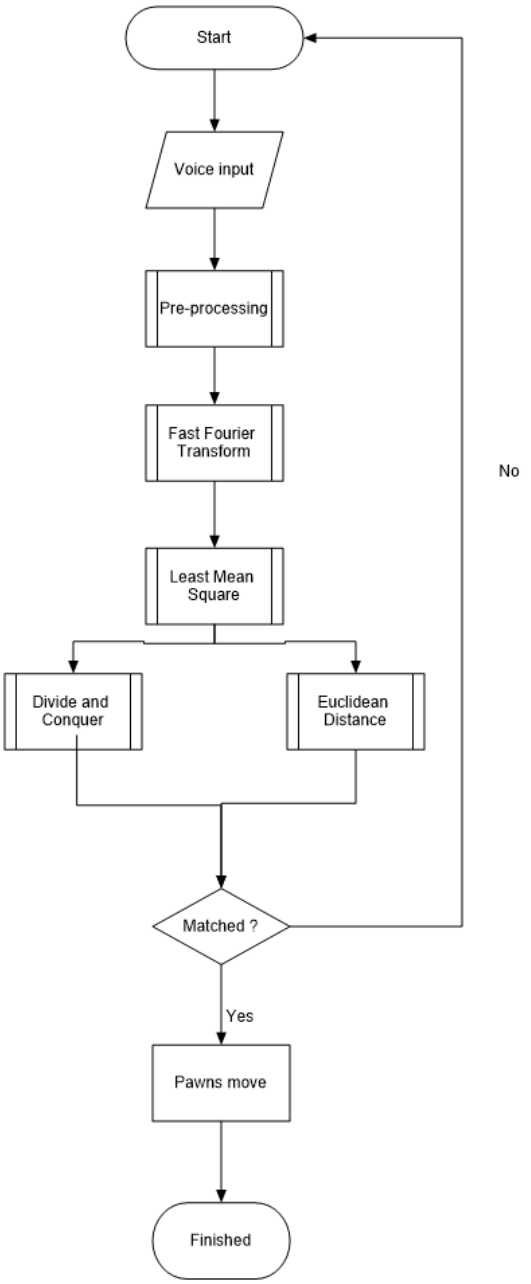
| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

Picture 3. Database of chess game

### 2.12 Analysis of the sound signal processing

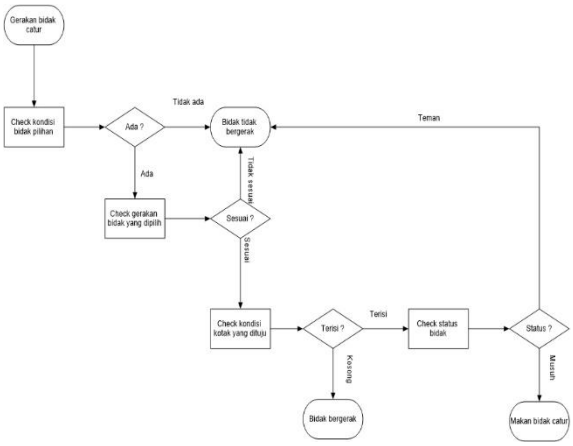
In the analysis of the processing of the sound signal is divided into several stages, the first stage is pre-processing or converting analog signals into digital signals using an analog to digital converter, the next stage is the Fast Fourier Transform, then the result of the FFT will be filtered for reduced noise his. Then it will be matched using Divide and Conquer algorithm and Euclidean Distance.




Picture 4. Sound signal processing Flowchart

## 2.13 Analysis of movements chess piece

After the matching process ends and generate matching corresponding to the data base, then the pawn will move.




Picture 5. Groove movement chess piece

The first step of this flow is to check the condition of pawns choice of whether there is or not. If there is, then check the movement of pawns been appropriate or not. If appropriate, then check the condition of the intended box if there is a pawn or not. If there is a pawn, pawn check the condition of the enemy or friend. If the enemy pawn takes pawn moves with the enemy.

## 2.14 NPC movements analysis

NPC stands for Non Player Character, which means the ability of a computer retaliation of an action system. This capability is an Intelligent Aritificial also called artificial intelligence. In this chess game, NPC is applied to the enemy pawn, the black pawn. Movement chess NPC constantly adjust to the movement of white pawns.

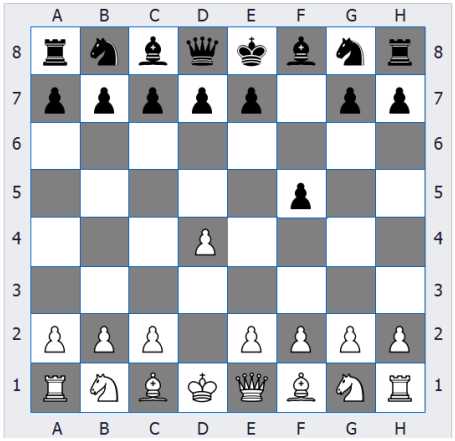
### 2.14.1 Movements reply NPC

In this chess game, an example of a movement that has been done by the white pawn player is movement PION4 – D – 4, which means the pawn with the serial number "4" to move to the box the letters "D" and the number "4". After a pawn moved from the initial position to the goal box, which uses AI enemies, will retaliate. Countermeasure that can be done by AI, as follows:

1. PION1 – A – 5
2. PION2 – B – 5
3. PION6 – F – 5
4. PION7 – G – 5
5. PION8 – H – 5

According steps AI above, AI will think the best step that can be done now and in anticipation of measures enemy ahead, then the movement of pawns to be done is PION6 – F – 5, which means pawn serial number "6" moves to the box the letter "F" and the

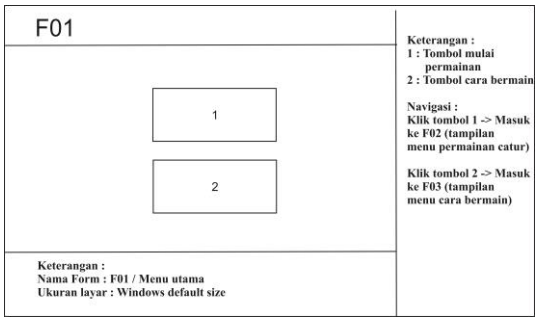
number"5".



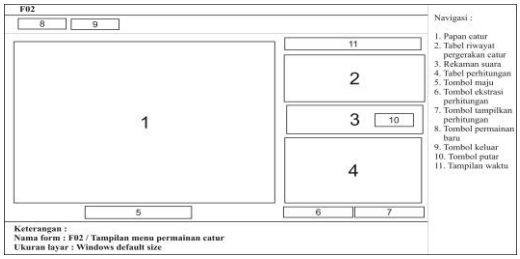
Picture 6. NPC movements

### 2.15 Design interface

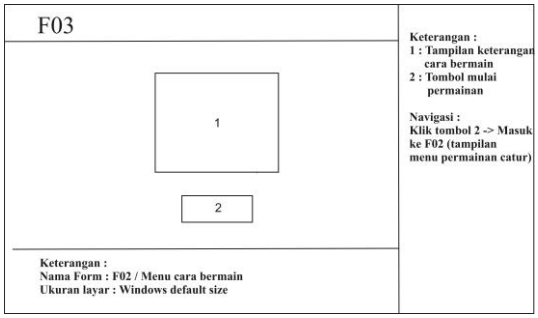
The design of the interface is needed to represent the true state of the application to be built. Interface design in this application are as follows:




Picture 7. Initial appearance




Picture 8. Menu chess game




Picture 9. Menu how to play

### 2.16 Testing system

In testing this voice recognition, voice input format used is in accordance with the game of chess. Sound recording format is divided into 3 every voice input by a pause of 1 second. The following sound formats that have been determined as follows:

1. Pawn to be used .
2. Box of letters that will be addressed.
3. Box number to be addressed.

There are 10 people consisting of 5 women and 5 men who will be tester with the following criteria:

Table 1. Criteria testers

| Criteria | Men age | Women age |
|---|---|---|
| **Kid** | 8 Tahun | 8 Tahun |
| **Teenage** | 17 Tahun | 18 Tahun |
| **Adult 1** | 34 Tahun | 32 Tahun |
| **Adult 2** | 53 Tahun | 52 Tahun |
| **Oldster** | 74 Tahun | 70 Tahun |

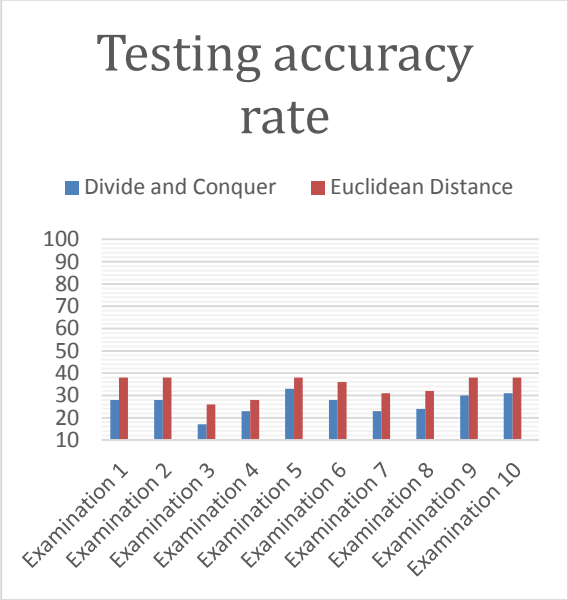
Based on the above table , it can be seen that it meets the criteria for phase's, which includes the stages of human life. Those criteria are divided into two groups, namely men and women. By age's adjusted criteria.

Using the 10 chess pieces that berbebeda movement and represents almost all chess movement. For each test, the player will perform 10x voice input.

Table 2. Testing chess piece movements

| Testing to- | Pawn movement | | |
|---|---|---|---|
| | Format 1 | Format 2 | Format 3 |
| **1** | Pion2 | B | 4 |
| **2** | Pion7 | G | 3 |
| **3** | Benteng1 | A | 5 |
| **4** | Benteng2 | H | 6 |
| **5** | Kuda1 | D | 2 |
| **6** | Kuda2 | G | 3 |
| **7** | Mentri1 | B | 2 |
| **8** | Mentri2 | E | 2 |
| **9** | Ratu | D | 6 |
| **10** | Raja | E | 2 |

Here is the result of 10 times of the voice input from 10 different people based on 10 tests with a total of 1,000 data is illustrated by the graph below:




Picture 10. Graph testing accuracy test

Based on the above data, it can be calculated the average - average accuracy for each matching method using the formula of the average's groups as follows:

Table 3. Average's test of Divide and Conquer

| Value range test results | Mid point ($xi$) | Frequency ($fi$) | $fi * xi$ |
|---|---|---|---|
| **1 – 10** | 5.5 | 0 | 0 |
| **11 – 20** | 15.5 | 1 | 15.5 |
| **21 – 30** | 25.5 | 7 | 178.5 |
| **31 – 40** | 35.5 | 2 | 71 |
| **41 – 50** | 45.5 | 0 | 0 |
| **51 – 60** | 55.5 | 0 | 0 |
| **61 – 70** | 65.5 | 0 | 0 |
| **71 – 80** | 75.5 | 0 | 0 |
| **81 – 90** | 85.5 | 0 | 0 |
| **91 – 100** | 95.5 | 0 | 0 |
| **Total** | | 10 | 265 |

So can be calculated with the average's the data groups and the level of accuracy as follows:

$$x = \frac{265}{10}\% = 26.5\%$$

Tabel 4. Average's test of *Euclidean Distance*

| Value range test results | Mid point ($xi$) | Frequency ($fi$) | $fi * xi$ |
|---|---|---|---|
| **1 – 10** | 5.5 | 0 | 0 |
| **11 – 20** | 15.5 | 0 | 0 |
| **21 – 30** | 25.5 | 2 | 51 |
| **31 – 40** | 35.5 | 8 | 284 |
| **41 – 50** | 45.5 | 0 | 0 |
| **51 – 60** | 55.5 | 0 | 0 |
| **61 – 70** | 65.5 | 0 | 0 |
| **71 – 80** | 75.5 | 0 | 0 |
| **81 – 90** | 85.5 | 0 | 0 |
| **91 – 100** | 95.5 | 0 | 0 |
| **Total** | | 10 | 335 |

So can be calculated with the average's the data groups and the level of accuracy as follows:

$$x = \frac{335}{10}\% = 33.5\%$$

## 3. Closing

The conclusion is a summary drawn from the discussion made software, where software is created is the application of a chess game using Speech Recognition and compare the application of algorithms Divide and Conquer and Euclidean Distance, while the advice given to the use of these systems is a result of design to be material references to improve performance of this system for the better.

### 3.1 Conclusion

Based on the analysis that has been carried out on the construction of a chess game application that implements a comparison Divide and Conquer and Euclidean Distance to speech recognition, it can be concluded that the Euclidean Distance is more accurate results to be applied to speech recognition compared to the Divide and Conquer.

### 3.2 Suggestion

In order for these applications may evolve in the future, the authors suggest some of the following, namely:

1. Improving the results of processing voice signals received by the computer. In order to produce a better value than using Fast Fourier Transform algorithm.
2. Replace all role click the command button into voice, to better reach out to many groups.

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