Speech-based Question and Question Answering Classification for Afaan Oromo Language

Thesis Prepared

By

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ACCEPTANCE

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Accepted by the Faculty of Informatics, St. Mary's University, in partial Fulfillment of the requirements for the degree of Master of Science in Computer Science

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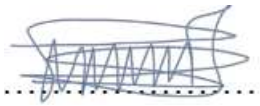
DECLARATION

I, the undersigned, declare that this thesis is my original work, prepared under advisor Dr. Michael Melese all resource used for research have been duly acknowledged. I further confirm that the thesis has not been submitted to any higher education institution for the purpose of taking degree.

Name Signature



Dr. Michael Melese

St.Mary's University 2023, Addis Ababa

DEDICATED

This research dedicated to all people who help me for my success and make my life comfort.

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First and for most, I would like to express my heartfelt thanks to the Almighty god, for giving me the strength, determination, endurance and wisdom to bring this thesis to completion. And I am deeply grateful to my advisors Dr. Michael Melese for their constructive suggestions, review and concern. Also I say thanks to my mother Mimi Abera, she always been with me supporting, helping and appreciating in my journey to be a better man today.

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Table of Contents

LIST OF TABLES

LIST OF FIGURE

ABBREVIATIONS LIST

ASR	Automatic Speech Recognition
DSP	Digital Signal Processing
DSRM	Design Science Research Methodology
DTW	Dynamic time warping
HMM	Hidden Mokrov Model
IE	Information Extraction
IR	Information Retirival
MOS	Mean Opinion Score
NLP	Natural Language Processing
QA	Question Answering
QAS	Question Answering System
SVM	Support Vector Machine
STT	Speech to Text
TTS	Text to Speech
UAT	User acceptance testing
NSWs	Nonstandard Words
SWs	Standard Words
SVO	Subject-Object-Verb
WEP	Word Error Rate
SWER	Single Word Error Rate

ABSTRACT

One of the information retrieval disciplines that accurately predicts answers to a given question from massive documents is question answering. Our research concentrated on developing an interactive model as a result. An interface using both Afaan Oromo speech recognition integrated with factoid question and answering. An automatic question classification system for speech-based questions for Afaan oromo question answering is what this project aims to design and build. After all, the study is integrate of both voice recognition and question-answering techniques.

Numerous tools were used in the construction of the system's prototype. from those cygwin, python, perl and Neatbean 8.0 for Java coding. These study contains large number of Afaan Oromo documents for speech testing, training and also for answer extraction for question answering. The corpus collected from different Afaan Oromo newspaper online newspaper such as (Fana, Bariisaa, Bakkalcha and Ethiopres) and internet.

We used 2,152 dataset for question-answering to evaluate the systems quality and also speech based question sentences corpus trains by 21 different people (male 13, and women 8 with total trains of 1344 speech dataset) those who can speak and read Afaan Oromo language and tested by both who trains and not trained. Each individual reads 64 questions aloud, and the questions types are about places and person. The model provided recognition accuracy of ***80.2%*** *with* ***19.8%*** *WER. The speech recognition system's experimental findings showed accuracy of* ***78.4%.*** *The question classification without question and answering for both person and place question types classified with a 98% and 96% for both questions list respectively. But with question and answering the Rule based question classification accurate* ***89.1%*** *precision,* ***91.6%*** *recall and* ***90.3%*** *F-measurement. The results of speech-based questions and automatic question classification for Afaan Oromo question-answering are generally achieves* ***71.45%*** *accuracy.*

The challenges with this research is that it did not parse a query using synonyms. As a result, in order to improve the performance of Speech-based question and Afaan Oromo question answering Classification system, semantic similarity using ontology-based structure is needed.

Keywords: *Afaan Oromo question answering, speech recognition, question classification.*

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Oromo language, also known as Afaan Oromo. Oromo language is a Cushitic language spoken by more than about 50 million people in Ethiopia, Kenya, Somalia, and Egypt and is the 3rd largest language in Africa [1]. Nowadays there is a huge volume of data available on the web. This huge volume of data on the web can satisfy most of the information need. But without the appropriate search facilities it is difficult to get the required information from the web documents. Search engines like Google, Yahoo, etc., help the users to get new concepts from different documents on the web. This is to mean that such kind of search engines return a ranked list of documents that contain the concepts that the user requested. Then the users by themselves go through the returned list of documents to filter the concepts that satisfy their needs [2]. Because information retrieval systems lack the capacity to completely comprehend users' requests, they, like most search engines, return a list of documents that are irrelevant to the query. Users send a query to the search engine in order to obtain what they want, and the search engine subsequently ranks and provides content that are linked to the query words. Users must read and pick material of interest from the returned document manually, which takes time, and the information provided by search engines is not tailored to the query [3]. There are two mechanisms which to make those access easy.those are Information Retrieval (IR) and Information Extraction (IE).

NLP technologies are used in the IE approach to accurately indicate a valid text. Deep analysis of queries (i.e., user inquiries) to comprehend the users' intent, as well as deep analysis of the content to derive proper replies, are both part of IE (sentences or passages). Users were dissatisfied with the search engines' performance since they could only return ranked lists of relevant documents [4]. Relevant documents should be obtained using a question answering system in order to offer accurate responses to questions posed in natural language. One of the IE approaches used to extract accurate responses for a given inquiry is question and answer (QA). QA is one of the IE techniques that is used to extract precise answers for a specific question.

Types of questions asked in Question Answering (QA) systems directly have an effect on the answers. We organize types of questions into different categories. The different categories of question types are Factoid type questions (***what, which, when, who, how***), List type questions (***a list of facts or entities as answers***), Confirmation Questions (***yes or no),*** Causal Questions (***why or how***) and Hypothetical Questions (***any hypothetical event and no specific answers of these questions***) [5, 6].

A classification of question answering system is classified in to two catagories those are Open domain and closed domain Question Answering system [6]. Open domain Question Answering systems are not restricted to any specific domain and provide a short answer to a question, addressed in natural language and In Closed domain QA system, there is restriction of domain which is based on web and questions are related to a specific domain. Closed domain Question Answering system consists of limited repository of domain specific questions and can answer a limited number of questions. Open-domain QA system supports any domain questions and answers which are collected from different sources, such as; internet, reporters, newspaper, and articles. Open-domains which are questions almost about everything in the study [7].

Question processing, document processing, and response extraction are all components of a Question and Answer (QA) system. The question processing module is in charge of selecting question kinds, expected answer types, question focus, and the appropriate question to send to the document retrieval component. Using Rule based question classification, determine the question type, i.e., what the inquiry is about and what can be done. The question focus is used to determine the Rule based question classification. The intended answer type is linked to the question type and the emphasis of the inquiry. The most important purpose of defining the expected answer type is for the answer extraction module to quickly extract the correct answer. In addition, the questionprocessing module provides an appropriate question that will assist in relevant documents. The document retrieval component is in charge of locating relevant documents within a collection. It's similar to how IR systems, like as search engines, present relevant documents to users depending on the inquiry they've asked. The document retrieval component is obvious, as an irrelevant document results in an incorrect or NO response. Depending on the needs and procedures utilized in the QA system, the document retrieval component may include paragraph/sentence retrieval. The answer extraction module, which is a critical component of

quality assurance systems, employs a variety of ways to extract the right answer. This lesson will use several methods and strategies to obtain the precise answer[8,9].

This research study focus on factoid question and answering system which integrated with speech based question that recognized from user input. Thus there is a need to design and develop a question and answering prototype which simplify search those huge documents.

1.2 Motivation

The technique known as automatic speech recognition (ASR) enables people to use their voices to communicate with computer interfaces in a way that, in its most advanced forms, closely resembles natural human speech. A difficult endeavor, finding succinct, specific responses to users' inquiries is question answering. Through the use of computational linguistics, speech-to-text software can recognize spoken language and convert it into text. Speech recognition or computer speech recognition are other names for it.

We are constantly looking for information. However, information and knowledge are not the same. We can easily get pertinent information thanks to the development of information retrieval and web search. A specialized type of knowledge-seeking information retrieval is question answering. Not only are we interested in finding the pertinent pages, but we are also interested in finding answers to specific questions. NLP, IR, and rule-based model representation all come together in question and answering.

Now today some NLP application are constructed for Afaan Oromo [16]. QA technology will become more and more crucial as it gets harder and harder to get answers on the web using traditional search engines. Also Factoid questions make up a large portion of the real queries entered into search engines. After inserted to search engines instead of providing shorter answer for user for asked query a current search engines can return links and full-length data’s and also you can take time to identify documents were answer is occured.So NLP is the technology motivated as solution for analyzing and selection precise answer shortly for asked factoid type question and In order to handle language for a variety of jobs, higher levels of analysis are needed.

The art and science of question-answering systems coexist in their very nature. There is a global need for question-answering systems. The demand for technological aid is present in every area of life. As a result, it is worthwhile to investigate the fascinating topic of question answering.

1.3 Statement of the Problem

Language of the Oromo people, spoken in Northeast Africa and primarily Ethiopia and Kenya, as well as parts of Somalia and Egypt. As a macro language, it is estimated that Oromo is spoken by as many as 50,000,000 people [12]. Oromo is the 3rd most widely spoken African language after Arabic, Hausa and Swahili. From the Cushitic branch of the Afro-asiatic language family, it is used as a lingua franca also by non-Oromo groups in Ethiopia, Kenya and Somalia [10]. Numerous publications in the world, including newspapers, magazines, educational materials, government documents, and religious texts, have been produced in the language. You can access this information electronically in both online and offline locations [11]. As a result, each question must be carefully considered in order to provide the appropriate response using their respective languages' QAS methods.

Since the conception of QAS, numerous studies have been conducted in numerous languages with good results .in our country some research developed on local languages likes: Amharic, Tigrigna, and Hadiy…etc. Speech-based question for also done for Amharic language documents. But afaan Oromo Cushitic language which used Latin scripts which called "Qubee".however they have different linguistic, words, sentences, questions, answers and pronunciations [1, 11]. So the developed system previous not worked for afaan Oromo because they are different morphologically. In afaan Oromo and other local languages some research is done on question and answering.

Many researchs are done in various languages to solve the issue of question and answering .from those Afaan Oromo Question Answering System for Factoid Questions by [14],Definition Question answering system for Afaan Oromo Language by Dejene Hundesa[2], Afaan Oromo List, Definition and Description Question Answering System by Chaltu Fita[15,16], Amhari c Question answering for Factoid Question by [17,18].The above listed researches are takes text questions and provides answers in the text form.

The number of Afaan Oromo documents produced electronically is increasing quickly in our country ,like journal, newspaper, and research publishers begin disseminating their products online. However, since asking questions is a part of what makes people human, the answers to

these questions can be found in the newspapers. Due to this gap, there will be a greater need for a system that can takes questions, look up answers in the knowledge base, and give a straightforward solution.because without this it has the challenging of wasting time on identify documents.

So it's very important to construct speech based question and question answering classification which accept question simply in voice recognition technology and transfer it to question and answering. The QAS analyse, ranking, classify and retrieve the question and answer simple to solve above gaps.

1.4 Research question

As a result, the goal of this study is to create a prototype of Automatic question classification and speech-based question for Afaan Oromo question -answering as well as people to accessing information from large data stored.

In order to accomplish this, the following research questions are investigated and answered in this study:

- How the classification of question developed for Afaan Oromo QAS?
- Which feature extraction technique are appropriate for Afaan Oromo QAS
- How can voice question can be integrated to QAS?
- To what extend the QAS classify the Afaan Oromo language

1.5 Objective of the Study

The objective of this study is clasified in to two which is general objective and specific objective.

1.5.1 General Objective of the Study

The primary goal of this research is to create a prototype for speech-based question and question answering classification for Afaan Oromo languages.

1.5.2 Specific Objective of the Study

In order to achieve the general objective, the specific objective is a specific result that the research going to achieve within a given time frame.

- To review literature to understand the state-of-the-art in the area of QAS and Afaan Oromo language beside identifying the research gaps.
- To collect and prepare representative dataset for Afaan Oromo speech recognition and QAS.

- To design the general architecture of Afaan Oromo Speech-based question for QAS

- To examine and identify the study component methodologies, strategies, and tools, such as voice recognition and classify question for the queston answering system.
- To develop prototypes and for voice recognition, question answering classification afaan langauge.
- To integrate speech question with question anwering to fulfill the correct answer for question and answering.
- To report the finding of study for the upcoming research area.
- To evaluate the system's performance.

1.6 Scope and limitation of the Study

1.6.1 Scope

In terms of the study's scope, this speech based question for Afaan oromo question answering was created in the Afaan Oromo language, which the researcher is familiar with and which is the Oromia state's regional language. The question type to be forward is factoid question types, i,e .Particularly speech based question for factoid Afaan Oromo QAS.

1.6.2 Limitation

In the speech-based question and QAS for Afaan Oromo research the main challenges is Afaan Oromo language large-scale document corpus are a critical component of this research. This paper does not answer all possible correct answer for all asked question.Because the main problem is the structure matching technique; also, the questions are unclear and absence of WordNet-compatible semantic similarity, may be the answer of the question say no answer or retrieve false answer. The other limitation of the research is classification of the question which focus only on person and place, because collecting large corpus is difficult due to the language has not standard corpora.

1.7 Methodology

Methodology refers the broad plan and justification for your research effort are referred to as your methodology. It entails researching the theories and ideas that underpin the procedures employed in your industry in order to create a strategy that is in line with your goals. A variety of approaches have been used to achieve the study's general and specific aims.

1.7.1. Research Design

This study used the design science research approach methodology. It is a design and development integration science that are commonly used in fields like software engineering, computer science, information science, and information technology. It is a group of study approaches that employ design and development to comprehend underlying processes.

DSRM process include six steps:

- ✓ Define problem and why you motivate.
- ✓ Objective of solution
- ✓ Develop Prototype.
- ✓ Demonstrate and interaction

1.7.2. Literature Review

Before developing and testing the system, a related literature collection from journal articles, books, conference papers, and the Internet was reviewed to understand concepts related to automatic speech recognitions, question answering, and Afaan Oromo language phonetics and writing systems. We also looked at comparable research that was done previously for the Afaan Oromo factoid question and answering system [8, 14]. The best tools and methods were then evaluated, picked out, adopted, and adjusted with the goal of building a system.

1.7.3. Data collection

These study uses huge number of afaan Oromo document data for speech testing and training and answer extraction for question answering. The corpus collected from different afaan Oromo online newspaper such as (Fana, Bariisaa, Bakkalcha, and Ethiopian press) and internet. The target groups are then recorded speaking these sentences. After that, each sentence's captured data goes through segmentation and tagging stages. The researcher used 2152 pair's datasets for question and answering to evaluate the system quality and also speech based question sentences corpus by 21 different people (male 13, and women 8) those who can speak and read afaan Oromo language in Oromia banks.

1.7.4. Implementation Tool

To complete the study tasks, software and tools were employed to design and create the system. The majority of the methods and equipment are used, and certain software tools from earlier studies are included. The study's model was created using NetBeans 8.0.0 java Programming language

tools. Because it is reliable and independent platform. Lucene libraries also additionally utilized for answering a question.

Cygwin, Pocketsphinx Sphinx-Train, and Sphinx4 were the tools used for the training phase of the voice recognition system. The majority of those products feature a straightforward process for creating STT in this system. The Rule based model is generated and automatically classified using the Java programming language library. To examine the speech and identify its formants and other pertinent data from the speech file, Wave Surfer was also employed as a speech analysis tool. Based on the above tools, the researcher is able to design and build a prototype with three distinct components that are combined using the Java NetBeans 8.0 in Windows 11 computer.

1.7.5. Evaluation

Two general performance testing techniques are used in the system evaluation process. System performance evaluation as the first step and testing is the second step. Question data types prepared for person and places are used for question classification in the training part. For both respectively 20 and 20. Additionally, the test dataset included 20 question sentences spoken by two speakers. During the recognition phase, 2 users were utilized to verify the system's naturalness and understandability as well as user acceptance.

The Afaan Oromo speech recognition and afaan Oromo question-answering system, are tested independently to evaluate the system performance's correctness or accuracy. The analysis of voice recognition using sphinx tools to determine whether words or sentences are accurate matches. And also Precision, Recall, and F-measure are used to evaluate the accuracy of the question-answering system model. The final stage of the system tested both and evaluated as one.

$$\text{Precision} = \frac{\text{Correctly retrieved answer}}{\text{Total retireved answers}}$$

Or

$$\text{Precision} = \frac{\text{True positive(TP)}}{\text{True Positive(TP)} + \text{False Positive(FP)}}$$

$$Recall = \frac{\text{Correctl retrieved answer}}{\text{Total correct + Not displayed}}$$

Or

$$Recall = \frac{\text{True Positive(TP)}}{\text{True positive(TP)} + \text{False Negative(FN)}}$$

Where **TP** stands for true positive, **FP** for false positive and **FN** for false negative.

An indicator of a system's accuracy, the harmonic mean of precision and recall, or F-Measure or F-Score, reaches its best value at 1 and its worst score at 0. It is 0 if no pertinent solutions have been discovered, and it is 1 if the precise solution has been identified.

$$F - measure = \frac{2 * \text{Precision} * \text{Recall}}{(\text{Precision} + \text{Recall})}$$

A popular metric for evaluating the efficacy of speech recognition and machine translation systems is the word error rate (WER). Assessing performance is generally difficult since the reference word sequence—which is intended to be the correct one—can be longer than the accepted word sequence. In contrast to the phoneme level, the WER operates at the word level. In order to tackle this issue, dynamic string alignment is used to first align the recognised word sequence with the reference (spoken) word sequence.

The word error rater can then be computed as:

$$WER = \frac{S + D + I}{N}$$

Where:

S= is the number of substituted word,

D is the number of the deleted word,

I= is the number of the insertions/added,

N= is the number of words in the reference

When describing a voice recognition system's performances word recognition rate which contains number of correctly recognized words using this N-(S+D) equation.

1.8 Significance of the Study

In this direction, the findings of this study are intriguing. Although the Spech to Text Spech were designed for a general audience These are some of the primary benefits of adopting speech-to-text technology to save time. Automatic speech recognition technology reduces time by providing precise transcripts in real-time. The research can extract the necessary information from bigger document of afaan oromo. The study's main contribution is to bridge the gap between people's physical challenges and the World Wide Web.

The study offers a solution for less typing challenged users who prefer Afaan oromo voice as a means of accessing Afaan oromo documents. Furthermore, the study's significance is that it may be used to a variety of business applications using speech to communicate with machines. The outcomes of this study may aid in the knowledge of voice recognition components, question categorization approaches in Question and answering systems componenets , all of which are critical for system design.

The study's findings will be extremely useful to a variety of government, multilateral, and bilateral development partners, as well as Typing takes far longer than talking.. A document can be dictated three times faster than it can be typed. Software for dictation and transcribing results in lower transcription costs and a much simpler workflow. Speech recognition software can be used by any industry. Like for educational purposes and in developing future research.

1.9 Organization of the paper

There are six chapters in this thesis. The background of the study, the problem statement, the general and specific study objectives, the scope and limitations of the research, the significance of the formulated results and the organization of the thesis for the proposed research are all covered in the **first chapter**.

In chapter two. The literature is examined in order to have a thorough grasp of the subject and to identify any gaps. Information retrieval and information extraction are compared and contrasted. This chapter also discusses automatic voice recognition, speech synthesis, and afaan oromo language in relation to question and answering systems. This chapter explains what question answering entails in order to have a thorough grasp of question and answering as well as specifics on factoid questions.

In Chapter three.The basic Afaan Oromo and components of the proposed architecture for designing a speech-based afaan oromo question answering system, as well as their interaction, are discussed in this chapter. **Chapter four** is about the system's detailed design (implementation prototype). It goes through the algorithms we utilized to achieve the system's goals for each component.**Chapter five** deals with the tests performed in each component, as well as the outcomes obtained, as well as explanations of how such results occur. Finally, conclusions and research recommendations are in the **chapter six.**

CHAPTER TWO

LITERETURE REVIEW

2.1 Overview

This chapter offers to reviews the literature and related works in order to identify the gaps, model they used. And also this chapter starts with question answering, components like question processing, information retrieval and answer extraction. Also the process of speech recognition from input utterance up to text output are discussed in this chapter. Finally the gaps of reviewed literature are identified.

2.2 Question and Answering

Building systems that automatically respond to questions submitted by humans in a natural language is the focus of the computer science topic of question answering (QA), which falls under the umbrella of information retrieval and natural language processing (NLP) [20]. A question-answering implementation, which is frequently a computer programme, may query an organised collection of knowledge or information, generally referred to as a knowledge base, to construct its answers. Question-answering algorithms frequently use a collection of both unstructured and structured natural language texts to gather information.Those natural language document collections used for question answering systems may include local collection of reference texts, organization documents ,webpages, set of Wikipedia pages and world wide web [9].In the attempt it uses a natural language inquiry as the input and retrieves specific responses from the vast document collections included inside the corpus. Types of question answering systemem are classified in to two catagoreis those are Open domain Question Answering system and closed domain Question Answering system [9, 21]. Open domain Question Answering systems are not restricted to any specific domain and provide a short answer to a question, addressed in natural language and In Closed domain QA system, there is restriction of domain which is based on web and questions are related to a specific domain [9]. Closed domain Question Answering system consists of limited repository of domain specific questions and can answer a limited number of questions [6] [21]. While open-domain QA system supports any domain questions and answers which are collected from different sources, such as; internet, reporters, newspaper, and articles [9].

Open-domains which are questions almost about everything in the study and can only rely on general ontologies and world knowledge. On the other hand, these systems usually have much more data available from which to extract the answer.

The history of question and answering are baseball and lunar were two of the earliest systems for answering questions [9],[22]. Over the course of a year, baseball responded to inquiries regarding the Major League Baseball league. Lunar, in turn, provided answers on the geological evaluation of the rocks that the Apollo lunar missions brought back. In their respective fields, both question-answering systems were quite productive. QA system attempts to deal with a wide range of question types including; definition, list, fact, how, why, where, hypothetical, semantically-constrained and cross-lingual questions [23]. Since the research focused on factoids of questions and answers, it made an effort to expand on this area.

2.3 Question and Answering System Content

QA system consists of three separate contents question processing, Data procesing, and Answer extaction [9] [16].

Question processing is the process that establishes the question's emphasis, classifies the question type, establishes the intended answer type, and rewords the question into a number of semantically equivalent inquiries. The memory of the information retrieval system is expanded through question expansion, often known as reformulating a question into other questions with similar meanings.

Information retrieval (IR) recover the most important and relevant documents that will be put through passage filtering, which extracts passages that identify potential response strings. Because no valid answers can be found in a document if IR recall is not present, finding an answer cannot be processed further [9]. Performance in the IR phase while answering questions can also be impacted by the precision and ranking of candidate passages or sentences.

Answer extaction is one of the QAS contents, which sets them apart from text retrieval systems in the conventional sense. Identifying replies is the responsibility of this module, which will then use answer extraction to obtain the precise response before confirming it.The technology used in answer extraction is increasingly influencing and determining the outcomes of question answering systems.

2.3.1 Question Processing Content

Question processing content or module is is to process and analyses the question, and to create some representation of the information requested. Creating this representation requires the question processing module to determine: - question type, expected answer type and question focus [9], [24].

Question type is a process of classify the question .The type to which it belongs are used to determine the questions' types, and the data will then be processed to yield the expected response for each type of question.As it offers important guidance about the nature of the needed answer, the question type classification component is thus a helpful, though not essential, component in a QA system. Since pattern matching techniques are utilized, the question is first categorized according to its type: what, why, who, how, when, and where inquiries.

In the previous years, **question classification** was done by using SVM and rule-based approach. This approach was too specific for the users and it was difficult to achieve the purpose [25]. the other is SVM. The Rule based model based question classification takes benefit of flexibility over the SVM question classification but. It needs to rules which means it does not need hard-coded rules to handle new cases while the language model can be automatically maintained [9], [26]. If the desired keyword is not obtained, a pattern matching technique in rule-based systems can no longer predict the expected answer kinds.

Rule based Approach

The process of categorizing questions into different groups is known as question classification. The list of potential classes is specified and can be narrowed down to a few basic sets by looking at the key words, by the researcher defined in the rules." The total effectiveness of the Question Answering system depends heavily on how accurately questions are classified. As a result, most systems turn to a more in-depth study of the question, which establishes new restrictions on the answer entity.

There are numerous techniques to implement question classification. Using a set of rules that convert question types into patterns of questions is the simplest approach. On the surface form, regular expressions are used to express the patterns. Analyzing the interrogative phrases of the

question wh-terms is often how the answer type is determined. So this methods very easy for classification and we used it for question classification.

A support vector machine (SVM) is another algorithm to supervised machine learning technique for classifying and predicting types of question. It is largely utilised in Machine Learning Classification issues, though. SVM chooses the extreme points/vectors that help in creating the hyperplane [29]. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine. Consider the below diagram in which there are two different categories that are classified using a decision boundary or hyperplane [30].

Expected Answer Type

Question categorization is followed by the classification of answer types, which is a connected element. The classification of answer types is based on a mapping of predict question classification. After a question has been categorized, the various answer types could be identified using a Rulebased classifier mapping. The system should support a variety of answer forms since, as I said earlier, question classification can be imprecise and match word missing.

Question Reformulation

The module creates a list of keywords to be provided to the document processing module's information retrieval component after determining the "focus" and "question type." Standard methods like named-entity recognition, stop-word lists, and part-of-speech taggers, among others, could be used to extract keywords [9].

2.3..2 Document Processsing

In the document processing module of the quality assurance system, also known as the paragraph indexing module, the reformulated inquiry is submitted to the information retrieval system, which subsequently retrieves a ranked list of the Top Relevant Documents. The document processing module often relies on one or more information retrieval systems to retrieve data from a number of document corpora, at least one of which almost invariably includes the WWW. The information retrieval system's returned papers are then filtered and arranged. As a result, the primary objective of the document processing module is to produce a set of potential, ordered paragraphs that include the answer(s), and to accomplish this objective, the document processing module must perform information retrieval, paragraph analysis, and document processing [8].

Information Retrieval (IR)

The purpose of the information retrieval system is to get relevant results that are correct in response to a question that the user submits. QA systems are independent of IR systems, which gauge document and query similarity using the cosine vector space model. This is primarily due to the fact that QA systems often only require documents to be retrieved when they include all of the keywords. This is due to the Question Processing module's thorough selection and reformulation of the keywords [8].

Paragraph Filtering and ordering

Paragraph filtering can reduce both the number of candidate documents and the amount of candidate text in each document. The idea behind paragraph filtering is that the most pertinent documents should have the keyword(s) in the search query concentrated in a few nearby paragraphs rather than throughout the entire page and The aim of paragraph ordering is to rank the paragraphs according to an acceptability degree of containing the correct answer [8],[9].

2.3.3 Answer Processing Module

The final phase in the question and answering is answer processsing module.it contains identification ,extraction and validate answers from the ordered pharagraph [8].

The answer's identity depends heavily on the answer type that was established during question processing. The need to rely on a parser to identify named things arises from the fact that the answer type is typically not explicitly stated in the inquiry nor the response (e.g. persons, organizations, place, dates, etc.).

In answer extraction the recognition of the response candidates in the paragraphs is made possible by the parser. In order to extract only the pertinent word or phrase that responds to the inquiry, a set of heuristics is used once an answer candidate has been found. Measures of the distance between keywords, the amount of keywords that matched, and other comparable heuristic metrics may be used to base extraction. QA systems typically fall back to giving the best-ranked paragraph if no match is discovered [6, 8].

Answer validation is a part of the question-answering system that chooses dependable answers among response candidates obtained using particular techniques. Validation systems for answering questions can be broken down into two steps: the first involves gathering potential responses, and

the second involves validating each of those answers. It has been thoroughly researched up to this point to collect answer candidates in the first step. The following describes its typical technology: First, a question's answer type—such as PLACE or PERSON—is determined. Then, using queries created from the inquiry phrase, the documents that might contain answer candidates are obtained from the available document collection. Lastly, response candidates are gathered from the retrieved documents using named entities that fit the question's answer type [9].

2.4 Speech Recognition

Automatic Speech Recognition is a technology that enables people to use their voices to communicate with computer interfaces in a way that, in its most advanced forms, closely resembles natural human speech. ASR allows a computer to recognize the words a person says into a microphone or over the phone and translate those words into written text [9] [31].

In speech recognition there are some content and terms to accomplish the ASR correctly. From those list: - utterance, speaker model or pronunciation, grammar and vocabulary [31].

Utterance

Utterance is a vocalization or speaking of word or sentences by any person utterance speaking by any person may be single word, multiple word, phrase, sentences and may be paragraphs. The speech engine receives utterances to process. If the user remains silent, the engine issues what is known as a silence timeout, which informs the application that no speech was detected during the anticipated time limit Takes the proper action, such as asking the user for input again. A statement might be a single word or include several words (a phrase or a sentence]) [31].There are different types of utterances [9]:-

Isolated: - artificial pause should be inserted before and after each word speaks.

Continuous:-User speaks normally and continually the other is spontaneous which based on speaking rate, filled pause, correction and repetition and read properly something [9].

Speaker model

Speaker model in automatic speech recognition’s are speaker dependent and independent. Speaker dependent are speech which we used in training time at developing time. In Speaker independent speech recognize system accept speech from any speaker and recognize it.it does not depend on any speaker likes (age and sex.).

Pronunciation

To translate spoken input into text, the speech recognition engine employs a variety of data, statistical models, and algorithms. The pronunciation of a word is one piece of data that the voice recognition engine needs to process it. This data indicates how the speech recognition engine believes a word should sound. In order to help the speech recognizer understand the continuous Afaan Oromo speech, we must develop a pronunciation dictionary [31].

Grammar

Defining the terms and expressions that users can use to communicate with your program. The speech recognition engine is given definitions for certain words and phrases, which it uses during the recognition process. A grammar defines the words and expressions that the engine can identify using a specific syntax, or set of rules. A grammar can be as straightforward as a list of words or phrases, or it can be flexible enough to allow for enough variation in what can be said that it comes close to being able to function like real language [31].

2.4.1 Automatic speech recognition approach

There are different approach used in automatic speech recognition approach from those acoustic phonetic, pattern recognition and artificial intelligence are types approaches [9].

Acoustic phonetic

The acoustic-phonetic approach is based on the theory of acoustic phonetics, which holds that spoken language is composed of discrete, distinct phonetic units, and that these units are broadly characterized by a set of characteristics that become apparent over time in the speech signal, or its spectrum. It is assumed that the rules governing the variability are simple and can be easily learned and applied in real-world situations, despite the fact that the acoustic properties of phonetic units are highly variable, both with speakers and with nearby phonetic units (the so-called co-articulation of sounds) [57].

This is the preferred speech synthesis method because it is “the product of many studies in acoustic phonetics, coupled with principles of phonology. Assuming that the language under consideration

has an adequate description of allophonic rules and phonotactic constraints, the researcher can move directly to feature extraction. But a few questions must be answered first. [32].

Pattern recognition

Pattern training and pattern comparison are the two key steps in the pattern-matching approach. The approach's pattern-comparison stage compares each potential pattern that was learnt during the training stage directly with the unknown speeches in order to identify the unknown based on how well the patterns match.

The essential feature of this approach is that it uses a well-formulated mathematical framework and establishes consistent speech pattern representations, for reliable pattern comparison, from a set of labeled training samples via a formal training algorithm. A speech pattern representation can be in the form of a speech template and a Stochastic model (e.g., Hidden Markov Model) and can be applied to a sound smaller than a word, a word, or a phrase. The pattern-matching approach has become the predominant method for speech recognition in the last six decades [33].

Stochastic model are more suitable approach to speech recognition as it uses probabilistic models to deal with undetermined or incomplete information [34]. There are many methods in this approach like HMM, SVM, DTW, etc., among these hidden markov model is most popular stochastic approach today and it applied on the study [9][39].

Artificial intelligence

The artificial intelligence method combines the acoustic phonetic technology and the pattern recognition strategy. This makes use of the principles and ideas of acoustic phonetic and pattern recognition techniques.

2.4.2 Hidden Makrov Model

The main factor in the long-term success of HMMs has been their capacity to statistically predict the variability in speech. The acoustic modeling parts of the recognizer are nearly entirely based on HMMs in the majority of modern speech recognition systems. Using a Markov process that can be visualized as a state machine, HMMs offer a beautiful statistical framework for modeling speech patterns. HMM is statistical model that was first proposed by [58] and uses a Markov process that contains hidden and unknown parameters [35, 36]. The HMM model's alteration

parameters are temporal variability's, while the output distribution model parameters are spectrum variability. HMM uses signals from a finite-state Markov model and a collection of output distributions. These two types of variability are essential for speech recognition. Hidden Markov modeling is more general and has a secure mathematical foundation compared to template based approach. Compared to knowledge base approach, HMM enables easy incorporation of knowledge sources into organized architecture [37]. it has ability to estimate parameters from a large amount of data automatically, their simplicity as well computational feasibility.so for this reason this model is used to develop afaan Oromo speech recognizer prototype that converts speech question to text to retrievers the data from the large documents.

HMMs are becoming more and more popular as a result of their automatic capacity to estimate parameters from enormous amounts of data, as well as their simplicity and computing viability. In order to translate oral questions into text and search for appropriate element documents that contain responses, it was employed to construct the necessary prototype for Afaan Oromo speech recognition. When we need to calculate a probability for a series of observable occurrences, the Markov chain comes in handy. The events we are most interested in, however, are frequently concealed and go unnoticed. For instance, we rarely notice concealed part-of-speech markers in texts. Instead, we only see words, and we must deduce the tags from the word order. The tags are referred to be hidden because nobody can see them.HMMs algorithms defines as:

- *Q = q1 q2.....qN*

  one group of N states
- *A = a11 . . . ai j . . ... aNN*

  A matrix A of transition probabilities, where each entry, ai, represents the likelihood of transitioning from state i to state j, s.t. $\sum N\, j=1\ ai\, j = 1\ \forall$
- *O = o1o2 . . . oT*

  A series of T observations where each observation is taken from the vocabulary V = v1, v2... vV
- *B = bi(ot)*

  A series of observation likelihoods, also known as emission probabilities, each of which expresses the likelihood that an observation was produced from a particular condition.

- $\pi = \pi 1, \pi 2, ..., \pi N$

  A starting distribution of probabilities for states. I represents the likelihood that state i will be the first state in the Markov chain. Some states j might not be starting states because of the condition j = 0. Moreover, n i=1 i = 1

2.5 Related Work

In this content related literature are reviewed There are different QAS research done in different language for both local language and foreign language. Those related works are done speech based integrated with QAS and also question answering also done individually.

2.5.1 Afaan Oromo and Other Language Text Based QAS

Varies researches were done in Afaan Oromo question and answer based on text corpus. A different type of Afaan Oromo Question answer such as list, definition, description, factoid and non-factoid are done in different time.

Definition, List and Description Question Types for Non-factoid Questions for afaan Oromo language done by [16]. The research is focused on non-factoid question and answer for definition, list and description. This study's objective is to suggest solutions to significant issues in Afaan Oromo non-factoid QA, particularly in list, definition, and description questions. The suggested QA system includes question analysis, document analysis, document preparation, and components for extracting answers. Using rule-based methods, the classification of the questions is done. The method utilized in the component's document analysis gets relevant documents and uses filtering patterns on the documents that were obtained. The researcher used F-score, precision and recall to evaluate the performance of the system. The system evaluating question classification classified 98.3% correctly done. The F-score on the stemmed documents is 0.729 and on the other data it set is 0.764. Moreover, the average F-Score of the answer extraction component is 0.592. 2700 question-answer pair's datasets are prepared to evaluate system.

Other research is Afaan Oromo factoid question and answer have been attempted [48]. In the work research's goal was to find fact-based responses for users. The documents of data set collected from Oromia Radio and Television Agency, Fana's Afaan Oromo service, Online VOA, and periodicals published in the language, like Barisa, Kallacha, and Oromia culture and tourism bureaus, provided electronic Afaan Oromo documents.. The answer extraction module is used to

extract candidate answers from documents, whereas the question analysis module and the IR module are used to identify response types and extract candidate passages from documents, respectively. In order to broaden his search, the researcher also employed synonyms. To determine the various answer kinds, rule-based patterns were employed. According to the researcher, 92.2% of respondents correctly identified their answer type using patterns. Additionally, the researcher noted that the system displayed 0.83 recall, 0.71 precision, and an F-measure of 0.78. According to the researcher, the results were encouraging, and the employment of synonyms and phrase-based indexing further enhanced the system's performance.

In another study of the Amharic question-and-answer system revealed a clear pattern [17]. A technique used to identify the determine the question types, the possible question focuses, and expected answer depending on our language-specific data types as well as to build appropriate Information Retrieval queries investigate issues. Three different types of documents are the focus of one method of document retrieval (Sentence, paragraph, and file .The named-entity and pattern-based answer pinpointing algorithms developed help locating possible answer particles in a document. Approximately 89% of the questions are successfully classified by the Rule-based question categorization module. The document retrieval component shows greater coverage of relevant document retrieval (97%) while the sentence based retrieval has the least (93%) which contributes to the better recall of our system. The gazetteer-based response selection method, which employs a paragraph answer selection strategy, correctly responds to 72% of the questions, which is encouraging. The file based answer selection technique exhibits better recall (91%) which indicates that most relevant documents which are thought to have the correct answer are returned.

2.5.2 Speech Based Question and Answer

The speech based question and answer also done in different languages.it integrates speech recognition with question and answer to accomplish the tasks.

The primary study is conducted for designing and constructing to automatic question classification for speech-based Amharic question answering [9]. After all, the study is built using a combination of voice recognition, question answering, and speech synthesizer. Speech synthesis is done using unit selection methods, while question classification is done using SVM. 22600 news pieces from various online news sources, including Ethiopian News Agency and Ethiopian Reporter, were used in the study. These documents were produced for training and testing purposes. For this study, 84

voice question phrases were read by 24 participants—9 women and 15 men—from a corpus of 2,016 speech question sentences. The questions are numeric and person-related. The voice recognition system's experimental findings showed 85.58% accuracy. Furthermore. The speech synthesis also accurately pronouncing 80.86% with 3.17 and 3.45 accuracy in; intelligibility and naturalness based on MOS. In addition, the SVM question classification offers 82.92%F-measure, 73.91% precision, and 94.44% recall. In general, the speech-based Amharic question answering system achieves 72.75 % [9].

In addition to this proposed a prototype of towards speech based Amharic question answering system for open domain factoid questions [49]. As a component Use the Sphinx tool for speech recognition, the Lucene tool for question answering, and NetBeans to combination of the two tasks. The experimented result and evaluation shows that the performance of continuous Amharic speech recognition developed for question corpus registered 4.5% were using development testing and 84.93% recognition performance used live speech input data. The performance of answering questions is 76% average Precision in finding the right answers. After integrating the speech recognition and question answering, the performance registered used speech-based question answering system is 75% average precision in the retrieving correct answer of a given question. In the study of [49] there are some challenging to identify for speaker independence because they were done using less number of training on speech recognition process. Additionally, manual question classification was utilized to determine the different types of questions.

The scholars of [50] noted that, despite being difficult to write text using small keyboards and to browse web pages on small screens, mobile devices are becoming the predominant way of information access. The study of Qme, a speech-based question-answering system that retrieves answers to questions rather than web pages. They highlighted the benefits of the voice recognition and retrieval components of the system being closely integrated and provided bootstrapping strategies to differentiate between dynamic and static requests.

The research of [56] build an open domain with a voice interface, and the first prototype (SpeechQoogle) is constructed with three different modules: ASR, Question-answering, and speech synthesis. There have been 600,000 QA pairs collected. The associated audio model and language model are particularly built for the voice recognition module, which promotes the

character ACC to 87.17%. Finally, in open-set testing, the integrated prototype correctly answered 56.25% of spoken questions.

2.5 Summary analysis and Gaps from Related works.

Reference	Model and Decoder used in researches	Gaps
Bekele Mengesha.H...[9]	The researcher used sphinx4 library for speech recognition and he use SVM model for question Classification and question answering.	✓ It used SVM model for question answering classification. SVM is not clear classifies for question because not accurate on pattern matching algorithms .so we used Rule based question classification because rule based is good classifier for latten letters. ✓ SVM method needs more accurate training on question
Belisty M….[49]	The researcher used the sphinx and SVM question classification and question answering.	✓ The recognize not accurate for speaker independent because the number of trainer is small. ✓ Used manual question classification for identifying question types. ✓ It also used SVM question classification which is not accurate ✓ Method needs more accurate training on question.

Table 2. 1 Related Word analysis and Gaps identify

The works of those how done their work in our country Ethiopia. The above table shows their jobs and the model they uses to accomplish their work.inorder to identify their gaps.

Research gap: the number of electronically created Afaan Oromo data in our country, is rising at an increasing rate as studies, historical records, fiction, magazines, and many newspaper publishers began making their works available online. In addition people also ask question since it's in our fundamental nature to inquire and know somethings.So those peoples who ask question also need answer for their question from the data or documents quickly. Because more people needs their answers in little time rather than taking more time. This gap will increase the requirement for a system that can accepts information in question form, search the knowledge base for relevant information, and provide a direct response to the questions.

CHAPTER THREE

AFAAN OROMO LANGUAGE

3.1 Overview

Understanding the language's structure is necessary and aid in the creation of the suggested prototype, the fundamental structure of Afaan Oromo is presented in this chapter. This chapter discusses the nature of the language, including how widely it is spoken, its areas of application (such as newspapers, various Oromia states' offices, various research publications, higher educational institutions, etc.), how words are formed, its morphological makeup, and other crucial aspects of the language that are particularly crucial for this thesis.

3.2 Basics of Afaan Oromo Language

The Oromo are indigenous African people inhabiting the North Eastern part of Africa. They are the one and only dominant ethnic group in Ethiopia, where a sizable portion of Ethiopia's population and land mass reside in the Oromia region. Afaan Oromo is another name for the Oromo language. The third-largest language in Africa is the Oromo language, a Cushitic language spoken by more than 50 million people in Ethiopia, Kenya, Somalia, and Egypt [1]. The Afaan Oromo speakers are more numerous outside of Ethiopia than inside. People are speaking and teaching Afaan Oromo to their children in cities across the United States, Australia, Canada, and Europe. Foreigners who are interested in communicating in Afaan Oromo can also enroll in Oromo classes. It is used in Oromia region as official language. Afaan Oromo written in Latin script and has its own script. The Oromo oral heritage is extremely rich, and there are now adequate literary works published in the language as well as contemporary arts, including music and folk arts. Afaan Oromo, Amharic, Tigrinya, Gurange, and Omotic are all spoken by the Oromo people. They are mainly Muslim and Christian, while around 3% still follows the traditional religion like Waqaafenna, Qaluu and etc..Based on the worshipping of the god Waaqa [1]. The Oromo people mainly practice three different religions. Those are Islam, Waaqeffanna (traditional belief in Waaqaa or God), and Christianity (Catholic, Protestant and Christian). The Oromo speak Afan Oromo, a language that is a member of the Afro-Asiatic phylum's Lowland East Cushitic subfamily [51].

Afaan Oromo is a language spoken outside of Ethiopia in Kenya and Somalia, and also the official tongue of the Oromia Regional State in Ethiopia. It also a language used for learning and teaching in colleges for teachers, lecturer and as well as in area of schools. Additionally, it is taught as a major course at the BA, MA, and PhD levels in many Ethiopian universities. What is more, Afaan Oromo is also taught in North American Minneapolis College [51]. There are also radio and television programs in Ethiopia that provide information in Afaan Oromo. These include Ethiopian Radio, Radio Fana, Oromia Television, and Ethiopian Television (ETV) and Fana Television. Documents written in Afaan Oromo before 1991 were written in the Ge'ez script [51]. Since 1991, the Qubee alphabet with a Latin foundation has been used as Afaan Oromo's official script. About 26 consonants and 10 vowels make up the language.

3.3 Afaan Oromo Writing System and Phonetics

Afaan Oromo is one of the official working languages in Ethiopia. It is also the working language of a some states in the federal structure of Ethiopia, including the regional states of Oromia, Harari, and Dire Dawa, as well as the Oromia Zone in the Amhara Region. In Oromia, Harari, and the Oromia Zone in the Amhara Region, it is a key educational language. Along with other language, it is used on federal websites language. Today Afaan Oromo is a written language, serves as the official working language of the Oromia regional state. There is a unique writing and reading system for Afaan Oromo called Qubee.

3.3.1 Afaan Oromo Writing Systems

As a phonetic language, Afaan Oromo is spoken exactly as it is written. The language has a simple writing system based on the Latin alphabet. There are no skipped or mispronounced consonants or alphabets in the language, unlike English or other Latin languages. Every alphabet (qubee) is to be pronounced in clear short or quick and long or stretched sounds. The sounds are more prominent in words with doubled consonants. Additionally, when vowels are duplicated in a word, the sounds are lengthened or stretched. Oromo language has vowels and consonants, just like English.

In Afaan Oromo, there are five vowels: a, e, i, o, and u. those vowels are doubled when they pronounced as lengthened or stretched.Thoose are „aa‟, „ee‟, „ii‟, „oo‟, „uu‟.The consonant of Afaan Oromo is that much same within English consonant, yet there are unique Letters, such “**ch**”,”**dh**”,”**sh**”,”**ny**””**ph**”,”**ts**”,”**zh**” and “ **’** (hudhaa)”. “ch” and “sh” same speech as English. In Afaan Oromo, "dh" is formed similarly to the English "d" by slightly curling the tongue back and drawing

in the air such that a glottal stop is audible before the next vowel starts. Another Afaan Oromo consonant is “ny" is smacked with the lips outward in a manner similar to how "gn" sounds in English. These few unique letter combinations are frequently used to create words. For instance, ch is used to mean "eating" in nyaachuu, sh is used to mean shan "five," dh is used to mean dhaabachuu"stop," ph is used to mean buuphaa "egg," . In general, the 36 letters called “Qubee” in Afaan Oromo (26 consonants and 10 vowels) are used [16].

Qubee (Sagaleewwan) dubbii Afaan Oromo in capital and small.

A|a	B|b	C|c	D|d
E |e	F |f	G|g	H |h
I | i	J | j	K| k	L| l
M|m	N|n	O|o	P | p
Q |q	R |r	S |s	T |t
U|u	V|v	W|w	X|x
Y|y	Z|z	CH|ch	DH||dh
NY|ny	PH|ph	SH|sh	’(hudha)

Grammar

The Afaan Oromo alphabet is crucial because everyday people uses its structure to write and read communicate each. Even if you know how to write some words, without them, you will not be able to pronounce them correctly. You will be more understood when speaking Afaan Oromo if you pronounce each letter of a word correctly. Afaan Oromo uses a Subject-Object-Verb (SOV) structure. Although the word order can be flexible because it is a declined language (nouns vary depending on their function in the sentence), verbs always come after their subjects and objects. In general, indirect objects come after direct objects. In Afaan Oromo preposition and post positions rules also more frequent.

Afaan Oromo Vowels: (Dubbachiftuu)

The vowels in the Afaan Oromo language are denoted by the five letters a, e, o, u, and i. In Afaan Oromo, vowels are often pronounced in the same way. When stressed, these vowels can either be opened, as in maaliif (why), dhuugi (drink), or closed, as in muka and tahi. Every word in Afaan Oromo is pronounced powerfully because the vowels are always pronounced sharply and clearly, as example:

- ✓ a**:** dhaagaa,bara,macaafa,jalqabaa,afaan
- ✓ e: Seensa,Seena,Keenya,Beekuu
- ✓ i: Fidi,irraa,Xinnoo,biyya,Hoojii
- ✓ o: Gooftaa,Tokko,Yeroo,Kiyyoo,Boodde
- ✓ u: oduu, umaa, xumura…etc.

Afaan Oromo Consonants- Dubbifamaa

The majority of Afaan Oromo constants are similar to those in Italian, however there are a few exceptions and unique combinations.

		Labial	**Alveolar/ Retroflex**	**Palato-alveolar**	**Velar**	**Glottal**
Nasal		M	N	n ⟨ny⟩		
Plosive Affricate	**voiceless**	(p)	t	tʃ ⟨ch⟩	k	ʔ ⟨'⟩
	voiced	b	d	dʒ ⟨j⟩	g	
	ejective	p’ ⟨ph⟩	t’ ⟨x⟩	tʃ’ ⟨c⟩	k’ ⟨q⟩	
	implosive		ɗ ⟨dh⟩			
Fricative	**voiceless**	f	s	ʃ ⟨sh⟩	x ⟨kh⟩	h
	voiced	(v)	(z)			
Approximant		w	l	j ⟨y⟩		
Rhotic			r			

Table 3. 1 Afaan Oromo consonants (dubbifaama) (extracted from: Oromo phonology)

Afaan Oromo Double Consonants

Except for the combination consonants ny, dh, ph, and sh, all Afaan Oromo consonants have double consonant combinations if the phrase is stressed.

Afaan Oromo Stress

The stress is placed on the final syllable in some Afaan Oromo words: example: gammoojjii, ijoollummaa, ilaallu. However, few words have their first syllable stressed.

3.3.2 Afaan Oromo Phonetics

In the TTS and STT systems, a language's grapheme to phoneme correlation shows that a target word is converted from its written (grapheme) to its sound (phoneme) form. The associated characteristics of the language, such as voicing, tongue position, tongue height, place of articulation, and method of articulation, are utilized to define the phone set.

The alphabet of Afaan Oromo doubles the letters for the five vowel sounds to represent the standard Southern Cushitic arrangement of five short and five long vowels. The length disparity is contrastive. For example, bara 'year', and baaraa 'know'. In Afaan Oromo, germination is also crucial. For example, the length of a consonant can make words distinct from one another. For example, bara 'year ', barraa 'knowing' [31].

In Afaan Oromo Instead of the syllable's vowel, the more is the tone-bearing unit in Oromo. Two mora make up a long vowel or diphthong, which can have two tones. The tone of each mora is classified as high or low. There is only one high tone per word, and it must be on the last or next-to-last mora.

There are three tones in terms of phonetics: rising, falling, and high. Rules:

a. A falling tone is produced by a series of high-low notes over a long vowel.
b. A sequence of low-high is realized as high-high on long vowels.

A pitch accent could be used to describe this tone-based technique. Similar to what is found in Somalia. Tone is related to stress. The decreasing tone has less stress, the low tone has none, and the high tone has tremendous stress.

The following are the rules for indicating tone in written in Afaan Oromo:

- ✓ acute accent – tone is high
- ✓ grave accent – tone is low
- ✓ Circumflex - tone is falling.

3.3.2.1 The glottal stop (‘) (Hudhaa)

In Afaan Oromo, the word "Hudhaa" has a diacritical mark. Like in many other languages, the Oromo language has glottal sounds at certain points in the word's syllable. Hudhaa is mostly used in Oromo as a diacritical marker to alter the sound value of letters to which it is attached. The diaeresis-symbolized vowel is spoken separately from the preceding vowel as evidenced by the acute and grave emphases, which can indicate that a final vowel is to be spoken differently. In words with successive vowels of different types, such as ka'e, ba'ee, ta'ee, mo'a, xaa'oo, de'uu, and du'e, Hudhaa often appears between the letters. Therefore, Hudhaa is required whenever two consecutive vowels of a different type occur in an Oromo word.

3.4 Script and Orthography

The earliest draught of Afaan Oromo was written in the Ethiopian alphabet used for Tigrinya, Amharic, and Classical Ethiopian. A Latin-based script known as Qubee took its place in 1974. There are 31 symbols total, 5 of which are digraphs (their equivalents in the International Phonetic Alphabet are shown in square brackets):

Aa	Bb	Cc	CHch	Dd	DHdh	Ee	Ff	Gg	Hh	Ii	Jj	Kk	Ll	Mm	Nn
[a]	[b]	[tʃ']	[tʃ]	[d]	[ɗ]	[e]	[f]	[g]	[h]	[i]	[dʒ]	[k]	[l]	[m]	[n]

NYny	Oo	Pp	PHph	Qq	Rr	Ss	SHsh	Tt	Uu	Vv	Ww	Xx	Yy	Zz
[ɲ]	[o]	[p]	[p']	[k']	[r]	[s]	[ʃ]	[t]	[u]	[v]	[w]	[t']	[j]	[z]

- Double vowels are used to denote long vowels. Unless it is written as a digraph, a long consonant is also expressed by doubling.
- p, z, and v can be found in several dialects and loanwords..
- These letters stand in for the glottalized and implosive stops: [p'] for ph, [t'] for x, [] for dh, and [k'] for q.
- An apostrophe is used to indicate the glottal stop [ʔ]
- The affricates are shown as [t] as [ch], [d] as [j], and [t'] as [c].
- The fricative [ʃ] is represented with the digraph sh.

- The digraph ny stands in for the nasal [ɲ].

3.5 Morphology

Nominal. Case, number, and occasionally gender are indicated in noun markings.

Case: nominative, ablative, instrumental, locative, genitive, and absolute. Nominative and absolutive are the two primary conditions that result in agreement between the components of the noun phrase. The unmarked absolutive serves as a citation and can be used as a predicative or direct object.

Gender: feminine and masculine. Nouns are not gendered, unless they are used in certain dialects or while talking about persons.

Number: in Afaan Oromo number identify *singular or* plural. Singular identify single things like harre.Where plural identify more than one like harroota.The prefix –oota identify the plurals.

Pronouns: reflexive, possessive, demonstrating, and questioning.

For each situation, there are seven different personal pronouns that distinguish between three different people, two different numbers, and only the 3rd person singular's gender. They are declined in the nominative, dative, instrumental, locative, and ablative situations in addition to the absolutive:

	absol.	*nomin.*	*dative*	*instr.*	*locat.*	*ablat.*
1 s	ana, na	ani, an	naa, naaf	naan	natti	narraa
2 s	si	ati	sii, siif	siin	sitti	sirraa
3 s.m.	isa	inni	isaa	isaatiin	isatti	isarraa
3 s.f.	isii	isiin	ishii, ishiif	ishiin	ishiiti	ishiirraa
1 p.	nu	nuti, nu'i	nuu, nuuf	nuun	nutti	nurraa
2 p.	isin, isini	isini	isinii, isiniif	isiniin	isinitti	isinirraa
3 p.	isaan/isaani	isaani	isaanii, isaaniif	isaaniitiin	isaaniitti	isaanirraa

Table 3. 2 Personal pronoun in afaan Oromo [59].

Verbal: The lexical meaning of the verb is represented by the stem of an Afaan Oromo verb, while the tense, aspect, and subject agreement are indicated by the suffix. For instance, dem- is the stem ('come') in demne, "we go," while -ne denotes the past tense and first person plural subject of the verb.

Regular verb: The majority of Oromo verbs of afaan oromoo is "regular," they add the standard person-based and number suffixes to stems without making any other alterations. Below is an example of the present-future conjugations for the word nyachuu, with the bolded suffixes. These verbs' stems don't end in a double consonant (ch), a vowel (y), or a letter (w)..

Deemuu – 'to go'			
Ani	Nyaadha	nuti	nyaanna
Ati	Nyaattaa	isin	nyaattuu
Inni	nyaatee	isaan	**nyaatuu**
Isheen	nyaatte,nyaati	Isiin	nyaatttani

Table 3. 3 Afaan Oromo regular verb identification

3.6 Summary

The Oromo language, which is spoken by people in Ethiopia and its neighboring countries, is an Afro-Asiatic language belonging to the Cushitic language family. Noun, verb, adjective, and other word classifications in Afaan Oromo are significant to the language's writing system. The morphology of the Afaan Oromo language can be broadly divided into two types: derivational and inflectional. Derivational is the process of creating new words from preexisting ones, whereas inflectional is the adaptation of new word forms while maintaining the same meaning.

CHAPTER FOUR

SYSTEM DESIGN AND IMPLEMENTATION

4.1. Overview

This study's objective is to create and build a speech based question and QAS classification for Afaan Oromo languages. This is achieved by combining speech recognition question-answering, and rule-based Algorithms. The proposed system is moving in the direction of making an effort to close the societal gap in which the conventional methods of document retrieval do not accommodate all users. The most often used type of appropriate methods for human-computer communication settings.

4.2. System Architecture

The components of a speech-based question and answering system are speech recognizing, document preprocessing for document normalization and indexing, question analysis for question type identification, query generation, and query expansion, document analysis for document retrieval using the queries from the question analysis component and filtering the retrieved documents for the question type, and finally answer extraction for answer production from the filter change the output of the answer to text output. This system architecture is a depiction of a system with a functional mapping to hardware and software components, a functional mapping of the software architecture to the hardware architecture, and a functional mapping of human interaction to these components. The system is therefore depicted in the diagram below.

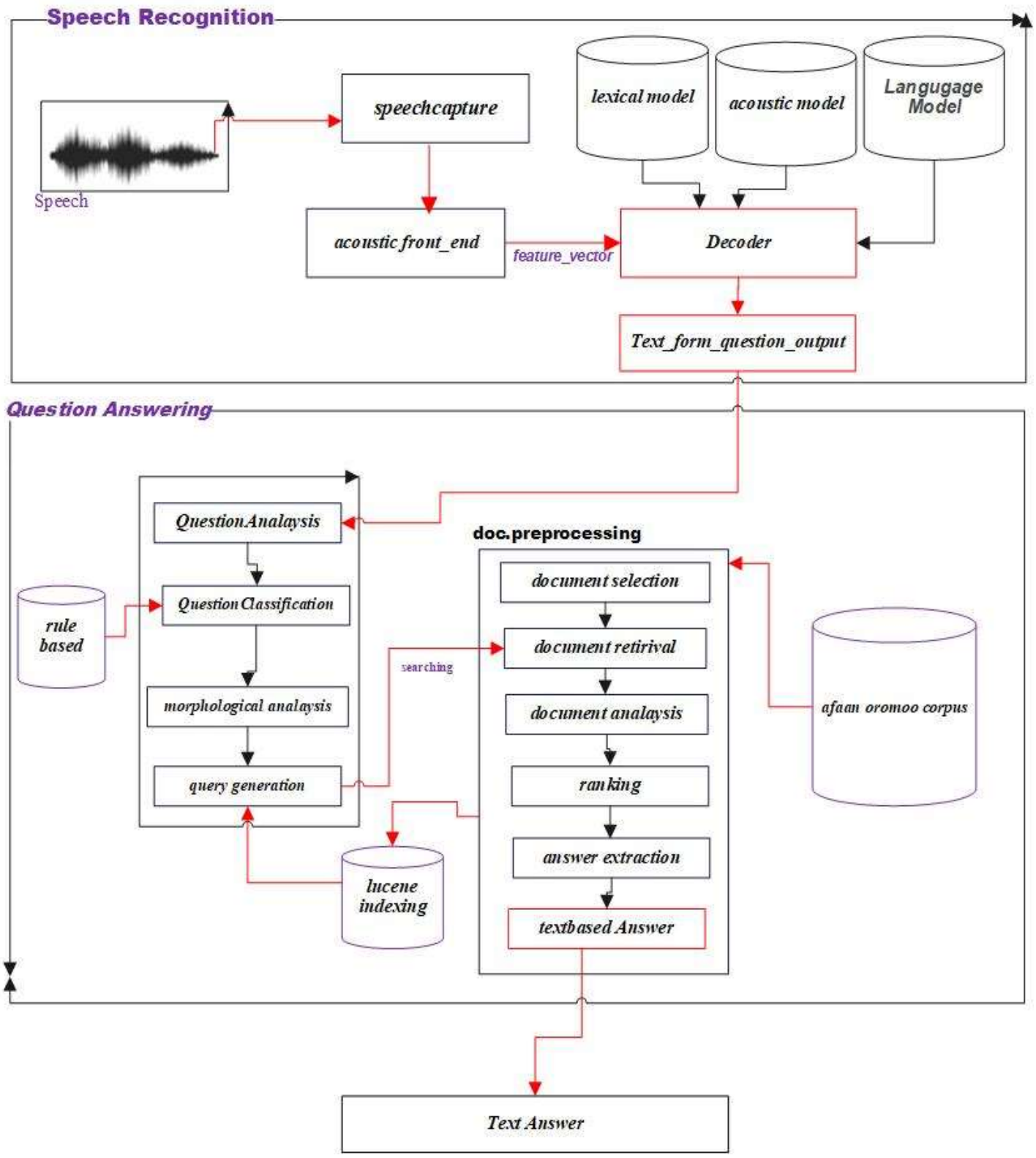

Figure 4. 1. System architecture for Afaan Oromo speech based question and answering.

The above figure 4.1 shows the structure of Speech based question for Afaan Oromo question-answering classification system in this study, we define the methods and algorithm needed to build a user interface for the system.

The system accepts question from user and processes them and recognised it and change into text. The question-answering system then analyses the text question, uses the appropriate procedures to classify the query, and then retrieves the precise response. Finally, the Answer is delivered in the text for. The overall descriptions of the architecture and the system's operation detail described below.

4.3 Afaan Oromo speech recognition

Automatic Speech Recognition is a technology that enables people to use their voices to communicate with computer interfaces in a way that, in its most advanced forms, closely resembles natural human speech. ASR allows a computer to recognize the words a person says into a microphone or over the phone and translate those words into written text [31]. A comprehensive ASR system based on the HMM-based CMUSphinx4 technology is constructed. Continuous recognition and speaker independence are features of the system. It can manage extensive vocabularies. Our method for creating Afaan Oromo sound models for the CMU .The Sphinx system consists of creating and honing linguistic and acoustic models utilizing Afaan Oromo voice data and creating an Afaan Oromo -character-based lexicon.

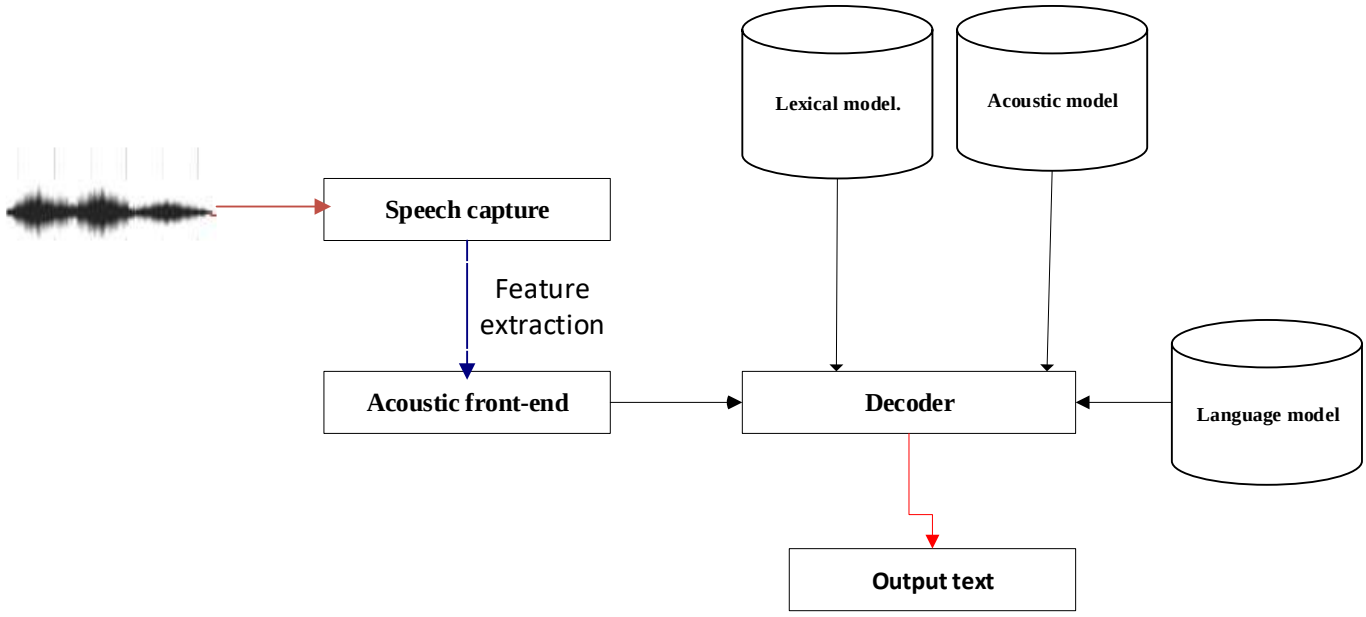

Figure 4. 2 parts of automatic speech recognition of afaan Oromo language

4.3.1 Speech Capturing

Speech capture or utterance is a spoken word, statement, or vocal sound. After we speak the Acoustic front-end receives utterances to digitize and extract features for further processing. The speech signal engine listen what you talk and make process and finally it change in to text or human readable format. Some high-level recognition interfaces are available. in sphinix4 those are: LiveSpeechRecognizer, StreamSpeechRecognizer and Speech Aligner. Our research uses LiveSpeechRecognizer.

4.3.2 Feature Extraction

The method of feature extraction involves converting the speech waveform to a parametric representation at a significantly lower data rate for later processing and analysis. By taking features from the input data, feature extraction improves the precision of learnt models. By eliminating redundant data, this step in the general framework lowers the dimensionality of the data. The Automatic Speech Recognition (ASR) process begins with features extraction, which is a crucial phase in which pertinent information is taken from a speech. A speech signal is first pre-processed (noise reduction, endpoint identification, pre-emphasis, framing, and normalization), and then a

feature extraction stage uses extraction techniques like Mel-Frequency Cepstral Coefficients (MFCCs), Discrete Wavelet Transforms (DWTs), and Linear Predictive Coding (LPC) to retain a set of predefined features from the processed speech [52].In this research MFCCs is implemented . This feature extraction technique's primary goal is to replicate the human ear. First, the MFCC is determined by dividing the voice signal into alternating, 25 or 30 frame segments. 10-millisecond intervals separated by milliseconds successive frames DFT stands for discrete Fourier transform. After each frame is calculated on each windowed frame, with an increased Hamming window function. High identification accuracy, good discrimination, and low coefficients of correlation are all characteristics of MFCC.

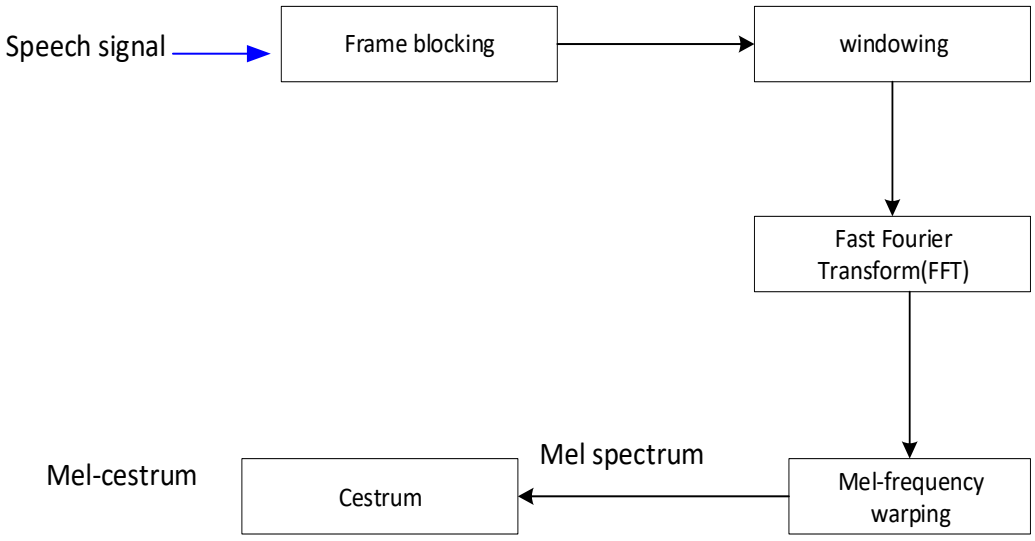

Figure 4. 3 MFCC flow for feature extraction.

In several pattern recognition issues involving the human voice, cepstral coefficients are said to be accurate. They are heavily utilized in speaker detection and voice synthesis. The high frequency range's wide filter spacing does not effectively account for other formants, which can potentially be above 1 kHz. Background noise may make MFCC features less accurate and make them less suitable for generalization.

4.3.3 Acoustic Model

The main part of Speech recognition is an acoustic model, which is made up of statistical representations of the sounds for words from speech audio recordings and transcriptions. The second element is a language model, which provides probability for word sequences. The acoustic

model is the central component of an ASR and is in charge of the bulk of the computational work as well as system performance. The acoustic model establishes a mapping between phonemes and potential auditory manifestations. It was designed to pick up spoken phonemes. A statistical representation of the sounds that make up words is used in its development, together with speech audio recordings, their text scripts, and other elements. A set of speech recorded files, a phonetic dictionary, a text file containing a parallel transcription of these speech files, and a list of phones are the four main types of data used in the acoustic model training process. The acoustic files containing those files in our researches. The acoustic model folder called ***Other.ci_cont*** which contains seven file created.

Recorded Speech Data: defines the requirements for question recording data, which are either NIST or WAV.It is necessary to prepare the questions that were chosen for training and recording those texts in order to create question speech. The wave file's following characteristics have been kept constant throughout the recording period: 16 kHz is the audio sampling rate. Bit rate (samples per bit): 16 (The element position will be divided into 65536 potential values at 16 bit per sample.). The channel also mono channel.

Dictionary: The Dictionary includes pronunciations for terms contained in the Language Model. The pronunciations separate words into groups of the Acoustic Model's sub-word units. The Dictionary interface also offers word categorization and permits the inclusion of a single term in numerous categories. We create dictionary name **nuguse.dic** and it lookslike:

BEEKAMAAN B AH AH K AE M EY AH N

BEEKAMEGAREEN B AH EH K AH M AH G AE R IY AH N

BEEKAMTII B AH AH K AE M T IY

BEEKAMTIIN B AH EH K AH M T IY N

BEEKAMTU B AH AH K AE M T UW

BEEKAMU B AH EH K AH M UW

BEEKAMUU B AH AH K AE M Y UW AH

File IDs Definition File: The training and test files define all audio file ids without extensions and references to the root folder .A *.fields file contains the wav directory's path in a file-system. Keep in mind that a *.fields file's content should only include the names of audio filenames.

Speaker_4/sp_1

Speaker_4/sp_2

Speaker_4/sp_3

Transcription Data: establishes in each file sentence to utterance mappings. Speech fields (filed file) are placed between parenthesis at the beginning <s> and </s>end of each line. These are not phone to audio mappings; rather, they are mappings between the words in the dictionary file's left column and the audio files. In the training file ids file, the order of the files is specified, and that order must be followed.*.transcription: The other_train.transcription and other_test.transcription files are text files listing the transcription for each audio file:our transcription file like this:

<s> AMEERIKAATTI AMBAASADDARRI ITYOOPHIYAA EENYU </s> (file_1)

<s> ATLEET SANBAREE TAFARIIN FIIGICHA DAANDIRRAA WALAKKAA MAARAATOONII EESSATTI INJIFATEE </s> (file_2)

<s> AYYAANNI IID ALFAXIIR WAGGAA KUMA TOKKO DHIBBA AFUR FI AFURTAMII SADAAFFAAN EESSATTI GAGGEEFFAME </s> (file_3)

Phoneset file (*.phone): should each line have a phone. In addition to the unique SIL phone for quiet, the number of phones should correspond to those utilised in the lexicon.we create phoneset called ***other.phone.***it contains phone like this:

HH
IH
IY
JH

Filler dictionary (*.filler): contains filler phones that the language model does not cover. Non-linguistic noises (such as laughter, "hmm," or breath). It might only be silent:

<s> SIL
</s> SIL
<Sil> SIL

Finally we set up a training script. To start go to ***other*** and run the following commands:

```
Administrator@DESKTOP-TDPFBTE /cygdrive/c/sphinx/other
$ python ../sphinxtrain/scripts/sphinxtrain -t other setup
Sphinxtrain path: /cygdrive/c/sphinx/sphinxtrain
Sphinxtrain binaries path: /cygdrive/c/sphinx/sphinxtrain/build
Setting up the database other
```

Figure 4. 4 training database other.

4.3.4 Language Model

Another crucial prerequisite for any ASR system is the language model. In order to create a language model, the word unigram counts are first calculated. These counts are then converted into a task vocabulary with word frequencies, which is then used to generate the bi-grams and trigrams from the training text. Finally, the n-grams are then converted into a binary format language model and the standard ARPA format.

Before we begin, you need to download a few components. Make sure you have the following Unix-compatible standard software. If you installed Linux or Cygwin on a Windows system, these are the necessary utilities. They typically come in stock. They are also not that hard to obtain. We install package like: Tar, gzip, gcc, python..etc. Finally language model called ***weather.lm*** is created.

Language model crated by this steps.

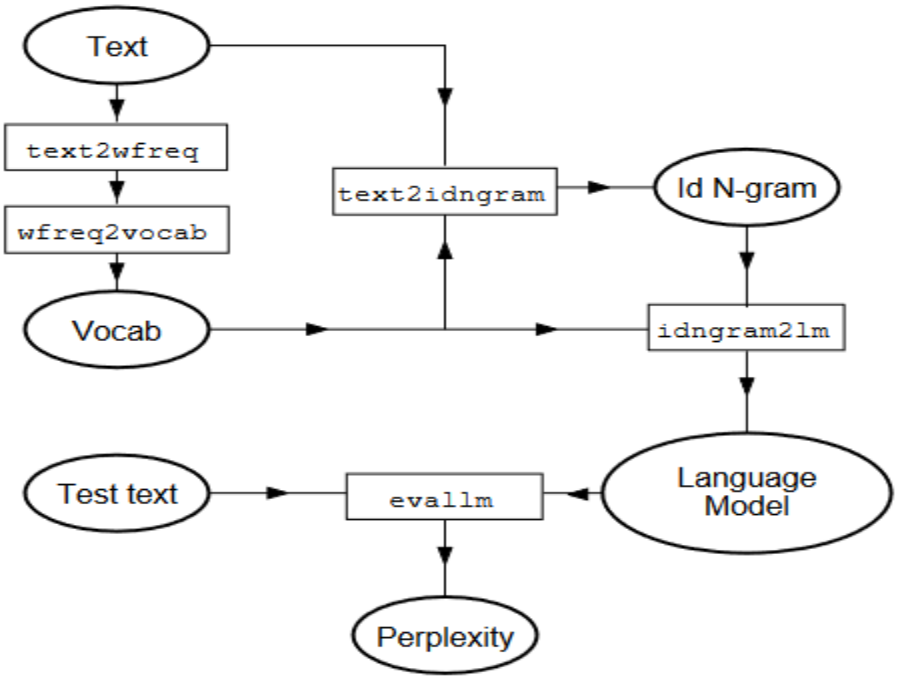

Figure 4. 5 text to language model change steps toolkit [55]

4.3.5 Lexical Model.

Lexical is just a collection of words whose pronunciations have been divided into phonemes, or units of word pronunciation. It functions a lot like a pronunciation dictionary. It resembles a pronunciation dictionary in many ways. The lexicon is crucial to automatic speech recognition because it connects the acoustic-level representation to the word sequence that the speech recognizer outputs. The lexicon has two functions: first, it defines the words or lexical items that the system is capable of understanding, and second, it offers the tools needed to create acoustic models for each entry.

4.3.6 Decoder

It comes from the coding theory roots of this particular stochastic model fitting. To select the most likely word sequence, the decoder basically examines all conceivable alignments, pronunciations, and word sequences. There are different offline tools or libraries used for speech recognition those are Vosk, CMU Sphinx, Snow boy Hotword Detection ,HTK…etc. Those are work offline but depend on the language that you are going to make speech recognize. From those sphinx tools support afaan Oromo Unicode without transliterating the language so due to this reason sphinx-4 is used for decoding,sphinixTrain, sphinixbase and sphinix3 are used sphinx tools for training and testing the system. Sphinx train is a module used for training the voice corpus that mostly contains the frontend, model and model loader, and dictionary and language models. The Sphinx Train must be downloaded for free from the CMU website and used with the above-mentioned prerequisites may change. The reasons why we use sphinx it has a powerful system for cross referencing documents, external documents, software apis, bibliographies, glossaries, searching and more. The configuration of the system typed in below:-

```
Configuration configuration = new Configuration ();

// Load model from the jar

configuration.setAcousticModelPath ("resource:/accoustic/");

configuration.setDictionaryPath ("resource:/oromoLM/nuguses.dic");

configuration.setLanguageModelPath ("resource:/oromoLM/weathers.lm");
```

4.3.7 Output Text

Any data that a computer or other electronic device processes and sends out is referred to as output.so after we process the code and finish the speech recognition finally we expect the text output.so the system finally put the results in text format.

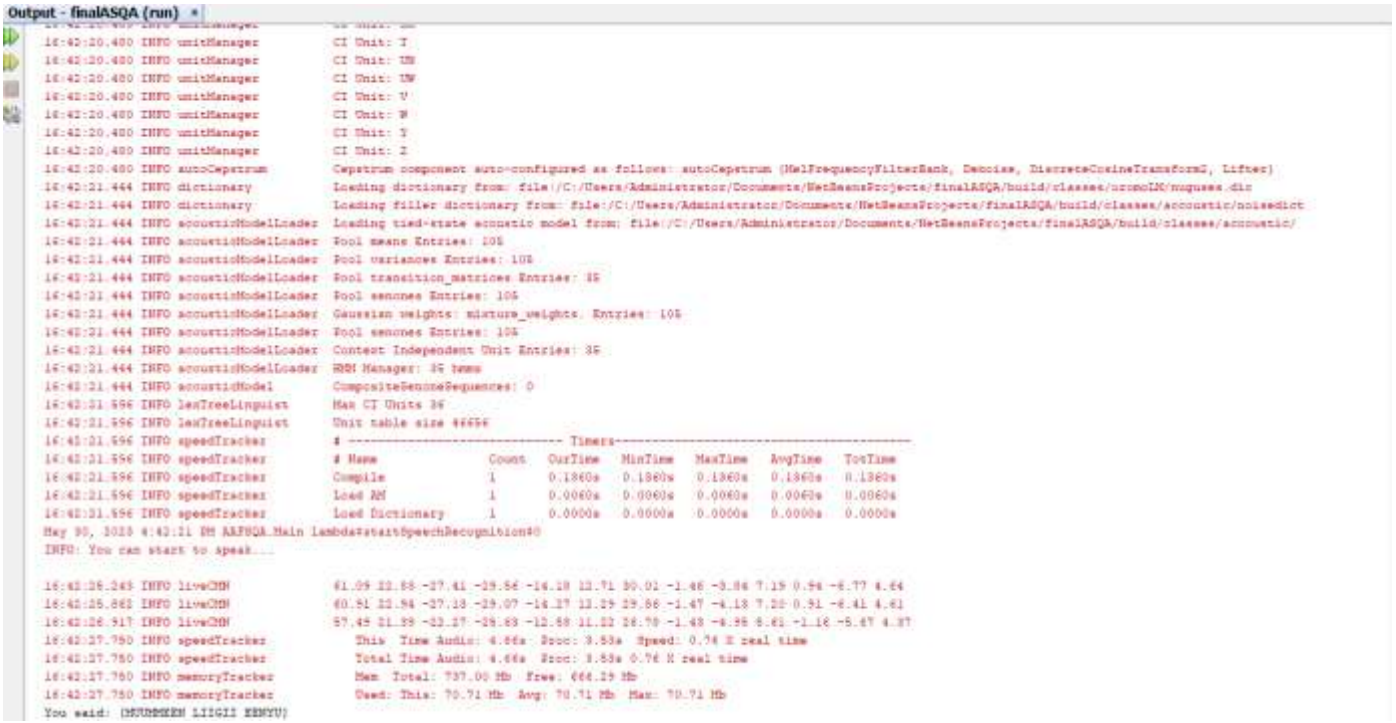

Figure 4. 6 Speech Recognition Output samples

In the above figure 4.5 shows the output *MUUMMEN LIIGII EENYU* based on the input sound from speakers. The system may add words, deletes and also substitute. Based on the above image the word LIIGII is added word and the word MINIISTIIRI is also deleted from trains question .so the accuracy of the system defined based on word error rate algorithms.

4.3.8 Recognize Question

Initialization is necessary before building a voice input interface. It required action to get the recognizer to pick up on the system user's speech. Speech is captured by the microphone and converted into a signal. Waveform data and the extracted features from the voice signal were parameterized into feature vector sequences. The decoder decodes the utterances and converts them into texts based on the statistics and probability that depend on the language, dictionary, and lexical model.

The java code developed for user how the user pronounce a question, how the system recognized it based on the model created during the training phase and how it transformed the question into text. The first step creating acoustic model and the second is identifying the language model, dictionary. This file contains, Dictionary, filler, language model, Decoder, Acoustic model, front-

end, sphinx-4 properties….etc. The configuration *oromoLM* file contains language model in binary and dump format and it also contains dictionary files called nuguse**.**

The technology uses a microphone to accept specific questions from users. The vocal inquiry was then recognized by the system and transformed into a text-based question. The text question is sent to QA systems via the QAS (speech) function after being recognized as a complete text question. When there is no noise and interruption the system recognize effectively. The system automatically substitutes, adds, and modifies words that fit the unrecognized term if the system cannot recognize it owing to an interruption.

4.4 Question and Answering

Building systems that automatically respond to questions presented by humans in natural language is the focus of the computer science topic of question answering (QA), which falls under the umbrella of information retrieval and natural language processing (NLP) [20].it contains different contents.

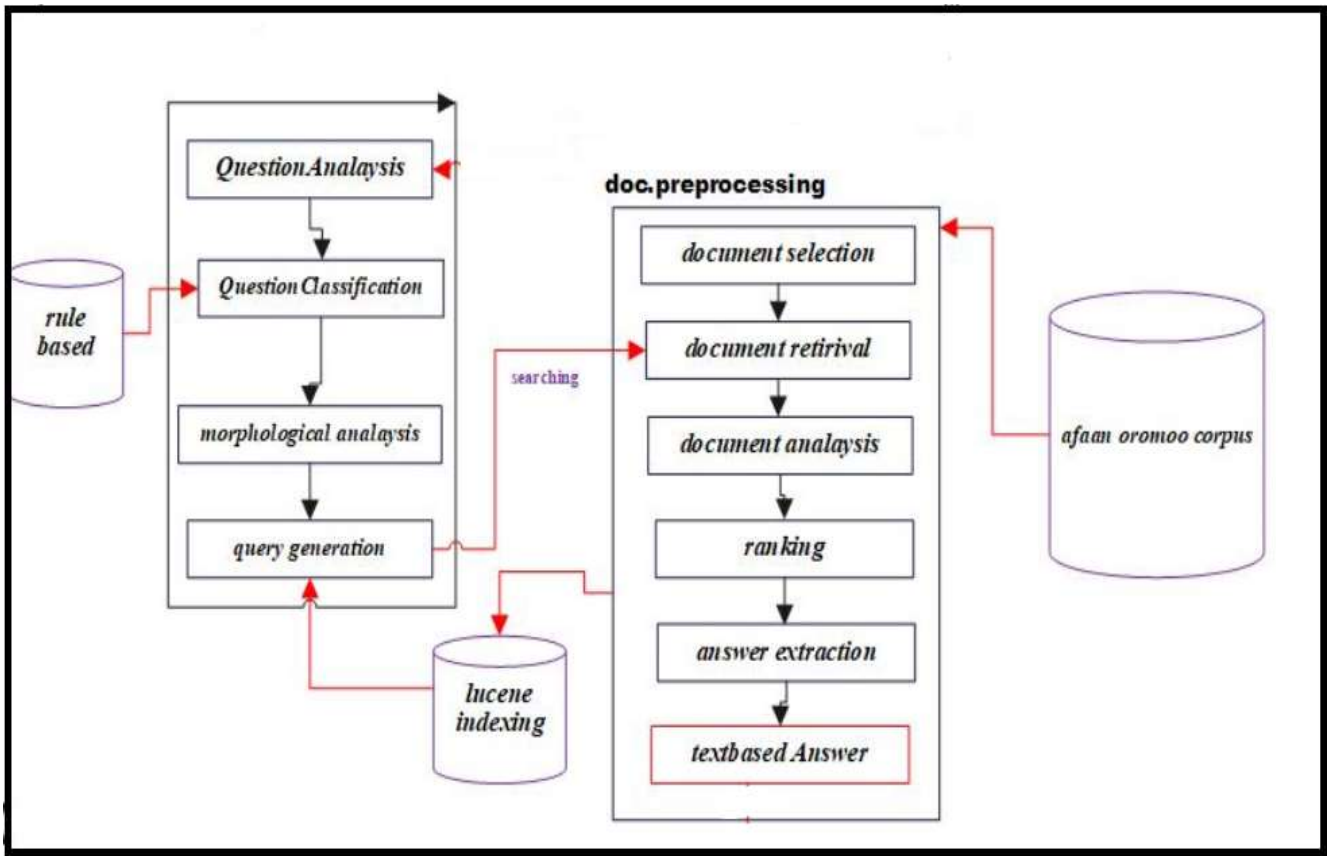

Figure 4. 7 Question and answering overall Architecture

4.4.1 Question Analysis

The first goal of question analysis is to extract characteristics that will probably be used in the answer extraction module. The second goal is to extract terms that will re-index the selected documents in order to retain only a subset of them and to provide additional evidence during the final matching. The focus, question category, and intended type of answer are the retrieved features. Understanding the type of information that the question is seeking is the major purpose of the question analysis component. Additionally, it is in charge of creating appropriate queries for document retrieval. The system's question analysis begins when a user asks a question. Components receive the user query and transmit it to their child components. With the following two goals in mind, question analysis is done: the initial step is to take some the second is to identify features that are likely to be employed in the answer extraction module; in order to save only a portion of the terms used to re-index the chosen texts, During the final matching, provide further evidence in support of them.

4.4.2 Question Classification

Regardless of the different types of architectures, the essential component of Question Answering Systems (QAS) is question classification. In order to extract answers from a big collection of documents and texts, the system must first be aware of what it is looking for due to the numerous sorts of questions (definition, factoid, list, yes/no, etc.).In this situation, questions ought to be categorized based on their kinds. A question's type, whether it be list, definition, or description, is determined by the question classifier subcomponent. We started by analyzing the query in order to identify the anticipated response. You can search for a person, a number, a time, or a location. Following that, we created a decision-question model based on the type of response. Any question-answering system's question classifier is a crucial module. Based on the anticipated answer categories, the relevance of the question categorization is calculated. The importance of the answer type reduces processing time and effort and also provides a potential method for choosing the right replies from among the available answer options. Person, Location, Organization, Date, and Quantity are examples of possible entity types for factoids. These entity kinds depend on the question's question particles.

S/NO	Question Particles		Expected/answer
1	*eenyu", "eenyuf", "eenyufa","eenyuf eenyu", "eenyun", "kan eenyu", "eenyu irraa", "eenyura", "eenyuni"*	*WHO*	*Peson,organization*
2	*"eessa", "eessatti", "eessarra", "kaneessa","eessaa irraa","essaf","hammaessaa","eessan","echati","echaan".*	*WHERE*	*Place*
3	*“yoom", "yoomi", "hamma","yoomiraa", "yoomif", "hamma yoomit","yomitti","yoomin","yoom fa","yoom fa'i".*	*WHEN*	*Time*
4	*"meeqa","hammam","meeqan","meeqaf","meeqatu", "meeqatti","hammamitti","hammamiif", "hammamin","meeqotaa".*	*HOW*	*Numeric*

Table 4. 1 question particles and expected answer type

In different research done previous or literature review different methods is used in question classification.so based on this the researcher construct rule based model for question classification. Because: rule based is one of the most robust and accurate algorithm among the other classification algorithms. And this research uses automatic question classification. To classifying questions using the rule based technique, the decision model is created.

Corsea class	Fine class
*Nama(Person),iddoo(Place) [**maqaa**]*	*Bakka [Biyya (magaalaa, kutaa magaalaa,ganda, aanaa, kebele, laga, gaara, haroo, galaana, hoteela, naannoo, yunivarsiitii, holqa, siidaa, riqicha, odola, mana barumsaa, masjiida, waldaa, kan biroo), pilaaneetii , Dhaabbata], . Halluu/Bifata, Weebsaayitii, Amantii, Afaan, Hojii/Ogummaa, Nama [Taphataan, Pirezidaantii, muummicha ministeeraa,Taphataan,,Barreessaa, Aanga'aa, Eksteenshinii, Kantiibaa/Bulchaa, Kan biroo], Dhukkuba, Dhugaatii, Nyaata, Beeylada, Meeshaa [konkolaataa, xiyyaara, kan biroo] Taphataan, atileetii, istaadiyeemii, garee, leenjisaa, garee kubbaa miilaa, kan biraa*
Numeric(Lakkoofsaa),Time(Yeroo)	koodii,lakkoofsa, guyyaa, fageenya, maallaqa, ajaja, dhibbeentaa, yeroo, kompiitara, saffisa, ho'a, waggaa, guddina, ulfaatina , kan biro

Table 4. 2 coarses and fines of classification of a question

The rule based algorithm is not need train the system's query classification in order to get the best accuracy/precision. We've established both the coarse- and fine-grained classes of answer types.

Based on the given data, the Question categorization forecasts the expected class. Examples of Afaan oromoo Factoid question and answer systems include the ones below. Based on the training data, the Question categorization forecasts the expected class. Illustrations of afaan oromoo the following factoid question and answer formats are examples. "***Ministirri Muummee Itiyoophiyaa eenyu***?" which means "Who is the Prime Minister of Ethiopia?" the coarse class is "**person**" and the fine class is "***Ministirri Muummee***".the other example ***"Magaalaan Adamaa Finfinnee irraa kiiloo meetira meeqa fagaatti?"*** means "How many kilometres is the city of Adama from Addis Ababa?" the corsea class is "***Lakkofsa*** (***Quantity)***" and fine is "**fageenya**" which means "***distance***".

For each natural language question posed
Check for question particles "eessa", "eessatti", "eessarra"
If question contains one of these question particles
*Classify question as **place** type*
Else check for question particles "yoom", "yoomi", "hamma","yoomiraa, ...
If question contains one of these question particles
*Classify question as **time** type*
Else If question contains terms like "yoom","yoomfaa", "guyyaa", "yoomif"
*Classify question as **numeric** type*
Else check for question particles eenyu", "eenyuf", "eenyufa","eenyuf eenyu", "eenyun"
If question contains one of these question particles, // question focus
*Classify questions as **person** type*
Else Try the IR based technique
End for

Figure 4. 8 Rule-based QAS Classification Algorithm to determine type's question

4.4.3 Morphological Analysis

In natural language processing, morphological parsing is the act of figuring out the morphemes that make up a given word. It must be able to differentiate between morphological and orthographic rules. The results of the search engine are improved through morphological analysis and generation. Assume that the output will be impacted if a term is submitted as input but is not included in the lexicon. In that instance, the word's morphology is examined. The morphological analyzer provides the word's root and allows you to combine all of a word's morphological variations into one index entry, or its common form.

4.4.4 Query Generation

The natural language queries won't be sent directly to the document retrieval component as they stand. Any alteration that increases the likelihood of matching pertinent documents should be made. This subcomponent is extremely important since improper queries may return the incorrect document, from which the incorrect answer would be retrieved. The stemming, character/number normalization, stop words elimination, and synonym expansion features of the query generation subcomponent are included. We will go through each step that assists in creating the query in more detail below.

The first step in creating a query is to eliminate any stop words, including question marks and punctuation. The stop word removal algorithm is identical to the one we used in the document pre-processing module. Since stop words have already been eliminated from the index and cannot be used to match relevant documents, this subcomponent includes the stop word removal component. The remaining search keywords will then undergo character normalization, which helps to change the characters to the same format as used in the document preparation module, once the stop words have been eliminated. Character normalization must be taken into account at this step of question processing if pertinent documents are to match the inquiry.

4.4.5 Document Pre-processing

Input preparation is used in the field of NLP to extract valuable knowledge from unstructured text input. Choosing which documents from a collection should be retrieved to satisfy a user's informational need is the essence of document preprocessing. In document preprocessing there are different function listed below. Before retrieving documents as part of a QA activity in this system, a document preprocessing task is carried out using Afaan Oromo question and answer corpora. In fact, the document preparation component includes a function called tokenization that carried out within, useful in enhancing the likelihood that similar terms will appear in the question and the weighted answer sentences.

4.4.5.1 Document Selection.

There are two components that make up the document selection component: document retrieval, which is in charge of finding documents that might contain information relevant to as person, place, quantity of a target, and document analysis, which is in charge of sorting documents into relevant and irrelevant ones.

4.4.5.2 Document Retrieval

Finding documents that are pertinent to the given query is the duty of document retrieval, which makes use of keywords provided by the query-generating component. The user's query is the first thing that happens, and it ends with a list of documents that have been prepared for document analysis and answer extraction. It also acts as a link between the components for question analysis and response extraction. The goal of the IR system is to provide accurate, pertinent results in response to a user-submitted query. QA systems are independent of IR systems, which gauge document and query similarity using the cosine vector space model. This is primarily due to the

fact that QA systems often only require documents to be retrieved when they include all of the keywords. This is due to the Question Processing module's thorough selection and reformulation of the keywords. Finding relevant information from documents in the Afaan Oromo corpus that corresponds to a user's search is the goal of the document retrieval component. In reality, once papers have been preprocessed, their nature and content are stable. However, it is crucial to prepare parallel corpora before doing such document preparation activities. With the provided Question sets and Answer sets aligned at the sentence level as a source of data, it is necessary to train and test the system.for this document retrieval and processing we use apache lucene which is free and open-source search engine software library.

4.4.5.3 Searching

The generated query is then sent to the document retrieval component, which looks for documents that are believed to be related to the inquiry and could contain potential responses. QA systems frequently demand that documents only be retrieved if they contain every possible keyword. A paragraph is filtered using the highest question word that matches the documents and the paragraph's ordering, together with the distance score, score for missing keywords, and identical word sequence score.

4.4.5.4 Indexing

A Document serves as both the search and indexing unit in Lucene. There are one or more Documents in an index. Searching entails obtaining Documents from an index using an Index Searcher, while indexing entails adding Documents to an Index Writer. In order to search, an index must already have been created. A query is created (often using a query parser), which is then sent to an index searcher, who then provides a list of hits. The user can select which field(s) to search on, which fields to give greater weight to (boost), how to do Boolean queries (AND, OR, NOT), and other features using the Lucene query language. By adding documents containing the field(s) to Index Writer, which analyses the document(s) using the analyzer before creating, opening, or editing the necessary indexes and storing or updating them in a directory, we may use Lucene to index terms. The Index Writer tool can be used to create or change indexes. It does not read indexes.

4.4.5.5 Document Analysis

The document analysis uses a list of the most likely responses and a question categorization description to determine the appropriate response. Researchers can better understand and organize primary sources original accounts from people who have firsthand experience of a subject by analyzing documents. Researchers obtain ideas and data for their studies from reputable sources in order to bolster their assertions. This procedure enables researchers to assess the value and intent of the sources they utilize to determine whether the data they include will be useful for their research. Understanding this procedure better could make it easier for you to manage your resources and do research more successfully.

4.4.5.6 Ranking

Information retrieval (IR) includes a procedure known as document ranking. It displays the documents that were found in the order of their estimated levels of relevance to the query. The majority of conventional document ranking techniques are based on calculations of similarity between documents and queries. One of the key issues in information retrieval is the ranking of queries. It's the scientific/engineering discipline behind search engines. Example "***pirezidaantiin itoophiyaa eenyu***?" which means who is the president of Ethiopia? For this answer we can get some document but for answer we need one document.so to identify these ranking document is very important.

4.4.5.7 Answer Extraction

The best passages from the best documents are recovered during the information retrieval stage. From these passages, prospective solutions are gleaned and ranked during the linguistic processing stage. In order to simplify paragraph filtering and ordering after collecting the documented index, a distance vector is used. The answer extraction method is based on hybrid pattern matching and gazetteers, the most fundamental and extensively used subset of answer extraction techniques. The two criteria utilized to select which answer is the top-ranked one are the quantity of predicted answer types in a phrase and the quantity of phrases that the question and the document terms match. Answer extractions extract relevant terms by measuring the distance between keywords.

4.5 software tools used for development

For creating speech-based Afaan Oromo question answering, a different of tools are available. Sphinx-4 tools for voice recognition and decoding, Lucene for question-answering systems, a rule-

based lecune analyser for question classification, and NetBeans for integrating all modules are some used tool in the research.

Sphinx tools: Sphinx is an n-gram statistical language model and hidden Markov acoustic models (HMMs)-based continuous-speech recognition system. An established set of tools for creating speech apps is the Sphinx toolkit for speech recognition.

Sphinx4: Pure Java speech recognition library called Sphinx4 is used. It offers a quick and simple API that uses CMUSphinx acoustic models to convert speech recordings into text. Both desktop and server programmers can make advantage of it. In addition to voice recognition, Sphinx4 aids with speaker identification, model adaptation, alignment of existing transcription to audio for time stamping, and more.

Sphinx 3: is a Large Vocabulary ASR System that is slightly slower but more accurate. It serves as an evaluation-focused server implementation of Sphinx. It makes use of HMMs with continuous PDF output. It supports a variety of operating modes. The original Sphinx-3 version has the more precise model, "known as the flat decoder."

Pocket Sphinx5.0.0: One of the open source, speaker-independent continuous speech recognition engines with a big vocabulary developed by Carnegie Mellon University is called Pocket Sphinx. Sphinx variant suitable for embedded systems, such as those based on ARM processors. Fixed-point arithmetic and effective GMM computing techniques are included in the actively being developed Pocket Sphinx. It is a voice recognizer that can be included into embedded technology. It has been carefully optimized for CPUs like ARMs. CMU's fastest voice recognition technology is called Pocket Sphinx. It employs HMMs with PDF output that is semi-continuous. Despite not being as accurate as Sphinx-3 or Sphinx-4, it runs in real time and is therefore appropriate for live applications.

Sphinx Train5.0.0: is a group of sphinx tools used for training acoustic models. It is a Sphinx training program from CMU. It develops vector quantized continuous or semi continuous models for the SPHINX decoder versions 3 or 4, which Pocket Sphinx also employs. Under certain circumstances relating to sphinx-2 limits, it is also possible to convert the sphinx-3 format to the sphinx-2 format. Sphinx Train supports MFCC and PLP coefficients with delta or delta-delta features.

Lucene search engine: A fully functional, high-performance search engine library, Apache Lucene is created entirely in Java. It is a technology that can be used for almost any application that needs spell checking, query suggestions, nearest-neighbor search over high-dimensionality vectors, full-text search, faceting, and structured search. A programming interface (API), not an application, is what Lucene is specifically. This indicates that all of the challenging tasks have been completed, leaving us to construct the simple code in order to meet the demands of our application.

Wave Surfer: *is* an open source tool for manipulating and visualizing sound. Speech/sound analysis and sound annotation/transcription are typical uses**.** Wave Surfer can be enhanced with plug-ins and integrated with other programmers. Customizable features allow users to design their own setups for the wave surfer. Localization assistance. Extensible - new functionality can be added through a plugin architecture, embeddable - Wave Surfer is a multi-platform widget that works with Linux, Windows, and OS X apps.

4.5.1 System interface

The below interface were human and computer communicate in computer. On this user can write, read and edit question. It is also the way through which a user interacts with an application or a website. This user inter face contains different text area, textbox, button. Those are:-

Gaffii:-interface where user can input question.

Debii:-text area where the system put the answer.

Figure 4. 9 Question and answering user interface templates

On the above using java swing the interface question and answer interaction done. This java Interface on the Gaaffi accept question and on the text area Deebii provides the correct answer. On the right side of text area called Madda it provides the passages were the answer extracted from.Deebii filanoo 1:, 2,3 and 4 also answer that are ranked for documents.

CHAPTER FIVE

EXPERIMENT RESULT AND DISCUSSION

5.1 **OVERVIEW**

In this Chapter we identify the experimentation result, the data set, the evaluation metrics, and the results of the performance of afaan Oromo speech recognition, the performance of question and answering and question classification and finally we measure the overall QAS. The reason for performance review is being done to determine how well the study is working and to make recommendations for the future.

5.2 Experimentation Environment

The prototype was constructed using Java programming language. The system uses sphinix4 for speech recognize which is free libraries and we use the lecune search indexing for question and answering. The reason why we select is: - In many devices, including laptops, data centers, game consoles, supercomputers, and mobile phones, Java is safe, quick, dependable, and compatible.

Sphinx: is a voice recognition library written entirely in Java. It offers a quick and simple API that uses CMUSphinx acoustic models to convert speech recordings into text. Both servers and desktop apps can make advantage of it.

Lecune: is a fully .functional, high-performance search engine library that was created entirely in Java. Nearly all applications that call for structured search, full-text search, faceting, nearest-neighbor search across high-dimensionality vectors, spell checking, or query recommendations can benefit from this technology.

Java programming language: is one of the key computing platforms and programming languages for numerous applications is Java. Sun Microsystems introduced it in 1995. Java is used by many applications, especially web apps since it has a lot of promise in the fields of web, games, databases, and many other applications. It includes a variety of compilers and editors, including the Text Pad, Eclipse, and NetBeans platforms.

The computer used to create and test the system has the following specifications:

- ✓ Windows 11 pro operating system,
- ✓ 8GB RAM Extendable to 16GB ,
- ✓ 500GB SSD Hard disk and
- ✓ Processor 11th Gen Intel(R) Core(TM) i7-1185G7 @ 3.00GHz 3.00 GHz.

The system used the following for testing:-

- ✓ Java 2 SDK.
- ✓ Java runtime Environment (JRE)
- ✓ NetBeans 8.0
- ✓ Cygwin
- ✓ Notepad++
- ✓ Python
- ✓ Perl
- ✓ Visual studio
- ✓ Ant

5.3 Speech Recognition System Prototype Components

This prototypes is collect sound from user and integrates with question and answering platforms. First it collect sound of question from users and going to answer extraction and display the answer after the answer is showed it change the answer outputs in the form of sound. This is the overall system flows.

5.3.1 Sound Recognition

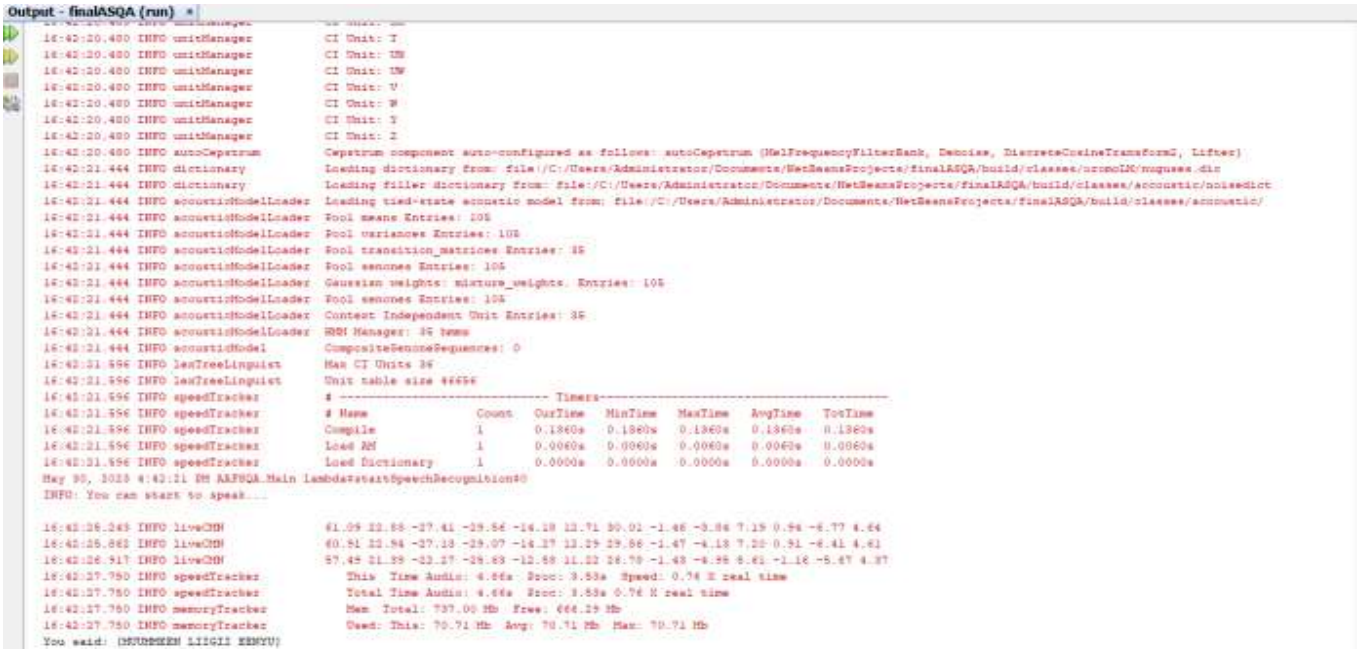

Figure 5. 1 speech accepted from user to question and answer.

The above image show of speech recognition output. First when we run java code that accepts the sound the image sample run code is displayed. The way to connect to a speech recognition is depend on the microphone on your computer The LiveSpeechRecognizer uses a microphone as the speech source which accepts sounds from user. If the microphone on it accepts the speech and change to text but if the microphone not work it shows error message microphone not work. Based on the above image experimental and evaluation is done for speech recognition.

5.4 Experimentation and Evaluation for Speech Recognition

5.4.1 Performance

The speech recognizer primarily accepts speech inputs and can identify sentences. A speech recognition system uses a sphinx decoder to convert spoken words into text sequences. It is made up of a speech database, an Afaan Oromo dictionary, language models, lexical models, and acoustic models.

The accuracy and speed of speech recognition systems' performance are typically measured. Speed is quantified using the real time factor, however accuracy can be measured in terms of performance accuracy, which is often graded with word error rate (WER).and Single Word Error Rate (SWER) and Command Success Rate (CSR) are additional metrics for accuracy.The speech recognizer primarily accepts speech as inputs and identify to sentences. A speech recognition system uses a

sphinx decoder to convert spoken words into text sequences. It is made up of a speech database, an Afaanoromo dictionary, language models, lexical models, and acoustic models.

5.4.2 Our Evaluation and Experiments

For this study, the speech has been taken place using 21 different speakers. Those speakers were from Oromia Bank those can speak, listen, and also read and write perfect Afaanoromo language. From those 13 are men's and 8 women's those works on IT Infrastructure division.

No	**Speaker's list**	**Sex Classification**	**Age contents**	**File Format**	
				File Type	.Wav
1	13	Men	20-45	***Sample Rate***	16000Hz
				Sample Size in bits	16
2	8	women's	19-40	***Recording Type***	Mono
				Signed	True
				Character type	Little-Endian

Table 5. 1 Data Set used for trainings

1344 question sentence were read in the speech corpus by 21 speakers (8 women and 13 men), who each read 64 question utterances for training purposes. The sentences were recorded and then chopped up to create a speech corpus Parameterized and prepared after that, wave surfer tools are used to identify speech samples. 64 questions were divided into two categories for testing and teaching speech recognition, such as person and place. The text corpus and speech corpus used in this study are used to train a speech recognition system. The challenges in this areas due to the time limitation we can't train more data. For future researcher making more than this training may increase the speech recognition accuracy. The result of the training shows that and 19% is word error and 81% accuracy.

5.4.3 Experiments

In this experimental we test the system using 20 question, divided to 2 groups.one group from train and one from other person that does not train. Means each group for one speaker. The speech data recorded- and tested. The testing application's code has to be modified so that it can read from an existing file when using a wave file. Additionally, that wave file must be processed in order for it to work with our system. Each file must successfully complete a format test as part of the checking channel before it can be used in the system. In the table above, the speech file's supported formats are listed. In this case, we immediately provide the recognizer with audio data using the microphone.

Speakers	Speaker1	Speaker 2
Number of Question/sentences	20	20
Total words	185	185
Number of Correct recognized Word	162	156
Number of Deleted words	10	12
Number of substituted Words	12	12
Number of Added words	16	18

Table 5. 2 Speech recognition experimental results

Based on the above table we identify the accuracy and WER (word error rate) for speech recognition systems. Which used sphinx4-5 and show results as below table.

Speaker Number	Accuracy	Duration In sec	WER(word error rate)
Speaker 1	79.5%	76	20.5%
Speaker 2	77.3%	78	22.7%
- Total	**78.4%**	**77**	**21.6%**

Table 5. 3 Total speech recognition accuracy and WER

The table above shows the performance of speech recognition based on the 2 speaker's speaker 1 from trainers and speakers 2 that does not train. The system recognize **78.4%** accuracy and **21.6%** word error rate.

5.5 Experimentation and Evaluation for factoid Question answering System

This content evaluate both question classification and question and answering.

5.5.1 Question Classification Evaluation

If the question's question type and the anticipated answer type are accurately determined, the solution to the question would likely be extracted. The performance of the question classifier should be assessed because it handles this task. Question classification is the process by which a system analyzes a question and labels the question based on its expected answer type. The effectiveness of question categorization is essential for extracting answers; questions that are incorrectly classified will produce incorrect or no answers as a result. The percentage of questions that were correctly and incorrectly identified as a measure of question classification. The below diagram shows the question classification experiments.

Figure 5. 2 Question classification analyzers

The above image shows the rule based question qualification.it depends on the rule above identified example, the place question particle's "**eessatti**" shows place based question. The challenges of other classification like SVM is a query is exist in different class so, SVM is not clear classifies a question So based on the above, when a user submits a question, the system instantly categorizes it based on the predicted term, such as (eessati).based on the above analyzer 74 question are prepared for both Person and place question types it analyzer classified 98% and 96% for both questions list respectively.

5.5.2 Question and Answering Evaluation

5.5.2.1 Evaluation Metrics

We required metrics that can give clear indications of how the system achieves its purpose if we were to measure the success of our QA System accurately. As a result, a variety of assessment metrics can be utilized to assess the effectiveness of this QAS. Each metric in this scenario emphasizes a different component, and the system performance is described using a variety of ways. Those three are evaluation metric Precision, Recall and F-Measure

These are the most widely used metrics for assessing the quality of IR retrieval and QA. Precision is the ratio of the number of shared words to the total number of words in the prediction. Recall is

the ratio of the number of shared words to the total number of words in the ground truth. And F-Score can be defined as harmonic mean of precision and recall. It is a Measure of system's accuracy. It considers both the precision and recall to compute the score. Our systems contains Precision and recall can be summarized as follows. Precision is calculated as the number of correctly Retrieved answered correctly document over the total retrieved list of answers.retrived correct means it contains (correct, not exactly correct and wrong answer and not answer). The recall is also calculated as a number of correctly answered questions among the list of expected answer sets where documents are first analyzed for the presence of correct answers.

When a user submits a question, the system instantly categorises it based on the predicted term, such as (eenyu). In this category, the term "eenyu display person".The correct answer could be the one which is displayed on the second text field. The other four text fields display the answer choice which is depend on the word in documents that have similarity. The answer and question displays based on question analyser which contains question classification queries and query generator.

We have assessed the rule-based question-answering system's performance. Because previous research done using SVM and other method. The challenges of SVM question classification is a query is exist in different class, so it's not clear for question classification. We take both question from place and also sample question from persons. There are 70 training questions for two types question "person" and "place " and for testing, we use 20 for person and 20 for place questions shows as in appendix III.

Questions		TP/correct answer	FP/answer but not correct	FN/No answer	Precision	Recall	F-measurement
					Percent	Percent	percent
Person	20	17	2	1	0.894	0.944	0.918
					89.4%	**94.4%**	**91.8%**
Place	20	16	2	2	0.888	0.888	0.888

					88.8%	**88.8%**	**88.8%**
Total	40	33	4	3	0.891	0.916	0.903
					89.1%	**91.6%**	**90.3%**

Table 5. 4 Performance of question and answering

The performance of question and answering using rule based question classification performs **89.1%** precision, **91.6%** recall and **90.3%** F-measurement. The challenges in rule based question classification based question and answering if the class of question wrong, the answer must be wrong.

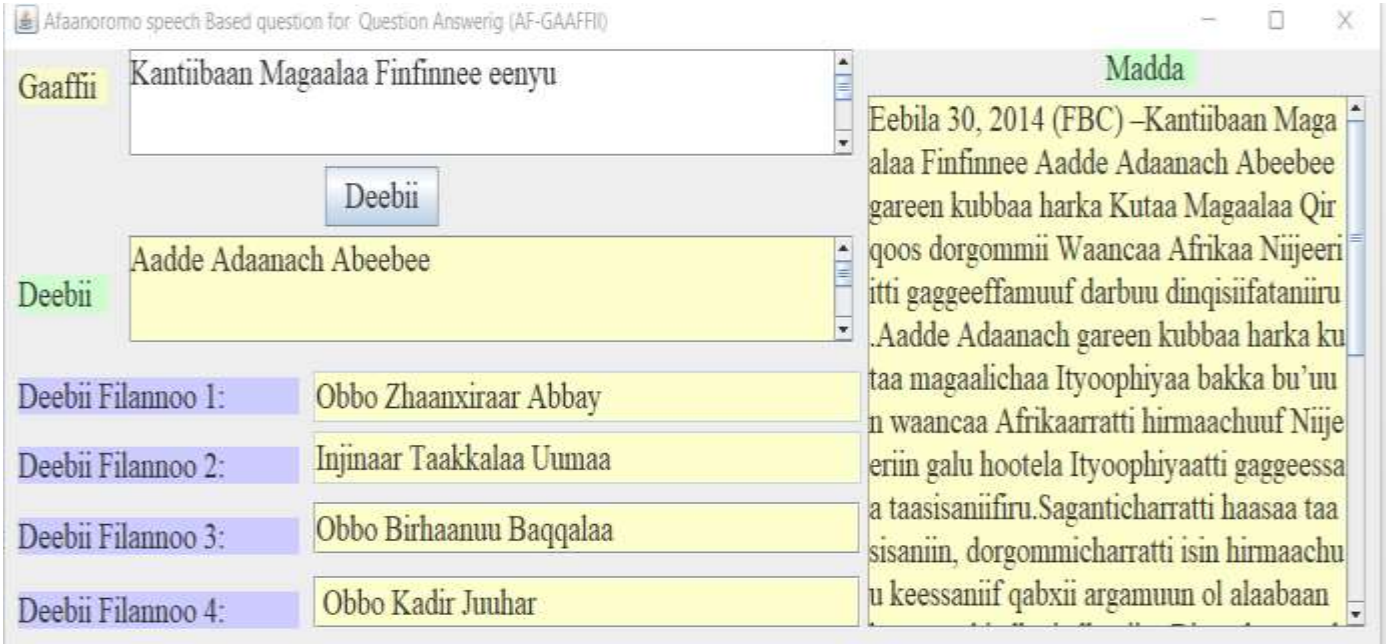

Figure 5. 3 Screen shoots of correct Person types answer

In above figure the question kantibaan Magalaa Finfinnee eenyu? Classifies question correctly and answer correctly.it classifies as person and Debii (answer) also correct Aadde Adaanach Abeebee.

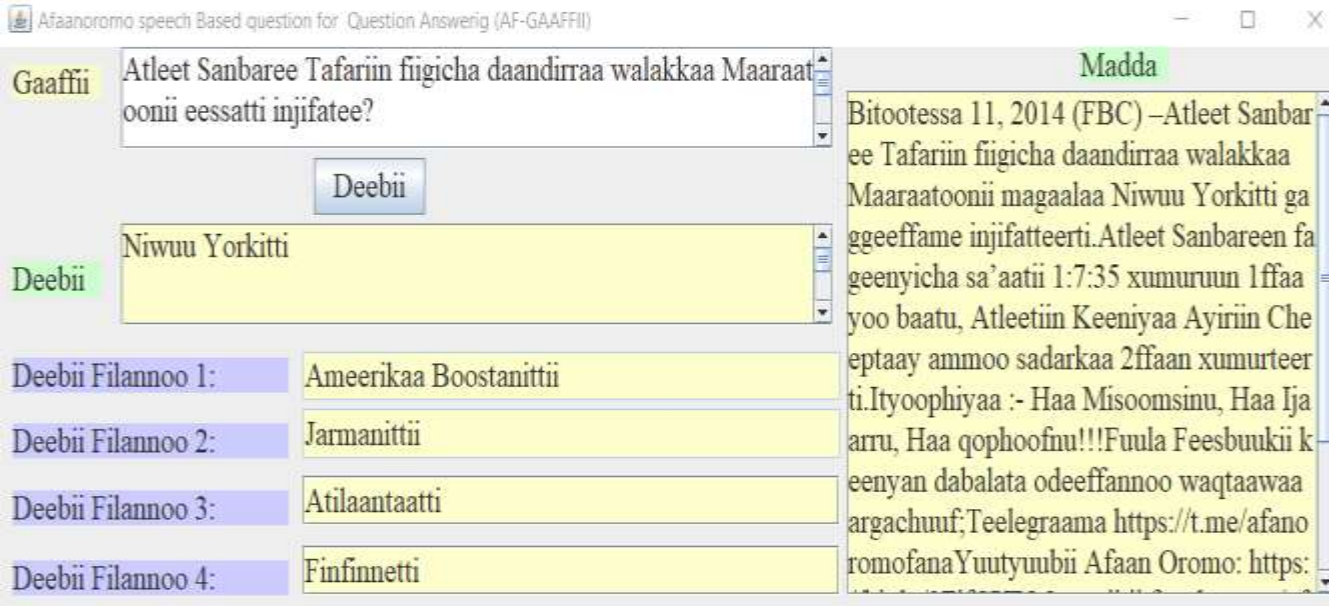

Figure 5. 4 Screen shoot of correct place type answer

The above figure 5.6 shows the answer for Atleet Sanbaree Tafariin fiigicha daandirraa walakkaa Maaraatoonii eessattii injifatee the question classify the question in to place and the answer for this question Niwuu Yorkitti which exist in documents.

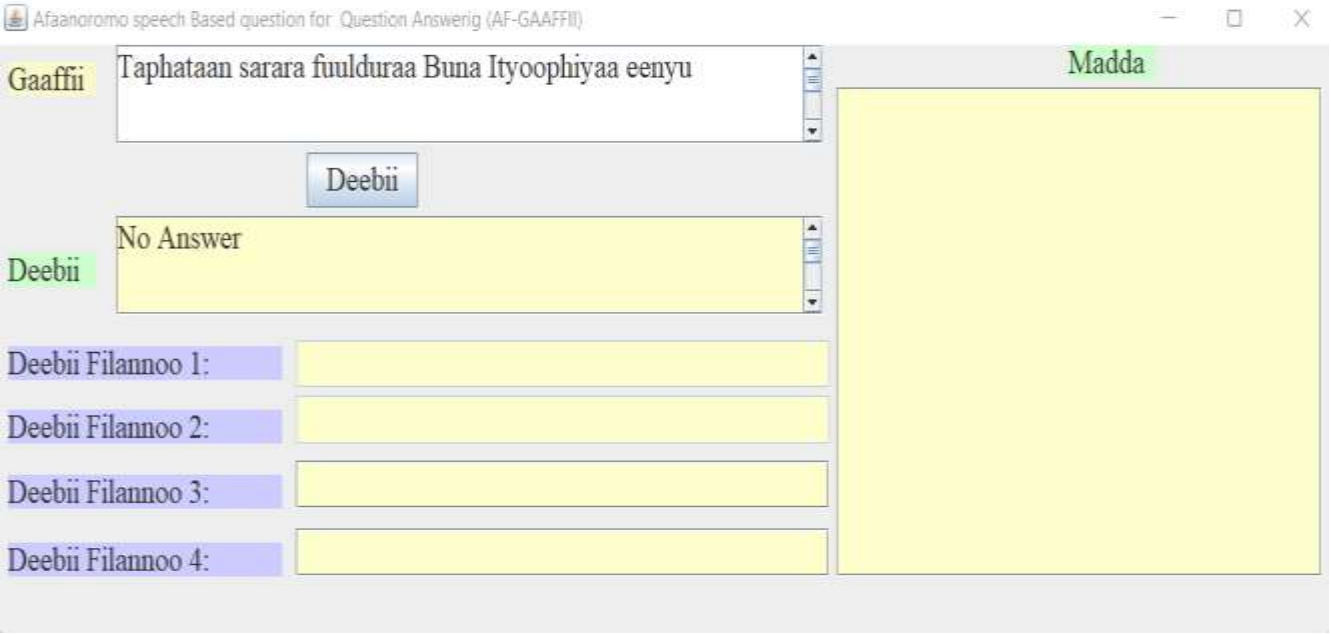

Figure 5. 5 screen shoot of No Answer question types

The figure above asks (Who is the Ethiopian coffee forward player). The documents exist in corpus and the answer should be Abuubeker Nasiir, but it returns No answer.

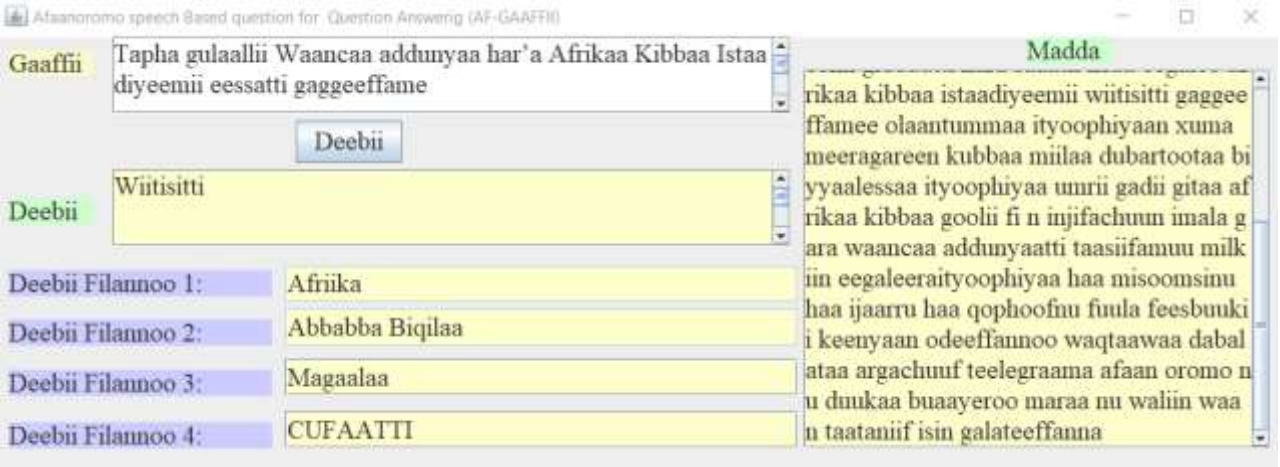

Figure 5. 6 Screen shoots of in correct answer types

In this above figure 5.8 the question classifies correctly but it does not retrieve correct answer from exist documents in corpus and the answer for this question should FNBtti.

5.6 Discussion and Challenges

In this study, we try to combine afaan oromo speech recognition with an Afaan oromo question-answering system using automatic question classification, which enables the question-answering system to accept speech queries and retrieve precise textual answers before producing responses in the form of text to the users for a particular query.

The main conclusions of this study are the development of an Afaan Omo Continuous Speech Recognizer and the use of question categorization methods for question answering by using rule-based algorithms based on performance attained and integrating them with question answering.

The speech recognition system's experimental findings showed accuracy of **78.4%.** The question classification without question and answering for both Person and place question types it analyzer classified 98% and 96% for both questions list respectively. But with question and answering the Rule based question classification accurate **89.1%** precision, **91.6%** recall and **90.3%** F-measurement.when we compare other related work. Amharic Speech recognizer for question answering question rate of 85.58% and the speech recognition of speechGoog show the

recognition rates 87.17% which we appreciate[9]. And also the experiments of questions and answering 89.1% precision and in the previous research indicates 73.91% using SVM algorithms. Our study gets good accuracy. Some challenges are the reason for why the system does not score best results.

CHAPTER SIX

RECOMMENDATION AND CONCLUSION

6.1 Conclusion

This work demonstrates the potential for creating an automated question categorization speech-based Afaan oromo question for automated question answering. The user asks the query using STT in afaan oromo native language. It extract the necessary response from question-answering systems and output the response as text, the user inquiries are compared with the documents.

In the first corpus collected and the speech recognition training and testing done.in the second round question classification and the question and answering system developed.in the final we connect both of to make to make Automatic question classification speech based question for afaan Oromo question and answering.in the speech recognition different component occurs from those Language model, feature extraction, dictionary, acoustic model and decoder like sphinx.to develop those models we use NetBeans 8.0,perl,python,Cygwin and notepad++.for decoding the code we use pocketsphinix5.0 and sphinxtrain5.0. We integrates those by java NetBeans.

On the second round creating factoid question and response systems for information extraction and retrieval. Question analysis, document retrieval, and response extraction make up the three primary parts of the question answering section. In response to the user's request, the question analysis component determines the kind of fact the user is looking for, such as a person, time, place, or amount.in this question classification done by Rule based qualification. Which classify question easily by define rules.

The component that gets created questions from the question analysis component that came before it searches for documents that contain information relevant to the user's query. This search is conducted within the directory of indexed documents. The answer extraction component will receive ranking copies of any pertinent documents it discovers. Finally the answer extraction is a component in charge of unearthing the information that is thought to be a response to the user's query and returning this information to the user in a specific order.

We test the system using 20 question, divided to 2 groups.one group from train and one from other person that does not train. Means each group for one speaker. The speech data recorded- and tested. The testing application's code has to be modified so that it can read from an existing file when using a wave file. The result of the training shows that and 19% is word error and 81% accuracy. The performance of question and answering using rule based question classification performs **89.1%** precision, **91.6%** recall and **90.3%** F-measurement. The challenges in rule based question classification based question and answering if the class of question wrong, the answer must be wrong. In general the overall performance of Automatic Question Classification and Speech Based Question for Afaan Oromo Question Answering achieves **71.45%** accuracy.

6.2 Recommendation

To improve the performance the Automatic Question Classification for speech based question for afaan Oromo question answering. Because it need different natural language processing modules. We specify additional future works that can be added to system to increase the performance of researches. We listed it below:

- ✓ Doing TTS based answering is highly recommend because it used for visually impaired peoples Recommended future work for the Afaan Oromo language.
- ✓ The question and answering support only factoid question. Thus doing for other non-factoid question and answering.
- ✓ Adding Afaan Oromo spelling checker to this system would help to avoid user input error when writing an afaan Oromo question.
- ✓ Adding afaan Oromo word-net is also increase the performance query expansion,beacuse it used to search documents from different angle.
- ✓ The performance of the system depends on the corpus size.so maximize the corpus data also recommended.
- ✓ Working with other question types like definition, list, biomedical also recommended.
- ✓ The system customized using java neat beans on desktop and we recommend develop on android, web and like artificial API.
- ✓ The research is done on users for monolingual Afaan Oromo language speakers. But, in Ethiopia, there are more than 80 languages so the next researchers' will propose on this.
- ✓ There are no perfect noise detection techniques, which are applicable to natural language processing in part of speech technologies for question answering. So for the next investigation, we recommend removing noises when question speech are greater than noise.

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Appendix I

List of Afaan Oromo stop words

Akkasumas	**Akum**	**Aanee**	**eega**	**Hoggaa**	**Jala**	**otumallee**	**yommii**
Iseef	**Karaa**	**ta'es**	**Fuullee**	**irraan**	**Isinii**	**Jirtutti**	**Kiyya**
Ala	**ergii**	**innaa**	**ishiirraa**	**jedhan**	**Keessan**	**nu'i**	**ta'uun**
Agarsiisoo	**eegana**	**Hogguu**	**Iseenis**	**jechaan**	**Kee**	**Naan**	**otuullee**
Akka	**eegasii**	**Hogguus**	**Ishee**	**jechoota**	**Keen**	**Naannoo**	**qaba**
gara	**Isaa**	**Isiniifis**	**Ka**	garas	Isaan	Isiinis	nuyi
Booddees	**gubbaa**	**Isaanirraa**	**Isinitti**	**Lama**	**Malee**	**Sunis**	**waggaa**
Malees	**hamma**	**Isaanii**	**Dabalatees**	**isaaniitiin**	**wajjin**	**Kanaaf**	**Dhaan**
kanaafi	**kanaafillee**	**Isaaniitiin**	**isinirraas**	**Isinis**	**waliin**	**Oggaa**	**ofii**
Booddee	**gidduu**	**Isaani**	**Dabalatees**	**hamma**	**isinittis**	**Kanaafis**	**sunniin**

Appendix II

List of Afaan Oromo Abbrivesion

Fkn.	Fakeenya
Bil.	Bilbiilaa
Ful.	Fulbaana
Mil.	Miliyoona
Onk.	onkololessa
Mud.	Muddee
W.B	Waree Bodaa
DH.k.B	Dhaalotaa Kiristoosin Bodaa
Wax.	Waxaabajjii

Appendix III

S.no	**Question**	**QuestionTypes**
1	Kantiibaan Magaalaa Finfinnee eenyu	Person
2	Ministir Deettaan Ministeera fayyaa eenyu	Person
3	Daayreektarri olaantuun Abbaa Taayitaa Nyaataa fi Qorichaa Ityoophiyaa eenyu jedhamuu	Person
4	Hogganaan Biiroo Eegumsa Fayyaa Oromiyaa eenyu jedhamu	Person
5	Minisirri Ministeera Fayyaa eenyu jedhamuu	Person

6	Abbootiin qabeenyaa biyya keessaa carraa gaarii fi haala mijataa uumametti fayyadamuun Paarkii Qonna Qindaa'aa Agroo Indaastirii Bulbulaa keessatti hirmaachuu akka qaban waamichi dhiyeesse eenyutu	Person
7	Ministirri Ministeera Albuudaa eenyu	Person
8	Taphataan sarara fuulduraa Buna Ityoophiyaa eenyu	Person
9	Bulchaan Godina Booranaa eenyu jedhama	Person
10	Kilabiin Ingiliiz Arsenaal leenjisaa olaanaa gochuun kan muude eenyu jedhamu	Person
11	Kilabni Ingiliz Astoonviilaan leenjisaa taasiisuun muude eenyu jedhama	Person
12	Ameerikaatti Ambaasaddarri Ityoophiyaa eenyu?	Person
13	Preezdaantii Federeeshinii Atleetiksii Ityoophiyaa eenyu jedhamtu	Person
14	Dhalattuu Ityoophiyaa lammummaan Hoolaand kan taatee Atileet eenyu jedhamtii	Person
15	Ministir Deetaan Tajaajila Kominikeeshinii mootummaa eenyu	Person
16	Preezdaantiin Baankii Misooma Itiyoophiyaa eenyu jedhamu	Person
17	Hogganaa Itti Aanaan Biiroo Fayyaa Oromiyaa eenyu jedhamu	Person
18	Ministirri Ministeera Maallaqaa eenyu jedhamu	Person
19	Ministiri Deettaan Ministira Maallaqaa eenyu jedhamu	Person
20	Ministirri Ministeera Fayyaa eenyu jedhamu	Person
21	Hojii Raawwachiisaa Olaanaan Baanki Awaash eenyu jedhamu	Person
`22	Daayrektarri Toannoo Bankii Biyyaalessaa Ityoophiyaa eenyu jedhamu	Person

23	Daayreektarri gabaa fi maamilaa Baankii Daashan eenyu jedhamu	Person
24	Preezdaantiin Baankii Daladala Ityoophiyaa eenyu jedhamu	Person
25	Preezdaantiin Mana Maree Waliigalaa Dhimma Islaamummaa Ityoophiyaa eenyu	Person
26	Itti aanaan Preezdaantii Baankii Intarnashinaalii Oromiyaa eenyu	Person
27	Muummeen Ministiraa FDRI eenyu	Person
28	Biiroo Fayyaa Magaalaa Finfinneetti daayreektarri tajaajila meedikaalaa eenyu jedhamu	Person
29	Chaayinaatti Ambaasaaddarri Ityoophiyaa eenyu	Person
30	Ityoophiyaatti Ambaasaddarri Chaayinaa eenyu	Person
31	Hogganaa Ittaanaan Mana Amantii Ortodoksii Itoophiyaa eenyu jedhama	Person
32	Daayreektarri olaanaan Dhaabbata Fayyaa Idil Addunyaa eenyu jedhamu	Person
33	Ministir Deetaan Ministeera Fayyaa eenyu jedhama	Person
34	Leenjisaan fiigicha dheeraa eenyu	Person
35	Ministirri Ministeera Hojii fi kalaqaa eenyu jedhamu	Person
1	Fiigicha fageenya 5KM Faransaay magaalaa eessatti gaggeeffamee	Place
2	Itti Aantuun kantibaa magaalaa Finfinnee aadde Adaanach Abeebeen guyyaa yaadanno wareegamtootaa Gurraandhala 12 sababeeffachuun eessa dawwatan	Place
3	Atileet Shuraa Qixxaataa Maraatoonii 2020 fageenyaa sa'aatii 2:05:41 eessatti injifatee	Place
4	Atileet Sisaay Lammaa dorgommi Maraatoonii dhiiroota 2021 har'a gaggeeffamee eessati injifate	Place

5	Fiigicha Maaraatoonii 48ffaa har'a eessatti gaggeeffame	Place
6	Ayyaanni Iid Alfaxiir waggaa 1443ffaan eessatti gaggeeffame	Place
7	Atleet Sanbaree Tafariin fiigicha daandirraa walakkaa Maaraatoonii eessatti injifatee	Place
8	fiigicha kiiloo meetira kudhan Ameerikaa magaalaa eessatti gaggeeffame	Place
9	Sagantaan Deemsa miilaa fi Biskileetaa akka naannoo Oromiyaatti ganama har'aa haala hoo'aa ta'een dorgommiiwwan Ispoortii garaagaraa waliin magaalaa eessatti gaggeeffamee	Place
10	Tapha gulaallii Waancaa addunyaa har'a Afrikaa Kibbaa Istaadiyeemii eessatti gaggeeffame	Place
11	fiigicha Maraatoonii Abbabaa Biqilaa 38ffaa Magaalaa eessatti gaggeeffame	Place
12	Dorgommii seekaafaa umrii waggaa 23 gadii qopheessummaa eessan gaggeeffame	Place
13	Dhaabbanni USAID deeggarsa meeshaalee garaagaraa Birrii miiliyoona 6.4tti tilmamamu eessaf laatee	Place
14	Dorgommiin fi agarsiifni Teeknooloojii, kalaqaa fi qorannoo bara 2013 naannoo eessatti gaggeeffame	Place
15	Diidiyar Diroogbaan hoospitaalasaa magaalaa eessatti argamu	Place
16	Dhibeen Maariyyee jedhamu Jaldeessarraa namatti darbu biyyoota eessatti	Place
17	Dorgommii Shaampiyoonaa Atileetiksii Addunyaa 18ffaa Ameerikaa eessatti gaggeeffame	Place
18	Dorgommiin Beetkiingii Priimayeer Liigii Ityoophiyaa marsaa 3ffaan magaalaa eessatti gaggeeffame	Place
19	Dorgommiin Liigii Kubbaa Miilaa Dubartoota Oromiyaa Marsaa 3ffaan kaleessa Magaalaa eessatti gaggeeffame	Place

20	Dorgommiin Maaraatoonii Riilee Ityoophiyaa 17ffaan Magaalaa eessatti gaggeffame	Place
21	Fiigicha Maaraatoonii idil Addunyaa bara 2022 Kooriyaa eessatti gaggeeffame	Place
22	Baankiin Siinqee waltajjii tajaajila baankii guutuu kennuu eegaluufi mallattoo daldalaa haaraa itti beeksisu hoteela eessatti gaggeeffame	Place
23	Shaampiyoonsi Liigii Biyyoota Bahaa fi Giddugaleessa Afrikaa qopheessummaa eessan gaggeeffame	Place
24	Gareen kubbaa Miillaa Afrikaa Kibbaa magaalaa eessa argamu	Place
25	Gareen shororkeessaa ABUT warshaalee fi galteewwan magaalaa eessatti saamee	Place
26	Jilli Atleetiksii Ityoophiyaa Shaampiyoonaa Atleetiksii Addunyaa umrii waggaa 20 gadii injifannoon golobe galgala kana eessa galan	Place
27	Jilli Ministira Ministeera Fayyaa Dooktar Liyaa Taaddasaatin durfamu magaalaa eessa galan	Place
28	Jilli Ministira Ministeera Daldalaa fi Walitti Hidhamiinsa Naannawaa Obbo Gabremasqal Caalaan durfamu buufataalee furdisa Loonii eessa dawwatan	Place
29	Jilli Atleetiksii Ityoophiyaa marsaa 3ffaan halkan eda gara eessa galan	Place
30	Jilli Atleetiksii Ityoophiyaa Shaampiyoonaa Atleetiksii Mana Keessaa Beelgireed 18ffaarratti hirmaate eessa galan	Place
31	Yaa ii Waliigalaa dhaabbata Fayyaa Addunyaa 75ffaa eessatti gaggeefame	Place
32	Ityoophiyaan oomishaalee akka muuzii, avokaadoo fi maangoo akkasumas oomisha foonii gara eessa erguf	Place
33	Jilli abbaa qabeenyaa Saa ud Arabiyaa Sheehi Hamzaan durfamu eessa galan	Place

34	Jila Atleetiksii Ityoophiyaa Shaampiyoonaa Addunyaa umrii waggaa 20 gadii Kolombiyaa magaalaa eessati gaggeefame	Place
35	Jilli Ministira Ministeera Daldaa fi Indaastirii obbo Malaakuu Allebaliin durfamu naannoo Indaastirii salphaa eessa dawwatan	Place

Annex

Source code for speech recognition

package AAFSQA;

import java.io.IOException;

import java.util.List;

import java.util.concurrent.ExecutorService;

import java.util.concurrent.Executors;

import java.util.logging.Level;

import java.util.logging.Logger;

import javax.sound.sampled.AudioSystem;

import javax.sound.sampled.Port;

import edu.cmu.sphinx.api.Configuration;

import edu.cmu.sphinx.api.LiveSpeechRecognizer;

import edu.cmu.sphinx.api.SpeechResult;

import edu.cmu.sphinx.result.WordResult;

public class Main {

private LiveSpeechRecognizer recognizer;

private Logger logger = Logger.getLogger(getClass().getName())

private String speechRecognitionResult;

private boolean ignoreSpeechRecognitionResults = false;

private boolean speechRecognizerThreadRunning = false;

```
    private boolean resourcesThreadRunning;
    private ExecutorService eventsExecutorService = Executors.newFixedThreadPool(2);
    public Main() {
        logger.log(Level.INFO, "Loading Speech Recognizer...\n");
        // Configuration
        Configuration configuration = new Configuration();

        // Load model from the jar
        configuration.setAcousticModelPath("resource:/accoustic/");
        configuration.setDictionaryPath("resource:/oromoLM/nuguses.dic");
      configuration.setLanguageModelPath("resource:/oromoLM/weathers.lm");
```

Sourcecode of QAS

```
package qa.all.afaanoromoo;
import java.io.File;
import java.text.NumberFormat;
import java.util.ArrayList;
import java.util.Date;
import java.util.HashMap;
import java.util.Iterator;
import java.util.List;
import java.util.StringTokenizer;
import java.util.Vector;
import javax.swing.JOptionPane;
import org.apache.lucene.analysis.Analyzer;
import org.apache.lucene.analysis.TokenStream;
import org.apache.lucene.document.Document;
```

```
import org.apache.lucene.queryParser.QueryParser;
import org.apache.lucene.search.Hits;
import org.apache.lucene.search.IndexSearcher;
import org.apache.lucene.search.Query;
import org.apache.lucene.search.ScoreDoc;
import org.apache.lucene.search.TopDocs;
import org.apache.lucene.store.Directory;
import org.apache.lucene.store.FSDirectory;
public class AQAMain extends javax.swing.JFrame {
    private static final long serialVersionUID = 1L;
        public String questiontype;
    public static String Queryword = null;// the analyzed query word accesible

        public AQAMain() {
      this.questiontype = null;
                initComponents();
        }
private void AnswerActionPerformed(java.awt.event.ActionEvent evt)
                        throws Exception {
                jTextArea2.setText("");
                jTextArea3.setText("");
                TAmarachmelis1.setText("");
                TAmarachmelis2.setText("");
                TAmarachmelis3.setText("");
                TAmarachmelis4.setText("");
    File indexDir = new File("SEIndexes ");
                QueryGenerator qgen = new QueryGenerator();
                AnalyzeQuestion an = new AnalyzeQuestion();
```

```
        DocumentNormalization dn=new DocumentNormalization();
        if (jTextArea1.getText().equals("")) {
                JOptionPane.showMessageDialog(null, "Please Enter a Question!!!.");
        } else {
                questiontype = an.AnalyzedQuery(dn.NormalizeQuery(jTextArea1.getText()));
                if (questiontype == null) {
                        JOptionPane.showMessageDialog(null, "Not Factoid Question!!!.");
                        jTextArea1.setText("");
                } else {
                        String q = qgen.QueryExpand((jTextArea1.getText()));
                         q= "\""+q+"\"";
                        Queryword = q;
                        if (!indexDir.exists() || !indexDir.isDirectory()) {
                                throw new Exception(indexDir
                                                + " does not exist or is not a directory.");
                        }
                        search(indexDir, q);
                }
        }
}
```