BRAILLE to TEXT CONVERSION FOR AFAAN OROMO USING DEEP LEARNING TECHNIQUES

WONDUWOSEN GUDISA DISASA

A Thesis Submitted to Department of Computer Science and Engineering

School of Electrical Engineering and Computing

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Computer Science and Engineering (Artificial Intelligence)

Office of Graduate Studies

Adama Science and Technology University

OCT 11, 2022

ADAMA, ETHIOPIA

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Advisor: Teklu Urgessa (Ph.D)

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Declaration Proportional

I hereby declare that this Master Thesis entitled "**Braille to text conversion for Afaan Oromo Using Deep Learning**" is my original work. That is, it has not been submitted for the award of any academic degree, diploma, or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Name of the Student	Signature	Date

Recommendation

I/we, the advisor(s) of this thesis, hereby certify that I/we have read the revised version of the thesis entitled "**Braille to text conversion for Afaan Oromo Using Deep Learning**" prepared under my/our guidance by **Wonduwosen Gudisa Disasa** submitted in partial fulfillment of the requirements for the degree of Mater's of Science in **Computer Science Engineering**. Therefore, I/we recommend the submission of the revised version of the thesis to the department following the applicable procedures.

___________________________	________________________	________________
Major Advisor	Signature	Date

Approval Sheet

I/we, the advisors of the thesis entitled "**Braille to text conversion for Afaan Oromo Using Deep Learning**" and developed by **Wonduwosen Gudisa Disasa**, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Major Advisor	Signature	Date
Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis **Wonduwosen Gudisa Disasa** have read and evaluated the thesis entitled "**Braille to text conversion for Afaan Oromo Using Deep Learning**" and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Computer Science Engineering

Chairperson	Signature	Date
Internal Examiner	Signature	Date
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External Examiner	Signature	Date

Finally, approval and acceptance of the thesis are contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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Date

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LIST OF ALGORITHMS

LIST OF ACRONYMS

AI	Artificial Intelligence
ANN	Artificial Neural Networks
CNN	Convolutional Neural Network
Colab	Collaborator
GPU	Graphics Processing Unit
KNN	K-Nearest Neighbors
ML	Machine Learning
SVM	Support Vector Machine
TPU	Tensor Processing Unit
WHO	World Health Organization
OBR	Optical Braille Recognition
PCSA	Proportional Character Segmentation Algorithm
BMP	Bitmap Image File
Mb	Megabyte

ABSTRACT

In the year in 1825, Louis Braille created the Braille writing system, the preferred written communication system for the visually impaired around the world. Since its introduction in Ethiopia in 1986, a large number of Afaan Oromo Braille documents have been produced.

In this study, an attempt was made to explore the possibility of creating OBR (Optical Braille recognition) system for real-life single-sided Afaan Oromo Braille documents.

Assistive Braille technology has existed for many years intending to help visually impaired people perform common tasks such as reading, writing, and communicating with others. Such technologies aim to help the visually impaired better adapt to the visual world. However, there is a clear gap in current technology for balanced two-way communication between visually impaired and sighted people, as little technology allows non-visually impaired people to understand the Braille system.

This study presents the paper in this language using convolutional neural network (CNN) model and Proportional Character Segmentation Algorithm (PCSA) to convert Braille images into Afaan Oromo text. In addition, a new dataset containing of 23,000 labeled Braille images consists of 37 Braille characters, including letters, punctuation and numbers corresponding to 71 different Afaan Oromo class.

The performance of the convolutional neural network model gave a prediction accuracy of 96% on the test set. The functionality performance of this artificial intelligence (AI) based recognition system can be tested in the future with an accessible user interface.

Key words: *Proportional Character Segmentation Algorithm (PCSA), convolutional neural network (CNN), artificial intelligence (AI).*

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Globally our modern world is built on our ability see. Without vision, many of us world struggle to learn, to read, to participate in school, find work and to live life to the fullest. Today, 2.2 billions of people have vision impairment and of these, at least currently there are 1 billion people include those with moderate or severe distance vision impairment or blindness (WHO, W.H.Orginization, n.d.). Even though limited literature is found in Africa, some studies are shows that approximately 26.3 million people in the African Region have a form of visual impairment. From the above-mentioned, 5.9 million are estimated to be blind and 20.4 million have low vision It is estimated that 15.3 percent of the world's blind live in Africa. (WHO, world health, 2019). 1.6 - 4.2% of the population is blind/ visually impaired. In Ethiopia, the prevalence of blindness is 1.6% (1.1% for urban and 1.5% for rural populations) and that of low vision is 3.7% low vision means partially impaired (2.0% for urban and 1.7% for rural populations) (Yemane, 2007).

As National Survey on Blindness, Low Vision and Trachoma in Ethiopia Overall the burden of eye problems in Ethiopia is huge. As shown in Table 21 about 1.2 million people are blind; 2.7 million people are living with low vision; over 9 million children are affected by trachoma; and over 1.2 million adults are suffering from Trachomatous trichiasis (TT) (National Survey on Blindness, 2006).

Table 1 Ethiopian Public Health Association report in 2006

Number of Blind Person	1 200 456
Number of individuals having low Vision	2 776 054
No of Children having Active Trachoma	9 034 931
Number of individuals with Trachomatous trichiasis	1 255 977
Number of Blind Person due to avoidable causes	1 049 198
Number of Blind Person due to cataract	600 228
Number of individuals having Low vison due to cataract	1 174 271
Number of individuals having Low vison due to Refractive error(individuals needing spectacle)	960 515

Writing by us is very important to put once an idea, personal feeling, thought, and to keep record of personal memoir. However here is a problem to read and write a printed text by the visually impaired individuals. Its widely known that visually impaired/blind persons use Braille to read, write, and communicate with each other and with those who can understand it.

In the early 1800s, Charles Barbier who served the French army was developed a night readable system known as “night writing”. The system is on a raised 12-dot cell; two dots wide and six dots tall (works, n.d.). In the 1824s, Louis Braille, develop the French Braille alphabet as an improvement on night writing (H.Works, n.d.).

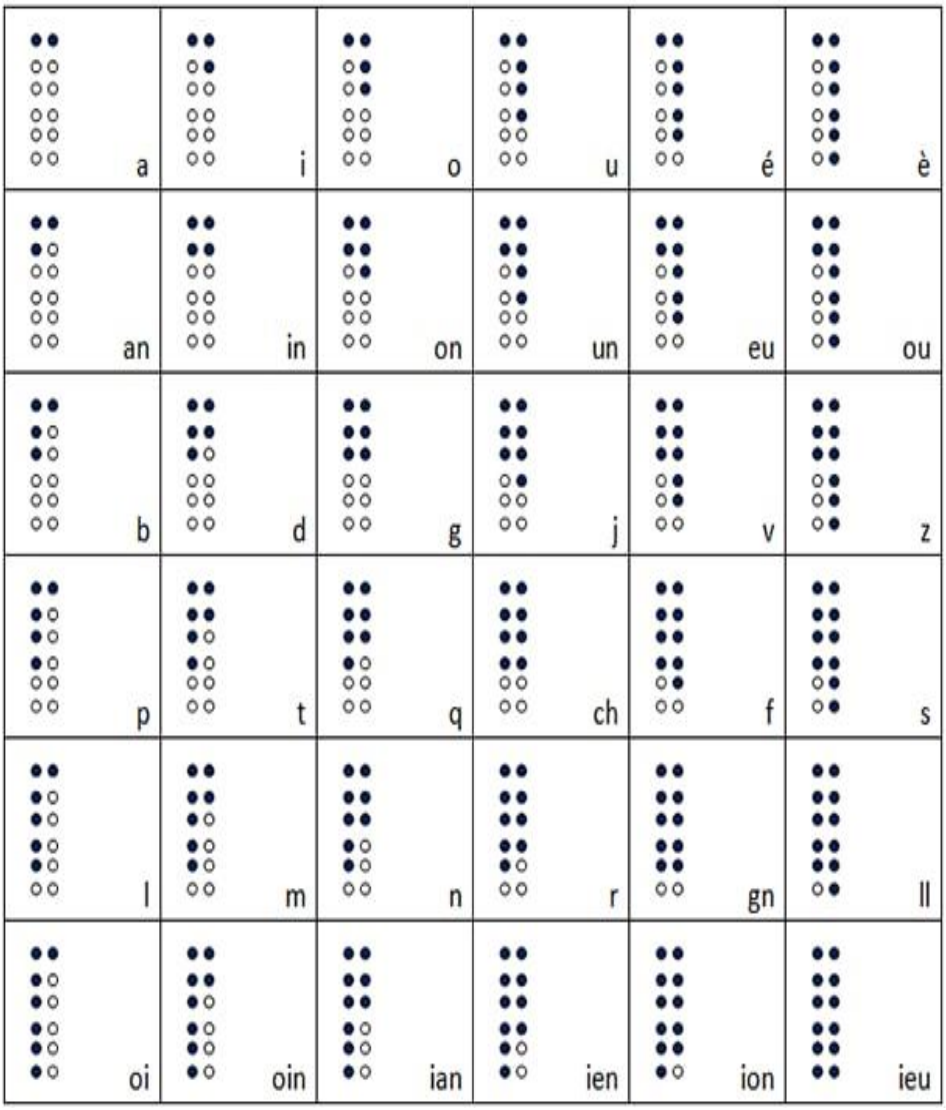

Figure 1 Charles Barbier’s Sonography Table, also known as “Night Writing”. Photo source:

Braille code is a system of writing which enables visually impaired individuals to read and write Braille document by touching from left to right. The Braille file contains a set of braille cells and each cell has consisted of six dots in the vertical two dots and horizontal three dots (Shreekanth, 2018).The braille dot represents $\mathbf{2^6}$ = **64**-character, one braille cell represent more than one character. The arrangement of the Braille cells six dots has a unique number to identify the dot positions in the cell by the following orders 1, 2, 3, vertical downward on the left side and 4, 5, 6 verticals downward on the right side, as shown in Figure1.

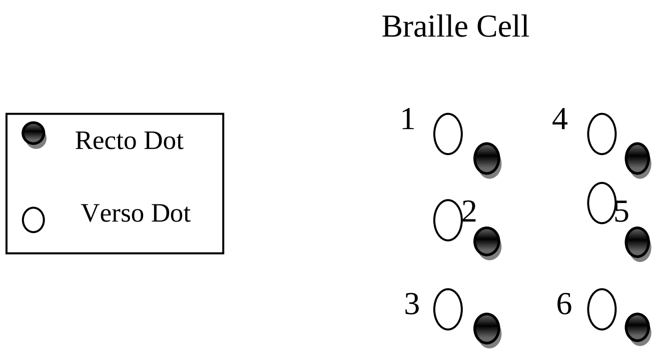

Figure 2 One Braille Cell Representation

The Braille system has three Braille Code Versions Grade 1, Grade 2, and Grade 3. The Grade 1 Braille represents each print character as one Braille cell which is a form of Shorthand where group of letters may be combined in to a single Braille cell (American Council of Blind, 2006).The Braille system has a low number information size in the paper compared with the natural language characters. A grade 2 Braille system is introduced to minimize the size taken by grade 1 Braille system. In grade 2 Braille, the Braille system has all elements of the Grade 1 Braille version and the addition of abbreviations and contractions (American Council of Blind, 2006).

The final type is grade 3 Braille, which is used for personal stenography, uses a nonstandard form of braille system. It contains more than 300 words of contractions and uses to the omission of a vowel (American Council of Blind, 2006).

Braille's first introduction to Ethiopia in 1924 (Yibeltal, 2012). In 1934 by missionaries designed the Amharic Braille alphabet by taking the 26 English Braille characters and creating new 8 Braille characters. in Addis Ababa was opened the first residential school for the blind in 1952. In 1957, a group of ten students with blindness presented a petition to the prime minister for official recognition of braille as writing and reading system (Yibeltal, 2012).

The dimensions of a Braille dot have been set according to the tactile resolution of the person's fingertips. The horizontal and vertical distance between dots in a character and the distance between cells that represent a word are known. Dot height is approximately 0.02 inches (0.5 mm); the horizontal and vertical spacing between dot centers within a Braille cell is approximately 0.1 inches (2.5 mm); the blank space between dots on adjacent cells is approximately 0.15 inches (3.75 mm) horizontally and 0.2 inches (5.0 mm) vertically. A standard Braille page is 11 inches by 11.5 inches and typically has a maximum of 40 to 43 Braille cells per line and 25 lines (Tahboub, 2015).as shown in Figure

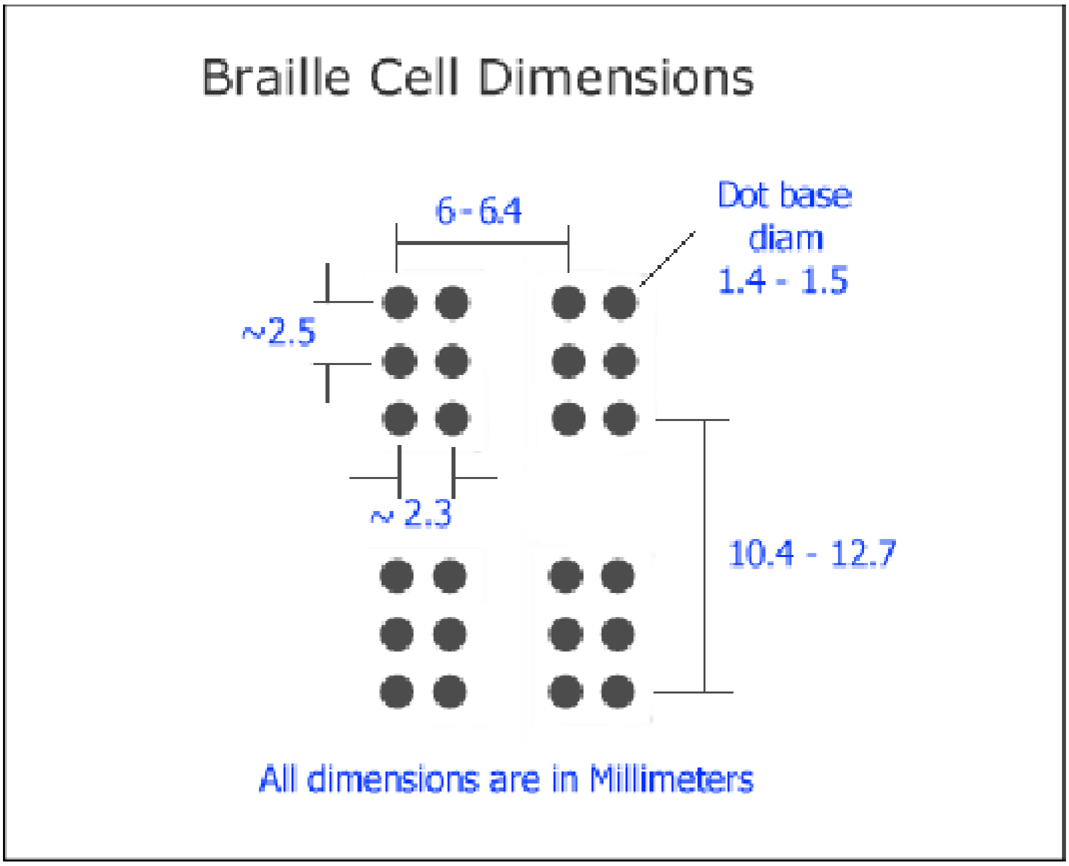

Figure 3 Braille Cell Dimension

Afaan Oromo braille words writing skills of blind student's skills, schools need to provide more skill trainings, sufficient support, educational about students' Braille reading and writing skills with teachers in Sebeta arrangements of dots which make up letters of the alphabet, numbers, and punctuation marks. As to the recognition of Amharic braille documents, two researches have been attempted by Alemu (ALEMU, 2009).and Chekol (American Council of Blind, 2006). Alemu has adopted a global-threshold technique for image finalization and applied mesh grid construction for the purpose of both segmentation and feature extraction. For recognition, Alemu used neural-network classification technique. Alemu achieved an accuracy of 92.5% on clean or well-formed braille documents. Chekol"s work is basically a continuation of Alemu"s work though he mainly focused on the pre-processing partnamely, noise detection and removal. Chekol achieved an accuracy of 95.5%, 95.5%, 90%, and 65% for clean, small-level noise, medium-level noise, and high-level noise braille documents respectively.

In Ethiopia, mainly in Addis Ababa, there are different education centers, such as AAU, Misrach Center, Entoto Blind people school, for visually impaired people at primary, secondary and tertiary levels. As a result, there has been a massive Braille documents (i.e. educational) produced and used by visually impaired people. But there is a gap in communication through documents between vision and visually impaired people.

1.2. Motivation of the study

Although the school for the blind was opened for Afaan Oromo Braille in 1982 around Sebeta, there is nothing to prevent Generate Proportional Gap between visually impaired and sighted people in Afaan Oromo language. The motive behind the research is that in our country there are a lot of visually impaired individuals who are engaged in different occupations and professions in private and public sectors. The documents and labels that are constructed and used by the visually impaired are not simply understandable by the majority of the sighted population, thus creating a gap of information and an imbalance in society in communication flow. As someone who is in a close relation with the visually impaired individuals, this study was conceived by considering any difficulties that an impaired individual or their close acquaintances may encounter daily.

In other direction my motivator to initiate me to identify this gab by Haben Girmas initiation Haben is short as follows

Haben Girma, the first deafblind person to graduate from Harvard Law School, is a human rights lawyer who promotes disability justice. President Obama named her a White House Champion of Change. She has received the Helen Keller Achievement Award, a spot on the Forbes 30 Under 30 list, and TIME100 Talks. President Bill Clinton, Prime Minister Justin Trudeau, Chancellor Angela Merkel have expressed their respect for Haben. Haben believes disability is an opportunity for innovation, and teaches organizations the importance of choosing inclusion. The New York Times, Oprah Magazine and the Today Show have featured her memoir, Haben: The Deaf Woman Who Conquered Harvard Law.

Parents of visually impaired child that struggle with understanding their child's braille system for reading and writing may have trouble communicating with and teaching their children and would likely benefit from having easily accessible OBR technology. Moreover, with the help of portable OBR systems, sighted staff's members working at institutes with the visually impaired individuals will have a more effortless time in understanding the resources used by the visually impaired. As such, this braille system has the potential to be useful in decreasing asymmetric communication that any non-visually impaired individual may face when trying to assist a blind individual (B M.Hsu, 2004). The technological devices need to be used to enhance Braille and no longer to change it. This point of view encourages that all blind students who have access to other technology also need knowledge of Braille skills for them to reach their most level of literacy and self-sufficiency (Mitiku, 2020.).

1.3. Statement of the Problem

In Ethiopia, there are a lot of visually impaired individuals who are engaged in different occupations and professions in the private and public sectors. The documents and labels that are constructed and used by the visually impaired are not simply understandable by the majority of the sighted population, thus creating a gap of information and an imbalance in society in the communication flow. For instance, an impaired student in college or university has difficulties taking exams by themselves without assistance to read them aloud the given questions. Parents of the visually impaired child that strive in understanding their child's braille system for reading and writing may have trouble communicating with and teaching their children and would likely benefit from having easily accessible Optical braille recognition (OBR) technology. Moreover, with the help of portable Optical braille recognition (OBR) systems, sighted staff members working at institutes with visually impaired individuals will have a more effortless time in understanding the resources used by the visually impaired. As such, this braille system has the potential to be useful in decreasing asymmetric communication that any non-visually impaired individual may face when trying to assist a blind individual (Hsu B.-M. , 2020) al. The technological devices need to be used to enhance Braille and no longer to change it. This point of view encourages that all blind students who have access to other technology also need knowledge of Braille skills for them to reach their most level of literacy and self-sufficiency

Braille is one type of communication for visually impaired individuals. Blind individuals are around 1.6% of Ethiopia's population, the first version of Braille is introduced in 1934 until now several Braille documents are created by different individuals in different professions teachers, students, artists, lawyers, and also employees who have a significant contribution to politics, religion, economic music and art, and social affairs of the social organizations. The documents can be found in Addis Ababa University Kennedy Library, Misrach Center, Sebeta Visually Impaired School, Ethiopian National Association of the Blind (ENAB), German Church Visually Impaired School, Entoto Blind People School, and in a different part of the country. Only those who can read and write Braille systems gain access to their Knowledge. This has created a wide generation gap between the visually impaired and the sighted society. Digitizing these documents not only facilitates the communication with visually impaired but also helps the preservation of historic Braille documents.
Braille is a simple, convenient, and highly accessible way of communication for the visually impaired society. Afaan Oromo has used English alphabet but Afaan Oromo has its own language rule A/Oromo Braille's representation has different than English Braille representation in Grade 1 Braille,

1.4. Research Questions

RQ1: - What are constraints to improve the Braille image-to-Text translation?
RQ2: - What kind of preprocessing techniques are required to prepare the dataset for recognition?
RQ3: - Which classifier is suitable to design a general model for Afaan Oromo Braille conversion?
RQ4: - What is the performance of the selected model?

1.5. Objective of the Study

In line with the above statement of the problem the following general and specific objectives are formulated to clarify the intent of the present research.

1.6. General Objective

The general objective of this research is to designing and developing Braille to text conversion model for Afaan Oromo Language.

1.7. Specific Objective

- Review previous work on the braille system in Afaan Oromo and other Languages and different methods of the conversion system.
- Collection of relevant Afaan Oromo braille documents.

- Identify special features of single-sided braille characters in character image recognition
- Analysis of the nature and characteristics of Afaan Oromo braille code.
- Designing an algorithm for the Afaan Oromo braille recognition system.
- Developing a prototype for the Afaan Oromo braille recognition system.
- Testing and evaluating the performance of the system using Afaan Oromo braille documents.
- Making conclusion and indicating the way forward for future works.

1.8. Scope and Limitation

- This research conducted a fourth version Grade 1 Afaan Oromo Braille hand punched and machine punched single side Afaan Oromo Braille. This study does not include Grade 2 and Grade 3 Afaan Oromo Braille versions.
- Lack of dataset on Afaan Oromo Braille Image.

1.9. Significance of the study

This study will provide better understanding about the Proposal of OBR System. It is important to the sense that is explores the major problems encountered by the visually impaired society.

1.10. Organizations of the Study

The paper is organized into five chapters. The first chapter presents the current research problem and its objectives of the study and approved methodologies. In the second chapter, an attempt was made to review the literature in Afaan Oromo braille system, braille character traits and braille recognition characteristics. Audit Relevant research work in the field of Braille problem is also discussed along with the techniques used. The chapter Three discusses the basic components and issues in the application of an artificial neural network. the fourth chapter Reports of experimental results of research. The experiment mainly consists of two parts: Part One It mainly includes image pre-processing, segmentation and feature extraction, and the second part It consists of the recognition phase which mainly includes training; Building and validating models in addition to analyzing and interpreting the results. Finally, concluding observations and recommendations for Future research is directed.

Chapter Two: Explain the background literature and related works regarding text encoding, attention mechanisms, and image to text translation. This chapter also explains the theoretical framework of machine learning, and Deep Learning.

Chapter Three: Explain research methodologies such as data collection methods, data preprocessing, design tools, development frameworks, and platforms, and evaluation methods are also discussed.

Chapter Four: Explain the proposed model architecture in detail. Model Architecture, Braille image encoding method, implementation and models mathematical correspondent descriptions have been made.

Chapter Five: Explains how the desired proposed model is implemented. and the working environment setup, spatial-channel aware CNN implementation, with training implementation, described using snip code. Experimental classes are also discussed.

Chapter Six: describe the desired proposed solution findings, compare the new result with the prior solution, and explain the meaning of the findings.

Chapter Seven: Concludes the research and gives bearings to conceivable future work.

CHAPTER TWO

2. LITERETURE REVIEW AND RELATED WORKS

In this chapter we will look at some of the topics related to the Braille system in general, and the Afaan Oromo Braille system in particular. Braille recognition systems using image processing techniques, applied tools and techniques they are presented at each level of accreditation system.

2.1. Introduction

Related literature or articles on Braille Recognition include books, magazine articles, conference papers, magazines, and the Internet. This is done to understand different OBR technologies, techniques and algorithms to solve problem domains related to other languages. A literature review is conducted on automatic Braille recognition to obtain an in-depth understanding of the area and to find useful approaches for the Afaan Oromo language Braille recognition.

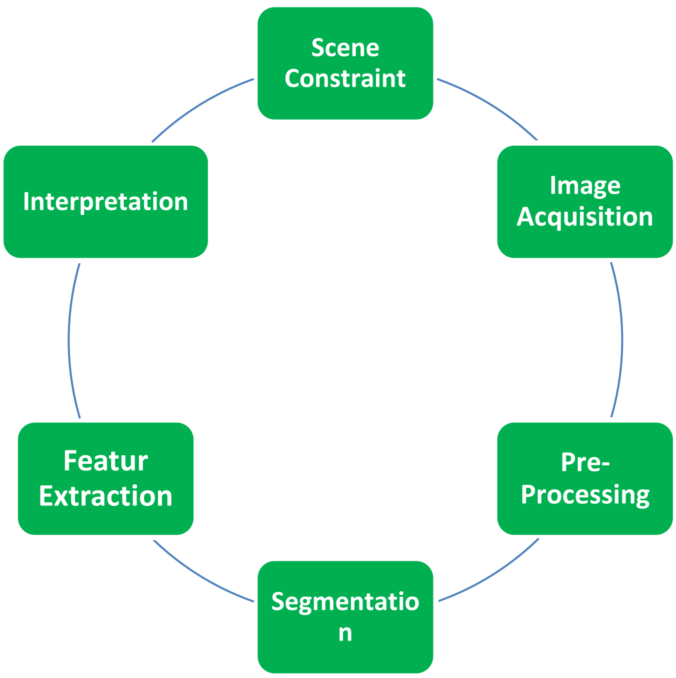

Figure 4 Braille Recognition Process

2.2. History of Braille

“Braille” began as a system of reading for the blind, where you would run your fingers across written letters of the alphabet, but this proved to be inefficient. It wasn’t until the early 1800s when Charles Barbier answered the call from Napoleon, the French military leader that Braille really began to take shape. Napoleon wanted a way for his military units to communicate without speaking and without using torchlight at night, and Barbier got to work on finding a way to make this possible.

Originally recorded for the Blind Script It was created around 1517.Francisco Lucas, of Saragossa, who invented a simple set of letters inscribed with thin plates Wood. This was later modified by the Roman Rampansetto in Italy around 1575. Instead of elevating the writing style, he turned it into larger blocks. in spite None of the systems were successful because of the difficulty of writing and reading. A.D. In 1651, Nuremberg's Georges Hard sorfer revived the traditional style of wax writing Tablets for the blind by cutting letters with a stylus. Twenty-five years Later, Pardera Terzi invented the same secret code based on a closed point system in the square. And other images as well as the layout of notes tied in strings. There were many. Attempts to create a method of writing and reading using other moving letters Pencil, tin and cast iron. The problem with such systems was that the letters were difficult to touch and difficult to model (C. Mackenzie, 1954).

Another previous effort was Maria Teresa von Paradise, an Australian Musical Actor and composer who helped Valentine Hayun establish a school for the blind with the help of a pin attached to a pillow, he established a system of teaching the blind. However, Founded in 1784 by the Valentine School of Paris School. First Student Frances Lesher Coincidentally, he can hear the "O" character details that appear strongly. Surprised on paper. Haw later tried to write books to teach the student. His The student made rapid progress and the system was a great success. However, it was not until 1825 that Louis Braille invented this script and invented the system that is blind to reading today. However, Braille practice was not limited to fifty years It was internationally accepted and in the Middle Ages, there were several other types of sculptures Planned and used; hiring some lines and points, others have a simpler look Roman capitals (C. Mackenzie, 1954).

Although Luis Braille originally wrote the text for Braille. Its system has been modified in many other countries. As a description of mathematical and chemical symbols, of Wrist watches, meters, thermometers and playing cards and also be listing geographic maps and plans for cities and buildings (A. Papandreou and B. Gatos, 2015) (C. Mackenzie, 1954).

2.3. Single Side Braille

Braille characters are often drawn from the top to the bottom of the document. Such as printed documents. Braille documents can be decorated with single or double dots. Braille documents are so large that it is important to use both side Sheet. But this is not the case with Afaan Oromo Braille.

2.4. Afaan Oromo Writing and Braille System

Braille code allows blind and partially sighted people to touch and read and write. People often misinterpret Braille as their own language. But, the reality is that Braille is a special language reading and writing system that does not need to be seen. Available in a variety of languages, including English, French, Spanish, Chinese, German, Arabic, Italian, and Hebrew. This section briefly discusses the characters used in Afaan Oromo language followed by an introduction about braille writing and reading with special focus on Afaan Oromo language**.** considered in adopting Braille to local language are the following

- Different languages should have similar Braille code. This is aims in simplifying the international publication, to avoid difficulties for those who are blind and interested to study different languages, and to create common understanding among blind society in the world.
- Languages that have the same sound or related languages that are similar in sound, in character number and type should have similar Braille code structure.

2.4.1. Afaan Oromo Characters

Oromo language is one of the Cushitic languages (such as Somali, Afar, Sidama, Geedo, and ancient Egyptian), the language of the ancient Cush that was spoken all over East Africa. Today, Afaan Oromo is spoken in most parts of Ethiopia, some parts in Kenya and is arguably the second largest language in Africa.

Afaan Oromo is a phonetic language, which means that it is spoken in the way it is written. Afaan Oromo uses the Roman alphabet, but it has its own consonants and vowels. Afaan Oromo has 28 letters called ‘qubee’. However, a new letter ‘Z’ is now included in the alphabet as there are words which require letter ‘Z’. Therefore, now it is correct to say that Afaan Oromo has 29 letters called qubee. Examples of words with the letter ‘Z’ include Ziqaya (gold), Zeeytuuna (guava), Azoole (river in Arsii), Zeekkara (Opera), Awaazoo, Zalmaaxaya (mess), Waziiza (fire place or fire work) and Zawii (insanity).

Table 2 Upper Case = Qubee Gurgurda

A	**E**	**H**	**L**	**P**	**U**	**Y**
B	F	I	M	QR	V	Z
C	G	J	N	S	W	
D	H	K	O	T	X	CH
DH	PH	SH	SH	NY	TS	ZH

Table 3 Lower Case = Qubee Xixiqu

a	**e**	**h**	**l**	**p**	**t**	**x**
b	**f**	**i**	**m**	**q**	**u**	**y**
c	**g**	**j**	**n**	**r**	**v**	**z**
d	**h**	**k**	**o**	**s**	**w**	**ch**
dh	**ph**	**sh**	**sh**	**ny**	**ts**	**zh**

2.5. Application of the result

The application area of the study is to fill the communication gap between the sighted and visually impaired individuals in different areas of professions like education, banking, justice, Health and other occupations for those who work with the visually impaired and do not read or understand Braille, it will be useful in terms of enabling the society to benefit from the knowledge and experience of the visually impaired societies in a well-organized and dynamic way. The result of the study will make a significant contribution to bridging the communication gap between the two textually separated societies: the visually impaired and the visually impaired in the teaching and learning process, the field of work, Justice and art. in many cases, various organizations specifically refrain from hiring the visually impaired individuals because they would not have a way to communicate formally through a written document unless there He is the person who mediates between to copy what the visually impaired produce to him printed format. Students in different stages: primary, secondary and higher education will benefit from it The result. The finding also benefits the visually impaired lawyer in their work environment.

Accordingly, the government, NGOs and society at large will do so Benefiting from research, where research outputs contribute to the development of a practical application.

2.5. Automatic Braille System

The purpose of this paper is to provide an automated system for identifying and modifying Braille pages. To edit Braille documents into Afaan Oromo text. The proposed system in this study includes six Operation fetch scene restrictions, image acquisition, pre-processing, partitioning, feature and Interpretation (C. Ng and V. Lau, 1999).

The Braille detection system is believed to facilitate communication between views Weakened and visionary community. This system allows blind people to access it the visual community literature allows them to share and do their works at the same time save for future accessibility. In recent years much research has been done on the area. Braille recognition locally and internationally.

Before converting hard code braille to computer printable and printable text, ABR The system goes through many processes. The most common operational are image capture, Prerequisites, Braille point identification, Braille cell formation and interpretation. These major Processes are described below in terms of what researchers have done and recommended in recent years in the area.

- Manually using a handheld stylus (to make the impressions) and slate (to hold the paper) by physically pressing each dot into Braille sheet. Writing Braille with a slate and stylus compares to write with a pen or a pencil. The stylus used to push the dots down through the paper, while the slate serves as a guide. The speed of writing Braille with the slate and stylus is about the same as the speed of writing Braille with a pen or pencil. However, the speed and accuracy would depend both on the skill and experience of the user, and the frequency of the use.
- Mechanically with the Braille typewriter. This has one key for each of the six dots in a Braille cell.
- Electrically using Braille printer that attached to computer system. Increasingly, electronic Braille embossers are being used in governmental departments, organizations, schools and other education institutions to produce material in Braille. Although there are several models of electronic Braille embossers, the focus is based on the following points (Chekol, June 2010.):
    - The speed of the embossers in characters per second

- Whether the embossers allow for independent operation by users who are blind
- Whether the embossers have voice output menus
- Whether the embossers are able to produce large volumes of Braille
- Whether the embossers have the facility to produce graphic.

2.5.1. Image Acquisition

Any character recognition system starts with finding the document in the form of an image. The detection process can be done with a digital camera or scanner. Flatbed Scanner type is a preferred technology in many studies. The reason for this is a flatbed Scanners are cheap options that make it easy to create and produce the desired image. In a short time. Scanners are also widely used in OBR.

The first operation in any pattern recognition system is to obtain pattern data in OBR mode you will get a braille image. For any radiation detection the process of image quality has a big impact on the recognition result. Therefore, Care must be taken when choosing the digital equipment that will be used and the lighting that will be used Measurement selection. Finding images can be done with a scanner or with the help of Digital Camera

2.5.2. Preprocessing

Pre-processing is a technique used to create a unique character. Most The image captured at the image acquisition level is not digital but widely used It is scanned. As a result, the scan introduces a high level of image noise Solution. At this stage, the image is converted to a gray scale to reduce noise. In Adding Process Adjusts and edits the digital values of the digital image. Next jobs. The preliminary stage is a set of Proportional to be implemented. A series of changes to the image. This includes gray-scale conversion, geometry Adjust, adjust brightness, eliminate noise, double click and edge drawing Braille points.

Full color to Grayscale Conversion: Gray balance images are made in just one bit. Price. They lack chromatic information. They are also known as monochromatic Images. Image pixel values range from 0 to 255. It only shows light Info. The conversion algorithm is not a full color image to a gray image. Unique and each algorithm has its own applications (Jie Li and Xiaoguang Yan, , 2010).

Image Geometry Correction: Geometric correction (sometimes abbreviated geography) is the process of changing the X and Y dimensions of a distant image, thus eliminating or distorting the original image and the X and Y dimensions corresponding to the selected geographic reference system. Scanned images can be rotated or rotated. Translated. Geometric correction is intended to eliminate these effects and to bring all scanners. Braille document image to a common reference point.

Image Brightness Adjustment: Dark circles or bright spots may occur due to irregular scanning light or part of the document page. If left untreated, these areas can cause subsequent category errors.

Noise Removal/filtering: Noise is when an error occurred while obtaining an image. A process that produces pixels that do not reflect the true intensities of the real scene. This noise generally presents itself as a random variable of gray-level values It is loaded with "appropriate" gray-level values, and is usually high Frequency.

Digital images are prone to damage by different types of sound. Common sounds Some sounds are salty and peppery and loud (Qing Chen, 2003.). Noise of salt and pepper both black and white pressures contain randomly distributed events. Gaussian Noise contains variations of intensity derived from Gaussian distribution and a An excellent model for many types of sensor sounds caused by camera electronics error (Qing Chen, 2003.). Sound filtering aims to reduce the noise generated during image capture.

Researchers are trying to develop a variety of noise detection and pollution techniques. To minimize the effects of decay during the detection process. Some of these Gaussian filters are used by many researchers. Gaussian filter is a low pass filter. Who wants to minimize high frequency noise from the image while on Waiting for Braille points detailed edge information at the same time (T. Agui and T. Nagao, 1994.).

Edge Sharpening/enhancement: Edge enhancement is performed to improve or Strengthen the edges of the braille points. According to (C.M. Ng, 1999,) edge improvement mainly It focuses on the beautiful details of the blurred image.

2.5.3. Segmentation

It is a process of distinguishing fractional points from a braille image Categorized by cell (Ebrahim Chekol, June 2010). These cells are classified into characteristics, more than any other word Stroke in Braille. It is the lowest abstract level in braille detection. A single point that can have six alternative locations in a cell.

Analysis because Braille pages only contain points (front) and page (background) a Binary images are lighter than gray-sized images (C.M. Ng, 1999,) (Néstor Falcón, 2005.). However, the Digital Braille page images are noisy, and there are many broadcasts on the gray level. Values, default value choice has a problem. At this stage, the regions corresponding to the braille points in the image are identified. points can be identified as small communication elements. This feature works with one-sided braille. Documents encounter (F. Zahedi and R. Thomas, 1993).

There are a number of different splitting techniques that can be applied, especially in braille images, e.g. mesh-grid and environmental (Local) measurement. Location measurement is performed using dot pixel variation. Strength as a starting point. Because its produce different color levels above and below. On the other hand, a straight and build-based mesh grid work Horizontal grid on tightly braided cells. It is practical and widely used in Braille because the braille cells are arranged in a vertical and horizontal positioned document.

2.5.4. Feature Extraction

Behavior extraction is the process by which the first set of raw data is reduced to groups that are more manageable. The nature of these large databases is a variable that requires a large number of computer resources to process.

Behavior is a Braille image representation (Jie Li and Xiaoguang Yan, , 2010). The main one the function of this process is to extract braille points from binary images. The image the formatting, preparation, and distribution stages aim to make the image more relevant Various Behavior Algorithms. Some behavior algorithms only work. Some algorithms compute each pixel of the image. On the other hand, the background image may be affected by noise or blurred for other reasons.

2.5.5. Braille Dot Detection and braille cell

Braille dot identification is an important part of braille detection. Numerous studies (J.P. Dubus, 1988) Tried to use Braille dots with unique color characteristics in Braille image. Braille the dots tend to have a pair of dark and light regions, which is somewhat different Background in Braille image. Double-sided Braille document, Dark Order and The light regions vary in rectangle and contrast points representing depression and walking in order (Figure).

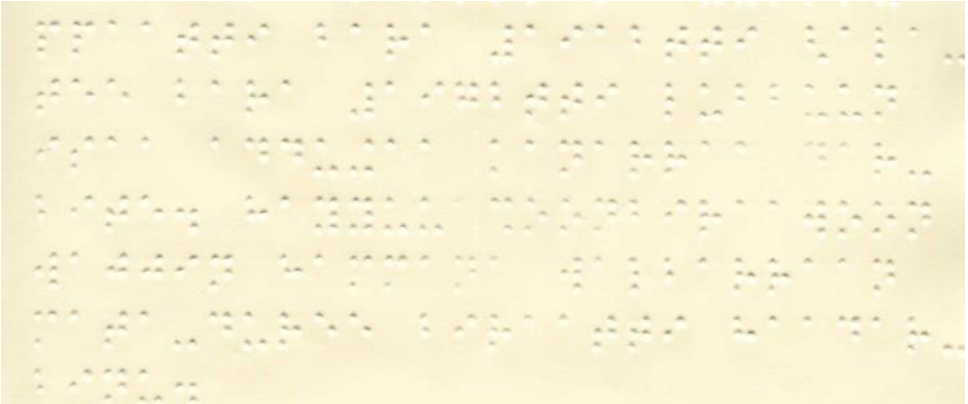

Figure 5 Single-sided RGB color braille image

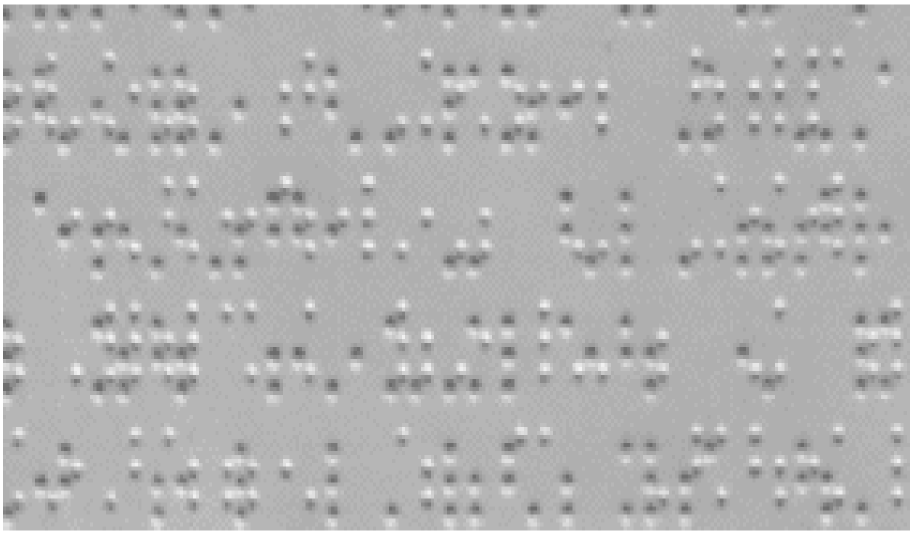

Figure 6 double-sided braille image

He used promotions and depression templates to identify points (both Front and rear) back. However, this seems to be a problem in a situation where there are dark and easy places of anxiety and stress Depression or anxiety disorder. Care must also be taken not to remove used black and white areas But that can also be used to describe depression because of white. Regions and black regions with prognosis and depression merged (J. Bhattacharya and S. Majumder, 2011).Similarly, Alsalman et al. (A. AlSalman, April 2012 Hammamet, Tunisia)

Implemented a possible top-down vertical search to confirm the presence of a pair of dot and black and light regions, if found in Accurate order, just like Braille dots.

Wong et al. (L. Wong, August 2004.) A different approach is used to identify columns (half characters). It may consist of one, two, or three points rather than contact with an individual. Points.

Half of the characters are drawn and assigned to one of the seven possible. Arrangements to be made from three possible points (neglected 16 "Empty Half Character") using a probable neural network. However, instead of applying Model, such as the neural network, makes predictions, point analysis simple Places give better results (A. AlSalman, April 2012 Hammamet, Tunisia). This is primarily because of the Braille meaning. An easy-to-find character can easily be converted to another real Braille character. Or the lack of points at the Braille point.

Menens et al. (J.Mennens, 1994) He used a method of constructing horizontal and vertical grid lines Crossroads where Braille points can be located. Braille cells they are then divided outside the built-in grid. This method, however, does not work be patient with the slightest difference between the positions of the braille characters Antonakoulos and Bridson (A. Antonacopoulos and D. Bridson, 3BX, United Kingdom) used a similar grid method Construction of the grid It does not require braille characters to be arranged in different lines in a specially designed way with relative flexibility.

If you have identified all the braille cell lines, Ritchings et al. (R.T. Ritchings, 1995) Divided braille cells inwards Each line is based on the analysis of the horizontal gap between the dots. They are two single-column characters and suggest caution Ambiguity can arise if both have points in the left column or in Right column. Braille points are grouped into braille cells by Wong and others. (L. Wong, August 2004.) by analyzing The distance between the point and the four possible neighbors.

Vision is the same feeling that we rely on above all others. It provides most of the information we receive from our environment. The eye that is the entrance It provides a double view of the visual information from the outside world to the brain More information for the brain than all other senses. Although the process It is very complex between the eye and the brain, visual perception and interpretation Movement usually takes place in ten seconds. There have been people over the last few decades they do a lot of work by trying to find machines. The machines were working lightly Mechanical works without any problems. However, for more complex tasks such as those required Sense of sight, the simplest thing for human beings, has always been very difficult for a machine Performance and calculation required. This fact is evident in behavioral recognition systems (A. Cheung).

Character recognition systems are used to modify characters in hard code documents Computer readable and editable text. One of these systems is Braille behavior recognition. It is a system that reads Braille documents and converts Braille characters into them. Reasonable text statements. This identification process is image-based Processing, artificial intelligence and computer vision capacity (WENDMU, june,2015)

Braille detection can be single-sided or double-sided, depending on the braille path. Document prepared. Unlike human recognition of objects as they are optical Detection systems work by minimizing the background of everything. This task in general and Braille recognition makes it very difficult. Especially with Double-sided documents where the dots on both sides are visible from one side, the dots Intensive bonding and single point separate Proportional is a challenge (WENDMU, june,2015)

The entire braille detection process is divided into five main functions. Get an image, Pre-processing, classification, characterization and interpretation. The identification process begins Getting a Braille document image with a scanner, digital camera or something else Digitization means. Digital images are already designed to filter out noise and clutter Information that is not useful for the accreditation process. They are different techniques.
From the pre-created image, it is applied to the part Braille points and forms a Braille cell. Finally, the properties of subdivided objects are used to translate text into the desired language Representation.
This study looks at the application of various braille detection techniques Convert Afaan Oromo Braille Documents to Afaan Oromo Print Characters. For this the purpose is to digitalis various approaches to Braille detection, such as image processing. Restrictions, partitions, behaviors, and recognition are evaluated.

2.6. Methods

Getting to know braille involves different image processing steps. It makes the search available diversified Techniques towards such a problem. As the main objective of the thesis is to adopt and/or elicit algorithms by learning about Afaan Oromo Braille, different methods of research are reviewed. Next part it describes the research methodologies used.

2.7. General Design of Braille Recognition

The overall design of the Afaan Oromo Braille recognition System is shown in Figure 4. Of the main focus of this work is highlighted by double rectangles.
The system can distinguish single-sided Afaan Oromo Braille documents. A series of steps to translate braille code characters into the same text representation They are needed. Braille detection systems, including data, on each character recognition system it is literally feeding into the system. Therefore, Afaan Oromo Braille documents are examples. Collected Braille document images were

obtained using a 200-pane scanner. The braille color images obtained by DPI are converted to gray scales. On the gray scale Such as noise filtering, intensity adjustment, volume reduction, Initial and morphological adjustments are performed. Before you double-click the image Partitioning, rectifying, and dot sorting is done using a moving window. Filter. The front and back dots are separated and placed into two binary images. Of Binary Braille images feed for enhanced fraction and feature output. Techniques. Finally, a search table is created based on which features are displayed. The literary features of Afaan Oromo are based on their representation.

2.7.1. Related Work

Relevant literature on OCR Braille recognition and conversion to print has been comprehensively studied Reviewed from various sources including: articles, books, journals, facts and Internet. This is done to understand the various OCR, mapping techniques and techniques Algorithms identified so far to address a related problem area. The researcher believes that these is of paramount importance because the aim of this research is adaptation and/or develop an algorithm that recognizes and converts the required Afaan Oromo Braille to represent the corresponding text.

2.8. Summary of Related Works

Reference	Research Question	Objective	Dataset	approach	Result
(Ali, 2015)	• Identification of recto and verso dots. • Recognition of Braille cells composed of recto and verso dots separately into the corresponding Amharic characters, numbers, and punctuation marks. • SepaProportional of overlapped recto and verso dots.	Design a double-sided Amharic Braille document recognition system and test its performance	Double-sided Amharic Braille documents were collected from Kennedy Library of Addis Ababa University, Ethiopian National Association for the Blind, and Misrach Center. The dataset evenly contains good and bad quality documents. Braille images were then acquired using a flatbed scanner with a resolution of 200dpi in “jpg” format.	Direction field tensor combined with the gradient field	The performance of the system is evaluated and achieves an average dot identification accuracy of 99.3% and translation accuracy of 95.6%.

(Wendmu, A Generalized Approach to Amharic Braille Recognition, 2015)	• What are the special features of double-sided Amharic braille documents? • What kind of preprocessing techniques are required to prepare the dataset for recognition? • What sepaProportional technique is suitable to achieve higher performance in separating	Explore techniques and algorithms for developing a double-sided Amharic braille recognition system that can enable to convert the content of the braille into textual format.	• Collection of Amharic braille document in AAU-Kennedy Library, Misrach Center, and Entoto Blind School. • 30 double-sided and 6 single-sided Amharic Braille documents are collected from Misrach Center and are used as a dataset to experiment with the developed system.	Grid construction algorithm	The average accuracy of 96.07% and 86.16% has been achieved for single-sided and double-sided braille documents respectively.

	front and backside dots in double-sided writing?				
(Hassen, 2011)		Design an Amharic Braille Recognition System.	Braille documents and information on Amharic braille code are collected from different libraries and institution	direction field tensor	The average accuracy of 98.5%
(TADESSE, 2011)	• Is there any consistent characters' representational pattern in the Amharic Braille writing system? • Which feature extraction technique is more effective to extract all valid dots within Braille images for character representation? • Which classifier is suitable for designing a	Design better feature extraction and classification schemes, in an attempt to improve the performance of the Amharic Braille OCR in real-life Braille documents.	Braille documents have been collected mainly from the AAU-Kennedy library. The collected documents are single-sided typewritten Braille documents with the standard Braille size of 11×11.5-inch, number of Braille sheets are 24, Total number of characters 9306.	J48 decision tree and the support vector machine (SVM) classifiers are investigated.	SVM and J48 decision tree classifiers register, on average, 97.25%, and 98.25% accuracy respectively.

	generic model that enables Amharic optical Braille recognition system to register better performance in real life Braille documents?				
(Chekol E. , 2010)		The general objective of this study is to explore the possibility of designing an Amharic Braille recognition system that tolerates noises or degradations in real-life Amharic Braille document images and achieves better performance.	Training dataset that contains 34, 238, 257,and 267 characters set	Artificial Neural Network	the system achieves an accuracy of 95.5%, 95.5%, 90.5%, and 65% for clean, small level noisy, medium level noisy, and high-level noisy Braille documents
(ALEMU , 2009)		The general objective of this research is to develop Amharic Braille OCR that enables to recognize of	Training dataset that contains 34, 238, 257, and 267 characters set	Artificial Neural Network	The study has shown better performance with all training and test sets, with 92.5%

		optically scanned Amharic Braille and convert it to the equivalent printed Amharic text character.			accuracy.
(Belay, 2020)		propose a method for text-line image recognition of Amharic	Amharic Optical Character Recognition (OCR) database called ADOCR. Amharic characters and punctuation marks. All images are grey scaled and normalized to 48 by 128 pixels, while the maximum string length of the ground-truth text is 32 characters including true blank spaces.	Convolutional Neural Network (CNN), Bidirectional LSTM (BLSTM), and Connectionist Temporal Classification (CTC).	Amharic Optical Character Recognition (OCR) database called ADOCR.

(Hsu B.-M. , 2020)		Convert a line of braille into its English counterpart.	a new dataset was constructed, containing a total of 26,724 labeled braille images, which consists of 37 braille symbols that correspond to 71 different English characters, including the alphabet, punctuation, and numbers.	Convolutional neural network (CNN) model and a Ratio character segmentation algorithm (RCSA).	The performance of the CNN model yielded a prediction accuracy of 98.73% on the test set.
(Shreekanth T. a., 2018)		converting Kannada Braille script to natural language	Converting Kannada Braille script to natural language.	k-means classifier	The average accuracy of the algorithm is around 85.5%. Average Mean Opinion Score (MOS) score of 4.54

Many of the reviewed related work focus on different languages but there were no studies in Afaan Oromo language.one of the studies done in our country is Amharic Braille Recognition The recent research works on the area that attempt to find good techniques for recognition of Amharic Braille Characters includes the works of Teshome , Ebrahim (Ebrahim Chekol, June 2010), Shumet, Miftah and Berihu

Research in Braille recognition would have significant contribution in facilitating smooth communication between visually impaired and vision society in every dimension of life. This in turn facilitates the efforts done towards improving the life of visually impaired society. other contribution rather than to language new natural dataset to be generated.

CHAPTER THREE

3. RESEARCH METHODOLOGIS

3.1. Introduction

As mentioned in chapter one, the objective of this study is to translate Afaan Oromo Braille to Afaan Oromo Text using Convolutional Neural Network (CNN). In this chapter, we have discussed how and in what ways we have achieved this objective this includes ways of collecting, processing, tools or materials used in collecting data, method selection of the model and feature extraction, and research tools. Additionally, it covers systematic method, practices, and approaches to conduct Afaan Oromo Braille to Afaan Oromo Text using Convolutional Neural Network (CNN), start from identified research area up to deploy a model.

3.2. Research Approach and Procedure of the Study

A diagram showing the general method is shown in Figure 4. After a braille image Obtained, it is first subject to pre-processing before approaching the accreditation system. The two The main steps in converting an image to Afaan Oromo text are: Proportional Characterization Allocation (PCSA) and Model Training and Prediction as shown in Figure 5. Each braille character distributed using PCSA is fed to the model individually. The result was an Afaan Oromo translation.

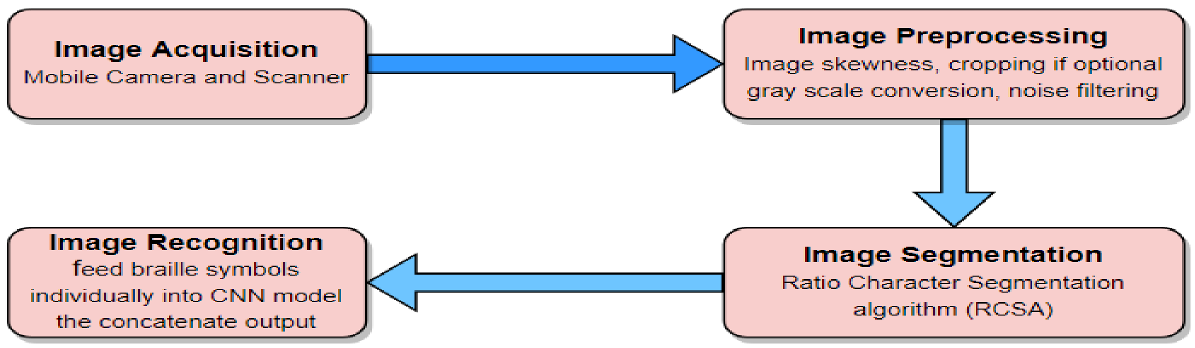

Figure 7 Overview of the steps involved in optical braille recognition (OBR).

3.3. Data Source

Deep and machine learning algorithms are designed to create models that learn from experience and examples. Those examples are templates or observations, also known as data sets. In order to train the learning model, it is a must to have appropriate dataset. Now a day’s researchers use either publicly available datasets or secondary datasets that have been prepared by the researchers themselves. In this thesis work, we prepare our dataset by our-self in two ways the first one form Hand punched braille books and machine punched braille books.

The data set used in this work is prepared from braille documents collected from Sebeta special need school Center. Braille documents can be prepared with any color. The color of document used in this work is mainly white and light yellow. This is because they are the most widely used and available ones. The braille documents are standard 11 inches by 11.5 inches’ size. Braille can be written single side or double-side. The focus of this work is the recognition of single sided Afaan Oromo braille document. But, the system is designed to work for single-sided braille recognition as well. Therefore, the documents single sided braille which are made of paper sheet embossed with the help of an embosser.

There is only one dataset found on publicly available this dataset is not enough and artificial that’s why we need to prepare natural image dataset

3.4. Implementation Tools

For the deep learning approach, there are several open-source software. In this study, we will use Tensorflow and keras. The term tensor refers to the representation of data as a multi- dimension array, and the term flow refers to the sequence of operational performed on tensors. Tensor flow is python-based library with a range of features for creating deep learning models Keras is an open-source neural network library that runs on top of Tensor Flow and is an efficient high-level neural network API written in Python. It is designed to provide quick experimentation with deep neural networks. (Yemane, 2007).

3.4.1. Dataset Source and description

The input to any braille recognition system is a digital image. Digital braille image can be achieved by scanning braille documents with a scanner or by simply taking a picture with a digital camera. Both techniques can provide the expected result. But, using digital camera requires adjusting light source and angle of camera which is most of the time imperfect and creates a skewed kind of image with non-uniform light intensity and shadow size. This requires additional preprocessing to improve the image. Therefore, in this work, we have to use different preferred to use scanner which is a cheap alternative that can produce an excellent digital image with minimal effort. The type of scanner used in this project is an HP and Canon flatbed scanner that produces digital image of the braille document into windows bitmap (BMP) format. The scanning is performed with 200 dots per inch (DPI) resolution which is the recommended level to get a good quality braille image for subsequent processes. Braille can be written with any colored paper sheet. The most dominantly used ones are gray, yellow, green and white. When scanning braille sheets with lighter colors, such as white and light yellow, the light released from the machine on the document during the scanning will affect the bright region of the dots making only the shadow region to appear in scanned image. These images could not enable identification of recto and verso dots. To solve this problem, we experiment other options such as scanning in gray scale rather than full color, reducing contrast and applying adaptive lighting system. From experiment, we have identified that the use of adaptive lighting system enables producing a better quality digital image for any colored braille document. The kinds of braille sheet used in this experiment are white, yellow and gray.

Table 4 Dataset property

Data Set Property	Description
Braille Sheet	
Single Side Punched (Recto)	18
Double Side Punched(Verso)	2(not used)
Braille Type	Grade 1
Total No of braille symbol(Character)	24,480
Background color	White/yellow
Image size 12.5mb	Image size 12.5mb
Digital Format BMP	Digital Format BMP
Document size 11" x 11.5"	Document size 11" x 11.5"
Type of braille Writing	Both hand punched and embossed

3.4.2. Afaan Oromo Braille History Dataset Description

Braille was not the first, or in any way, the only method of reading. There were many. Other ways created before and after Braille. Sincere desire It opened the door for blind people to access literature, which led to that Many experiments in different media.

It was first recorded in about 1517 to create a script for the blind. Francisco Lucas, of Saragos, who invented a simple set of letters inscribed with thin plates Wood. The Roman Rampansetto in Italy later modified this around 1575. Instead of elevating the writing style, he turned it into larger blocks. Even though none of the systems was successful because of the difficulty of writing and reading. A.D. In 1651, Nuremberg's Georges Hard sorfer revived the traditional style of wax writing Tablets for the blind by cutting letters with a stylus. Twenty-five years Later, Pardera Terzi invented the same secret code based on a closed point system in the square. In addition, other images as well as the placement of notes tied in a rope. There were many. Attempts to create a method of writing and reading using other moving letters Pencil, tin and cast iron. The problem with such systems was that the letters were difficult to touch and difficult to model.

Another previous effort was Maria Teresa von Paradise, an Australian Musical Actor and composer who helped Valentine Hayun establish a school for the blind with the help of a pin attached to a pillow, he established a system of teaching the blind. But, when Valentine House founded the school in Paris in 1784. First Student Frances Lesher Coincidentally, he could hear the "O" character details that were so strong. Surprised on paper. Haw later tried to write books to teach the student. His The student made rapid progress and the system was a great success. However, it was in 1825, Louis Braille invented this script and designed the system Reading blind today. However, Braille practice was not limited to fifty years It was internationally accepted and in the Middle Ages, there were several other types of sculptures Planned and used; By hiring some lines and points, others have a simpler look Roman capitals (Wendmu, A Generalized Approach to Amharic Braille Recogntion, 2015)

Braille is widely accepted because it is more compact than other systems. Continue or follow. He was incredibly versatile, able to express himself fluently. And scripts of any country. Suitable for math, music notes and easily. Other purposes. Its main advantages are in the fact that it is different from other types of carvings. It can be written easily and simply and can be read blindly. It is an amazingly practical script, preferred by the blind, widely opened doors for knowledge, literary works, Easy to write privately with blind friends and ample opportunities for employer The blind longed for.

Although there are obvious benefits, the general acceptance of Braille a Slow process (Wendmu, A Generalized Approach to Amharic Braille Recognition, 2015).

Although Luis Braille originally wrote the text for Braille. Its system has been modified in many other countries. As a description of mathematical and chemical symbols, of Wrist watches, meters, meters, thermometers and playing cards and also listing geographic maps and plans for cities and buildings

3.4.3. Data Preprocessing Techniques

Its main purpose is to convey the collected information in some meaningful way. Data pre-processing. We have a variety of databases in various disciplines of Afaan Oromo Braille books. Data collection are data pre-processing methods Depending on the type and type of data collection. Therefore, we used different pre-processing techniques separately as follows.

3.5. Development and Design Tools

Development and design tools are essential and necessary tools for making document implementation as well as prototype is very simple and convenient.

3.5.1. Development Tools

Computer Vision Annotation Tool (CVAT)[1] is image and video analysis tool used to label information for computer vision algorithms. Initially developed by Intel, CVAT is designed to use a professional user interface with a user interface optimized for computer-assisted presentation.as our type of data set all Afaan Oromo braille sign or symbol labeled in bounding box see sample labeled a text format braille sign in figure.

[1] https://cvat.org/

Figure 8 Labeling with bounding box-using CVAT

Roboflow[2] is a computer vision development framework for advanced data collection into process and model training techniques. Roboflow has easy access to public databases for users and also allows users to upload their own custom data. Roboflow accepts a variety of explanatory formats.

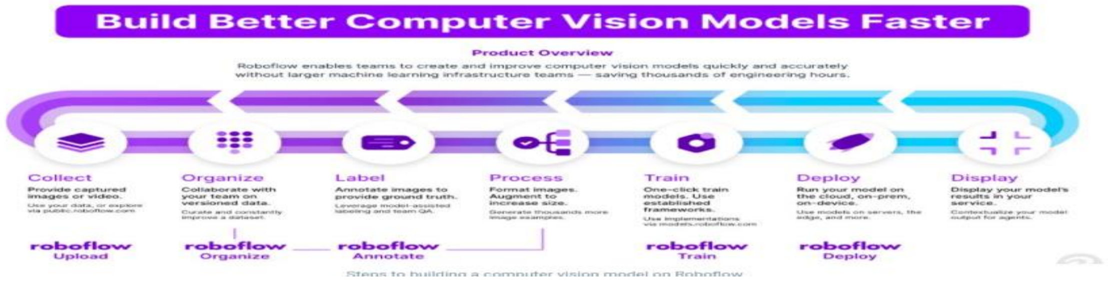

Figure 9 preprocessing rob flow

Google Drive[3]: Google is a cloud-based file storage service owned and operated by Google. The drive helps in sync, so files stored anywhere, anytime, can be found between all sync devices.

Tensorflow[4]: is also created by Goggle operators focus on machine learning. Tensor flow represents data as a tensor, whereas a tensor is a multidimensional array. The library uses a graph to implement learning algorithms. In the graph, the tensor is used as an edge and mathematical functions are used as nodes. Tensor flow helps to deploy and run ML algorithms on CPU, GPU, and cluster. **Colab**[6]: It is an open acronym for Jupiter Notebook. It is running entirely on the clouds. Collab does not need to be configured and has a lot of Python. Packages and library are installed. The environment has both CPU and GPU running time.

3.5.2. Design Tools

Draw.io[5]: It is developing software to create flow charts and custom designs. The software has many features that are easy to drag, drop, and use. In addition, it helps us to store the image in the cloud or in a local device.

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[2] https://app.roboflow.com/new-workspace-rbezt

[3] https://drive.google.com/drive/my-drive

[4] https://colab.research.google.com/?utm_source=scs-index

[5] https://www.diagrameditor.com

3.5.3. Deep Learning Model Algorithm

Deep Learning is part of machine learning algorithms that use multiple layers to extract high-quality features from raw materials. For example, in the image process, the lower layers can identify the edges, while the upper layers can identify concepts that are related to a person, such as figures or letters or faces, Deep Neural Network's ability to automate feature extraction is a huge advantage over tabular datasets. Also, it preserves the risk of dropping into common premises. But certainly, traditional ML algorithms perform undoubtedly for the tabular dataset. However, to make our work portable and accessible, we need to fit the model into edge devices. The first and the only method is using Tensorflow lite, which is used for deep learning models as a backend in the Keras library. Paradoxically other more complex deep learning methods would underperform for the tabular dataset. Therefore, we have chosen Deep Neural Network for braille image prediction.

3.5.4. Convolutional Neural Network (CNN)

In the past, the CNN algorithm was developed for image classification processing. It is an in-depth learning algorithm that uses image recognition, processing, and placement to identify objects and faces. It contains neurons that receive inputs, give them importance, and collect similarities.

A neural network designed to process multimedia information such as images and clock series is called a convolutional neural network (CNN). Includes behavior development and weight calculation during the training process. The name of these networks is derived from the implementation of a convection operator that helps solve complex tasks. The fact is that CNNs offer automatic **feature extraction**, which is a major advantage, the specified input data is initially transferred to the Behavior Extension Network, and the resulting properties are transferred to the Classifier network as shown in Figure 7.8. The feature extraction network includes multiple convection and integral Proportional layer pairs. The Conversion Layer includes a set of digital filters to perform the contour work on the input data. The pool layer is used as a dimension reduction layer and determines the roof. During back multiplication, several parameters need to be adjusted, which reduces the interaction in the neural network architecture.

Formerly CNN algorithms were built for image processing in mind. Nevertheless, not long ago researchers have used the algorithm in sound analysis and classification. In image classification, CNN has outwork the traditional ML algorithms. Our intention behind choosing the CNN model among many other corresponding DL algorithms is that CNN models have computational efficiency and speed where the comparative RNN models are less parallelize and therefore they are slower. RNNs can be very effective for audio synthesis but the problem we have is image analysis therefore we have chosen to work with CNN models. Also, its achievement for more than decades throughout those days, makes CNN models more desirable.

3.6. Evaluation Methods

The performance evaluated of the design of the Afaan Oromo Braille to Afaan Oromo text conversion evaluation is we used Accuracy, precision, recall, and F1 metrics at character and pixel levels evaluation. True positives are detected in Braille characters that intersect with ground truth characters with an IOU (intersection over union) of less than 0.5 and have the correct class (TP). They're called false positives if they're not (FP). As a result, FP detections involve both incorrectly positioned detections and detections with correct positions but incorrect Braille characters assigned to them. False negatives are ground truth symbols that do not have equivalent TP detected Braille symbols (FN) (I. G. Ovodov) Accuracy is the number of accurate predictions for the total input samples. The number of the researcher has used these evaluations (I. G. Ovodov) The metrics Accuracy, Precision, Recall, and F1 are defined as follows:

Accuracy: it is a proportion of correct results in the total number of cases.

I. Accuracy = TP+TN/(TP+TN+FP+FN)

Precision: it gives the proportion of true positive cases among positive predictions.

II. Precision = TP / (TP+FP)

Recall: it shows how many actual positives are correctly classified.

III. Recall = TP / (TP+FN) (2)

F1-score: it is the harmonic mean of precision and recall.

IV. F1 = 2·Precision·Recall / (Precision + Recall)

Where:

False Positive (FP) = when predicted positive and actual is negative.

False Negative (FN) = when predicted negative and actual is positive.

True Positive (TP) = when predicted positive and actual is positive.

True Negative (TN) = when predicted negative and actual is negative.

CHAPTER FOURE

4. PROPOSED SOLUTION OF AFAAN OROMO BRAILLE RECOGNITION

4.1. Chapter Overview

Braille is a textual approach for the blind. It allows them to share their ideas with the world as well as the world around them Form written in Braille. Digitizing Braille facilitates two-way communication between vision and a blind community. It also allows for the preservation of articles found in Braille Electronically this is a space saver and a better guaranteed option. However, Digitizing Braille is not an easy process. Many countries have tried to develop it. Braille identification system for their own language. There were efforts in Ethiopia. Teshome (Wendmu, A Generalized Approach to Amharic Braille Recognition, 2015)home, Ibrahim , Miftah (Hassen, Miftah, 2011), Shumet (TADESSE, SHUMET, JUNE 2011) and Berihu (Berihun Girma, 1994) To develop Braille Recognizes indigenous languages such as Amharic and Tigrinya. Continuity for these efforts Focusing on other languages like Afaan Oromo, Guragigna, Afarigna and etc. this study explores possible techniques Simultaneously recognize Braille documents for single-sided Afaan Oromo Braille documents.

First, single Side braille documents are collected and scanned using a flat plate. Scanner with 200 DPI resolution by applying the appropriate setting for light and contrast. The digital image has already been developed to reduce the noise and to match the image. Regions only. Proportional based on color RGB) in points Dots are performed to the recto. The important regions of the points are subdivided

And depending on the result of the partition, the features are output and transmitted to the translator Features matching the Afaan Oromo alphabet in the search table. This Chapter provides a detailed description of the major functions of the Afaan Oromo language Braille recognition was created through this work.

4.2. Architecture of the Proposed Work

As it is the objective of this study to recognize the input Afaan Oromo Braille sign convert into Afaan Oromo Text the data set has been collected from hand punched braille books have been used. Due to the nature of the data types, we cannot use double side punched braille book (design)

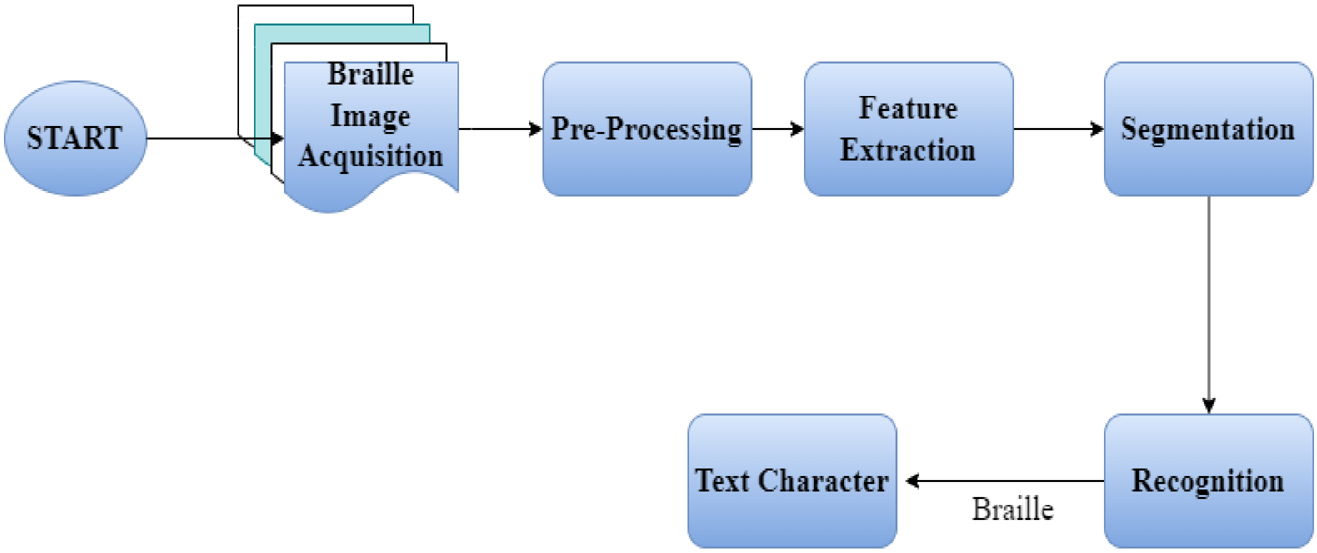


Figure 10 Architecture of the Proposed Work

4.2.1. Data Pre-Processing and Segmentation

Braille images can be obtained Image using cell phones cameras and flatbed scanner. To easily insert the image on the detection system. Before you process the image with PCSA, some properties, such as image confusion, need to be repaired. Easy to solve the problem of oscillation is to find a process technique using linear regression. A straight line through Braille points to find and correct a distorted direction (Hsu P. B.-M., 2020). Using general Linear regression formula:

$\mathbf{Y = bX + a}$ b can be derived as follows

$$b = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$

Where: - **n**: - is the number of pixels

$\mathbf{x_i}$ and $\mathbf{y_i}$: - are the coordinates of the image.

Another way to solve image confusion is to simply rotate the image in parallel. The vertical and horizontal lines in the image intersect the points exactly (Hsu P. B.-M., 2020). The other preliminary steps described in Section 2 are not muted and gray Braille data collection is required in this study because it already contains noise and filtered samples A model for learning imperfect Braille images. An additional pre-processing technique is required for this detection system The white area around the Braille image to ensure good image sharing during the process.

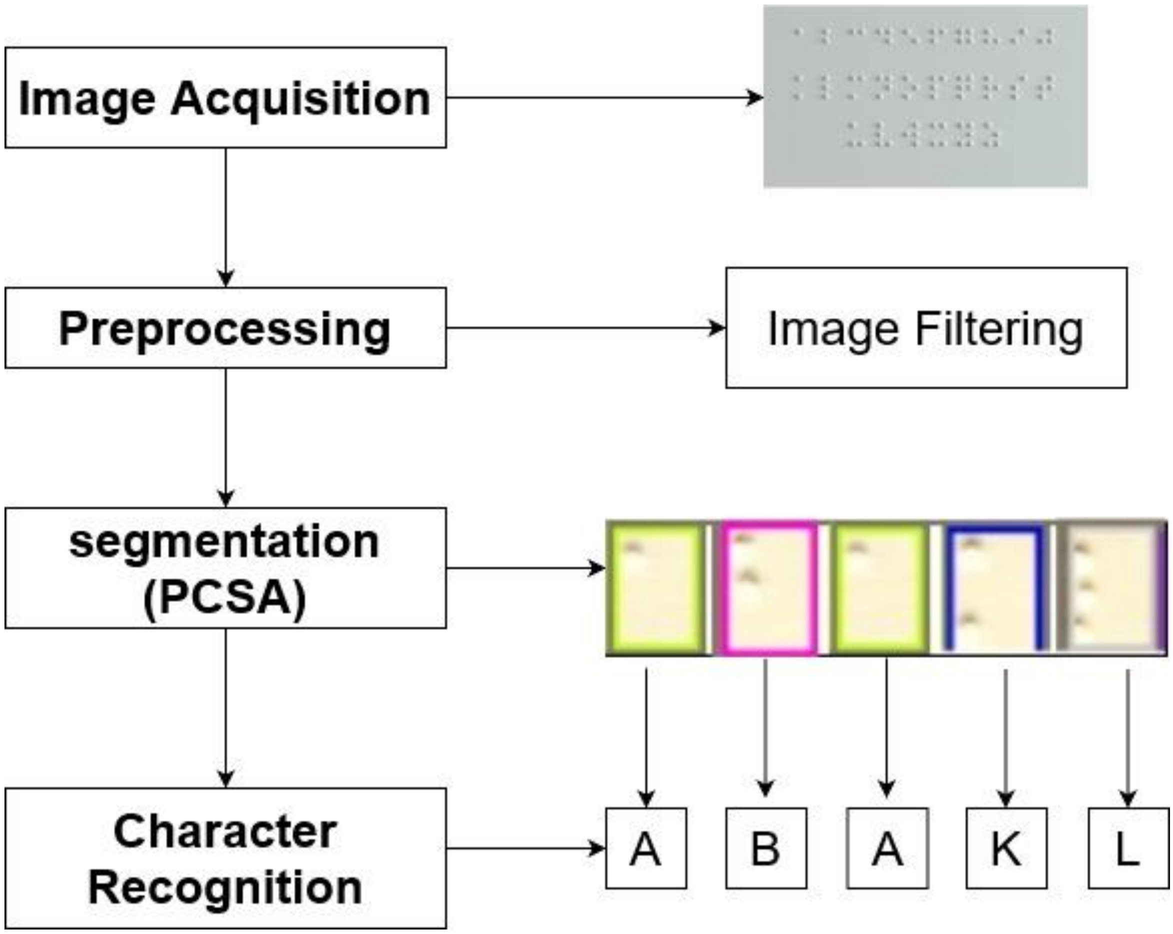


Figure 11 Design of Afaan Oromo Braille preprocessing steps.

4.2.2. Proportional Character Segmentation Algorithm

Many popular OCR libraries use in-depth instruction in image division to identify Single characters in image ; But from the gap around each Braille feature as shown in Figure 11, the braille cell is uniform due to the three-dimensional matrix structure. The Proportional Character Algorithm was created to break the braille image individually. Braille characters. This algorithm took the height of the Braille image and multiplied it by 0.8. Draw the width of a single Braille character in the image. This function has been extended. Due to the similarity of each of the Braille dimensions to the full line of Braille characters Cell. The number of characters in a braille image is obtained by dividing the total area. Braille image with a single Braille character in the image. Proportional division from The algorithm is determined by the Proportional of height to width for each Braille character, the expected input The algorithm was a one-line braille image, which was trimmed all the way to the shield as you can see in the picture above, the distance between each Braille character is about one-third. Figure 5. The step-by-step instructions for implementing the PCSA are as follows:

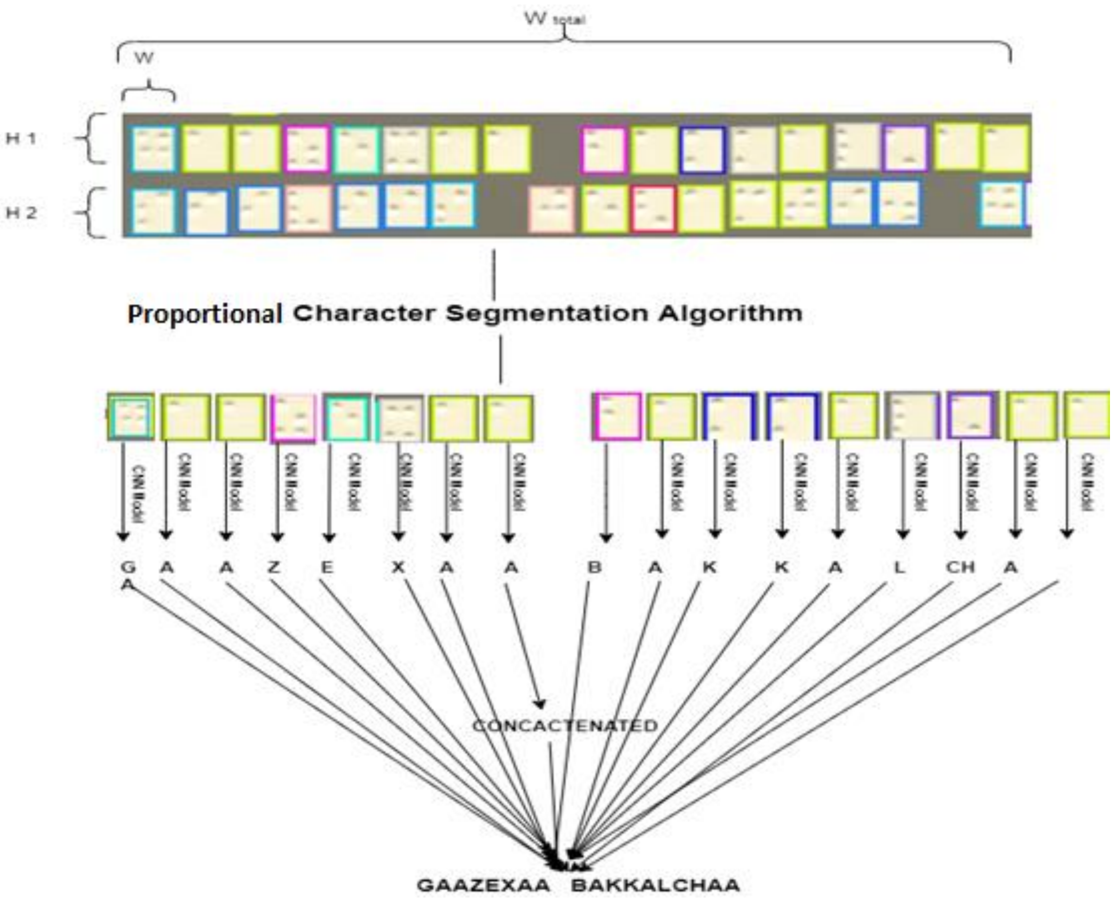


Figure 12 Diagram of the proposed approach for the Proportional character segmentation algorithm (PCSA)

Algorithm 1: to segmentation Braille Data
Input: Full Page of Braille Text **Output**: Segmented Braille Sell resize and permute image to 3 × 28 × 28 pixels $h \leftarrow$ height of image $w \leftarrow h * 0.8$ $w_{total} \leftarrow$ total width of image $n_{chars} \leftarrow w_{total}/w$ divide image into n_{chars} equal segments width-wise **return** cropped braille image

Algorithm 1 Braille Data Segmentation

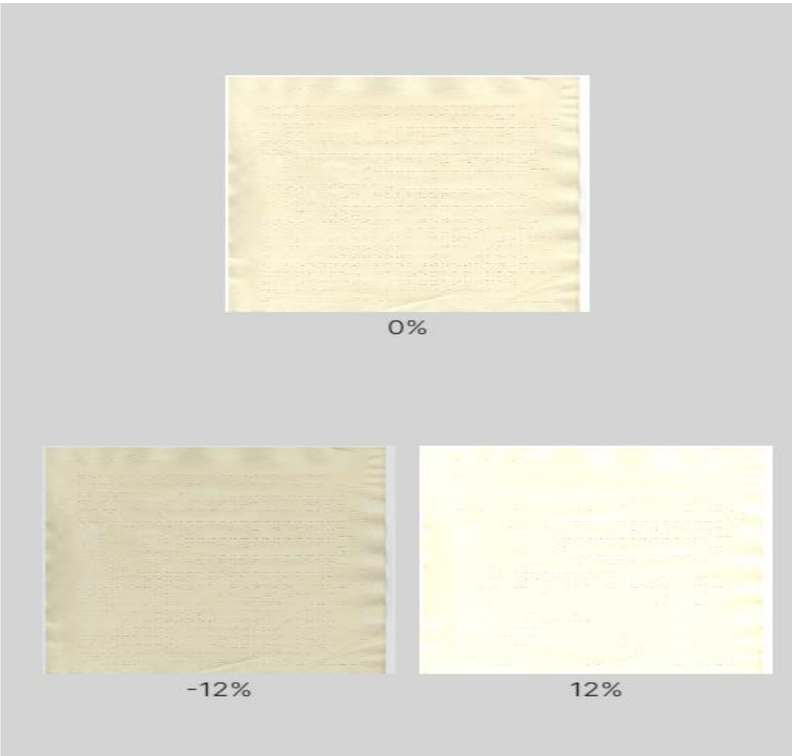
4.3. Augmentation

In this work, 4 different augmentation techniques are applied. 90-% degree rotation in the labeled image data prior to feature extraction Rotation augmentation, Hue Augmentation and Brightness after feature extraction are explained on the way those augmentations work for respiratory sound classification

90-degree rotations One common data augmentation technique is random rotation. A source image is random rotated clockwise or counterclockwise by some number of degrees, changing the position of the object in frame. Notably, for object detection problems, the bounding box must also be updated to encompass the resulting object.

Rotation One common data augmentation technique is random rotation. A source image is random rotated clockwise or counterclockwise by some number of degrees, changing the position of the object in frame. Notably, for object detection problems, the bounding box must also be updated to encompass the resulting object.

Hue: - augmentation randomly alters the color channels of an input image, causing a model to consider alternative color schemes for objects and scenes in input images. This technique is useful to ensure a model is not memorizing a given object or scene's colors. While output image colors can appear odd, even bizarre, to human interpretation, hue augmentation helps a model consider the edges and shape of objects rather than only the colors.



Brightness Add variability to image brightness to help our model be more resilient to lighting and camera setting**.**

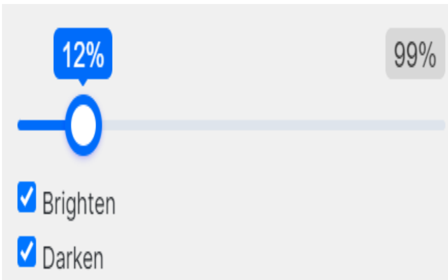


Figure 13 Brightness Between -12% and +12%

4.4. Model Building Algorithms

The Artificial Neural Network (ANN) is a machine learning technique involving connected neurons. Initiation of biological neurons systems. In Figure 11, each node is a neural cell and each arrow is an arrow. Represents an input connection from one node output to another node. Every relationship The weight that conveys the need is assigned. There is one input layer in all ANN models and. One effect layer, when the number of hidden layers can be adjusted. The process of nerve training A multi-layer network model is known as "deep learning".

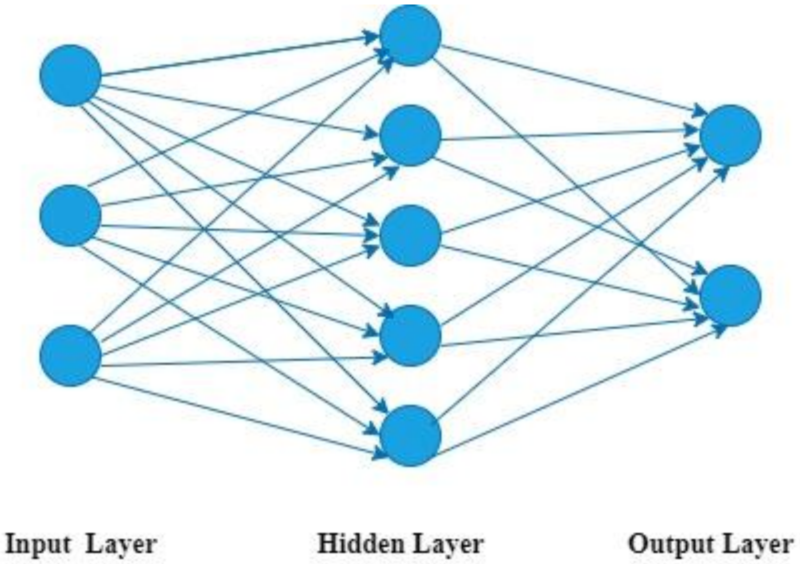


Figure 14 Diagram of a simple artificial neural network (ANN) model

4.4.1. Convolutional Neural Network for Afaan Oromo Braille Recognition

The convolutional neural network (CNN) was used to train the newly developed data set Due to its extensive success in image classification and recognition (Vision, 2018.). Includes CNN model Two convection blocks each with a convection layer, a maximum pool layer and a flowing ReLU. Following the linear layer, the dripping ReLU and the final linear layer as shown in Figure 12.

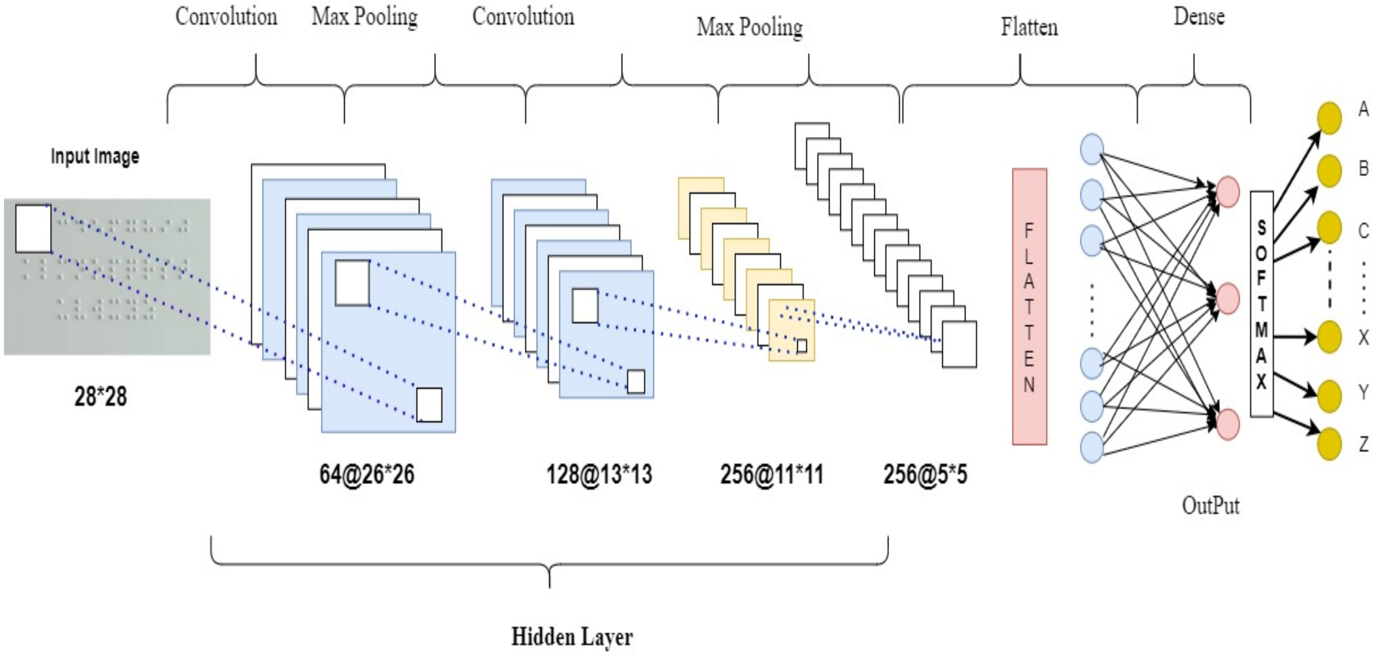


Figure 15 CNN model Architecture for Afaan Oromo Braille Recognition

A total of 80% of the data is allocated to the training set and the remaining 20% is test set. Equal between test and validation sets. the training set and test set percentage is 80/20 because of some paper review is recommended (Hsu B.-M. , 2020). A training set was used to train the CNN model, a The test set was used to predict how well the model was trained to predict and classify Braille images. Additional verification steps are included for hyper parameter selection. Make sure the metrics do not meet the post-training level or, in other words, to ensure that the model does not learn the information and noise in the training set correctly and does not fit correctly More information and predict future data more accurately. However, the test set served as a “true” measure Because nothing was optimized for the test set and performance was possible Search for hyper parameter to match the verification set by testing excess metrics. Bach A size of 36 was used for each of the three subdivisions. Details such as batch, learning speed 1e-4, the disappearance of the cross entropy as a function of loss, and Adam's modification algorithm as an in-depth lesson Optimized, based on several experiments on the training performance of the model.

CNN is made of several types of layer, like Input Layer, Convolutional Layer, Rectified Linear Unit(ReLU), Pooling Layer and Out Put Layer

Input Layer The input features contain time-frequency patches with specified height and width. Therefore, the input has a shape of input height by input width. the input layer of the CNN consumes the extracted features.

Convolutional Layer This is the first step in the process of extracting useful features from the image. And the heart of the CNN model is a convolutional layer. Convolutional layer has many filters that perform convolution. Each image is considered a pixel values matrix. In this layer, each neuron is used as a kernel. In building the CNN model we have used eight (**8)** layers and 2-layers of pooling or down sampling. The detail of each layer is described as follows (YAN, 2019).

Activation Function There are different activation functions among them ReLu and Softmax are the famous activation functions used to ingrain features of nonlinear combination. In the output layer we use Softmax activation function. However, in the middle of model function we used ReLU.

Rectified Linear Unit (ReLU) Adjusted linear unit are a special application combines nonlinear and modular layers in convolution neural network. Of the pool or download layer is responsible for reducing the specific size of activation maps. The pooling or down sampling layer is responsible for reducing the special size of the activation maps.

Pooling Layer are used to reduce the size of feature maps. Therefore, it reduces the number of parameters to learn and the amount of calculations performed in the network. This layer includes features in the feature map region created by the Conversion layer.

- Pooling is required to down sample the detection of feature maps.
- Pooling layers provide an approach to down sampling feature maps by summarizing the presence of features in patches of the feature map. Two (2) common pooling methods are average pooling and max pooling that summarize the average presence of feature and the most activated presence of a feature respectively.

Out Put Layer next to the fully connected layer another layer with activation function of Softmax with 37 output nodes is used. The Softmax activation gives us the probability of each class in deciding the higher probability among them. The higher probability, the higher in deciding chance of input to fall in one of the given 37 classes.

CNN Result summery

Eight (8) total layer and two (2) Pooling layer

80 epochs for test and 600 epochs for training

```
#model.compile(optimizer="Adam", loss="SparseCategoricalCrossentropy", metrics=["sparse_categorical_accuracy"])
```

CHAPTER FIVE

5. IMPLEMENTATION OF THE PROPOSED SOLUTION

5.1. Chapter Overview

In the last chapter, we looked at the architecture, design, and working principles of the Afaan Oromo Braille Recognition. This chapter echoes the proposed solution in the form of a valid code implementation. Performance includes pre-processing, model building, testing and evaluation and finally prototyping. The details of each implementation component are explained as follows.

5.2. Working Environment

We chose python programming because of its popularity and richness in various libraries language to perform all prerequisites and implementation. Python is an open source library. A language with many
contribution and support groups. In information science and Machine Learning the leader is the programing language (M. Yli-heikkilä, "Data Science Languages,").

We chose the python program because of its popularity in various libraries Language to do all the pre-processing and implementation. Python is an open source Language a lot of contribution and support groups. In information science and machine learning, It is the main language of programming (M. Yli-heikkilä, "Data Science Languages,"). But Java programming language in Android Studio is used for prototyping. libraries along with their respective version and description is presented. Those libraries like Keras, Tensorflow, Mathplotlib, Numpy. Panda, Scipy and Sklearn.

5.3. Dataset

The data set used in this work is based on Braille documents collected from the Sebeta Special Need School. Braille documents can be made in any color. The color of the document used in this The work is mainly white and light yellow. Because they are widely used and Available. Braille documents are standard 11 inches by 11.5 inches. Braille can. Write single or double sided. The focus of this work is on recognizing the two-dimensional Afaan Oromo Braille document is not available. Because of this system is designed for single-sided braille Recognition as well. Therefore, the documents collected include both Hand punched and machine punched single side braille the machine punched which are made of paper sheet embossed with the help of an embosser.

5.3.1. Deployment Environment

We used Google Colab to run the model, free GPU and TPU a platform set up by Google. The Nvida K-80 GPU offers 12 GB of RAM with Google Colab. 12 hours of high life that operates by connecting to VMs Over a period of time with Colab, 8 GB RAM, physical computer systems, Intel (R) Core i5, CPU 2.0 GHz Processor, Windows 10 64-bit operating system with NVIDIA GEFORCE 30 series seventeen design of graphics have been used. Prototype at Android Studio v-4.2 Physical Android phone v.9 as a debugging device (T. Carneiro).

5.3.1. Libraries and Header Files.

The modules are implemented using very helpful libraries and header files. Those libraries along with their respective version and description is presented

Table 5 Libraries and header files

Library	Version		Usage
Keras	2.4.0		for Python deep learning
Tensorflow	2.6.0		Back end Keras
Scipy	1.7.0		Statically and mathematical routines
Panda	1.3.3		Data manipulation and visualization
Numpy	1.21.1		Multi-dimensional data manipulation
Mathplotlib	3.4.3		Data visualization

5.4. Afaan Oromo Braille Classifier

We have seen the design and work principle of the Afaan Oromo Braille solution presented in Chapter 4. In this sub-section, we hear the design of the building being coded by python. Implementing contains a variety of pre-processing techniques as well as model-building and evaluations. All pre-processing and modelling algorithms are based on command and other built-in functions; Where to load an important library that's been used.

5.4.1. Preprocessing Implementation

Pre-processing implementation includes reading the image with annotated data, segmentation, resampling, and followed by data augmentation to maintain the balance between different classes and simultaneously feature extraction. To perform all those preprocessing implementations we have started by loading the file containing image data with its respective annotation file. Since we are working with colab, the data is obtained from google drive using the drive library. To train a network and make predictions on new data, your images must match the network's input size. If you want to resize your images to match the grid, you can resize or crop your data to the desired size. By applying random increments to your data, you can effectively increase the training size. Augmentation can also be used to train networks to be invariant to distortions in image data.

5.4.1.1. Braille Image

The data refers to Afaan Oromo braille symbols, especially Afaan Oromo Grade 1 braille uncomplicated means that there is also a Braille symbol for each letter as for the punctuation. Just as there is not enough information to gain recognition from braille to text . a lot of Online searches show a lack of Braille character data that meets the needs of this study. A few They are available in foreign languages, have broken relationships, are not publicly available. Contains braille images that are not suitable for training with a capable detection system Learn imperfect and blurred images. Also, a new database has been built. Considering Braille does not always appear to be photographed or printed or may be distorted. Due to camera angles or light, it is known that a significant set of characters will .be 7 out of 15 Needed to train the model.

Figure 16 Sample cropped images from the braille dataset.

5.4.1.2. Annotation Reading

Braille images were collected from a rare book Collections. Images are then cut into single characters and characters are then assigned individually. To ensure that there is no training, testing and certification sets overlapping in terms of source images, only randomly selected braille characters are cut Image of each source and included in the data set. The data is exported as a csv file, Image tags and source directories used for model training. Including noise and filters Image quality, contrast, brightness, and color change (Figure bellow) added not only to increase the size of the data set, but also to better train by allowing the model to know and Predicting Braille imperfections. The database was created by cutting various Braille images. The images were not the same size. To solve this problem, all images in the database have been resized. Up to 28 × 28 × 3 pixels. These dimensions are scaled to 3 × 28 × 28 pixels before testing to the model.

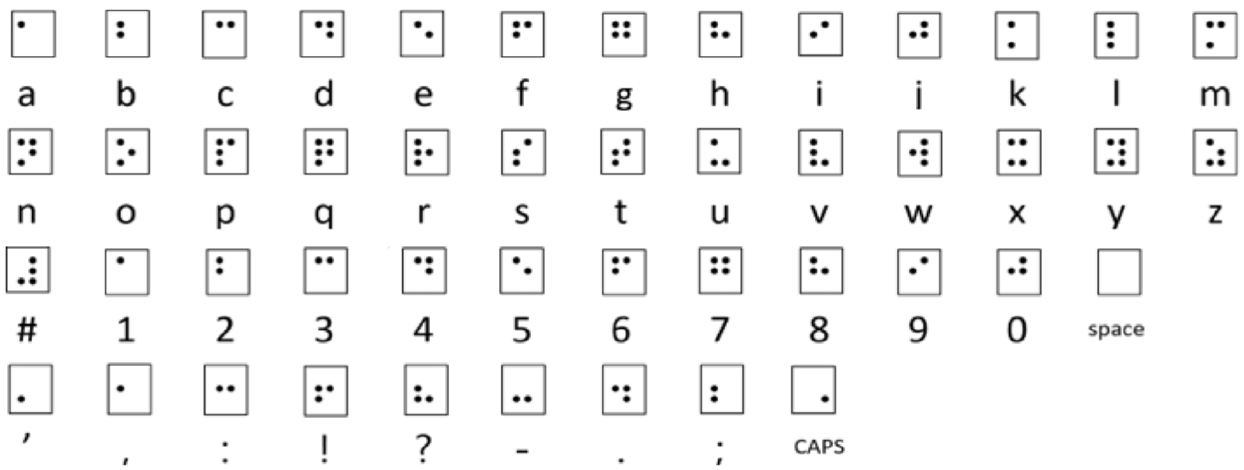


Figure 17. The 37 different symbols in the braille

5.4.1.3. Braille Image Segmentation

There are a variety of my class techniques, such as the PCSA and the environmental measurement, especially in braille's images. Location measurements work by using differences in dot pixel levels as the price of a bargain. Because they emit different colors from the top and bottom. Braille images can be obtained using cell phones and permitted cameras. To easily insert the image on the detection system. Before you train the image in the PCSA and CNN models, some properties, such as image confusion, need to be repaired. Easy to solve the problem of oscillation is to find a process technique using linear regression. A straight line through Braille points to find and correct a distorted direction . Using general Linear regression formula:

5.4.1.4. UCrop for segmentation

Cropping extracts, a subset of the image and preserves the spatial extent of each pixel. You can crop images from the center or from random places on the image.

Our image cropping library for Android uCrop became very popular on Github and we decided to tell you how we improve it. We hope that after reading this article, cropping images on Android will be easier than ever!

5.4.1.5. Augmentation

Augmentations are manipulations that exposed the model to a wider array of training examples by creating different versions of similar content to the data. The Braille dataset has a problem of data imbalance, to overcome this augmentation plays a huge role. In addition to this, augmentation helps us to create other useful training samples that somehow resemble the real world. For that reason, the model's ability to generalize increases. Among many augmentation techniques, we have chosen four augmentation techniques in detail we have discussed in chapter four.

Augmentation braille image is implemented using roboflow library, takes image library and related an explanatory file converts a multi-dimensional array format and a specific volume. Contains updated or updated information that contains all the criteria used to decompose

Table 6 Single Side Braille Type Augmentation Processing

Type of Augmentation	No of Labeled Braille per each page	Dataset for each Augmentation
90-degree rotations	340 * 18	6120
random rotation	340 * 18	6120
Hue	340 * 18	6120
Brightness	340 * 18	6120
Total		**24,480**

5.4.2. CNN Model Implementation

Convolutional neural network is better than a feed-forward network since CNN has features Extraction sharing and dimensionality reduction. Because of parameter sharing in CNN, the number of parameters is reduced thus the computations also decreased. The main intuition is the learning from one part of the image is also useful in another part of the image. Because of the dimensionality reduction in CNN, the computational power needed is reduced.

According to the architecture mentioned in Section 4.5.1 of this Thesis. the CNN model we used Braille Image prediction applies to Keras library. Sample code from the implementation is shown below.

CNN Architecture. CNN is made of several types of layer, like Convolutional Layer, Non-Linearity Layer, Rectification Layer, Rectified Linear Units (ReLU), Pooling Layer, Fully Connected Layer, Dropout Layer.

• **Convolutional Layer**: The main task of the convolutional layer is to detect local conjunctions of (B M.Hsu, 2004)s from the previous layer and mapping their appearance to a feature map.

• **Non-Linearity Layer**: A non-linearity layer in a convolutional neural network consists of an activation function that takes the feature map generated by the convolutional layer and creates the activation map as its output.

• **Rectification Layer:** A rectification layer in a convolutional neural network performs element-wise absolute value operation on the input volume.

• **Rectified Linear Units** (ReLU): The rectified linear units (ReLUs) are a special implementation that combines non-linearity and rectification layers in convolutional neural networks.

• **Pooling Layer**: The pooling or down sampling layer is responsible for reducing the special size of the activation maps.

• **Fully Connected Layer**: The fully connected layers in a convolutional network are practically a multilayer perceptron (generally a two or three layer MLP) that aims to map the $m1(l-1)\times m2(l-1)\times m3(l-1)$ activation volume from the combination of previous different layers into a class probability distribution.

• **Dropout Layer**: Dropout is a technique used to improve over-fit on neural networks, you should use Dropout along with other techniques like L2 Regularization.

• **Softmax:** Softmax function calculates the probabilities distribution of the event over 'n' different events. In general way of saying, this function will calculate the probabilities of each target class over all possible target classes. Later the calculated probabilities will be helpful for determining the target class for the given inputs.

```python
from keras import backend as K
from keras import layers as L
from keras.models import Model,load_model
from keras.regularizers import l2
from keras.callbacks import ModelCheckpoint,ReduceLROnPlateau,EarlyStopping

K.clear_session()
model_ckpt = ModelCheckpoint('BrailleNet.h5',save_best_only=True)
reduce_lr = ReduceLROnPlateau(patience=8,verbose=0)
early_stop = EarlyStopping(patience=15,verbose=1)
entry = L.Input(shape=(28,28,3))
x = L.SeparableConv2D(64,(3,3),activation='relu')(entry)
x = L.MaxPooling2D((2,2))(x)
x = L.SeparableConv2D(128,(3,3),activation='relu')(x)
x = L.MaxPooling2D((2,2))(x)
x = L.SeparableConv2D(256,(2,2),activation='relu')(x)
x = L.GlobalMaxPooling2D()(x)
x = L.Dense(256)(x)
x = L.LeakyReLU()(x)
x = L.Dense(64,kernel_regularizer=l2(2e-4))(x)
x = L.LeakyReLU()(x)
x = L.Dense(37,activation='softmax')(x)
model = Model(entry,x)
model.compile(loss='categorical_crossentropy',optimizer='adam',metrics=['accuracy'])
#model.compile(optimizer="Adam", loss="SparseCategoricalCrossentropy", metrics=["sparse_categorical_accuracy"])
```

Code Fragement 1 CNN Model Implementation

5.4.2.1. Model Testing and Evaluation

For simplicity of data modeling, we used the Keras Data Generator Library. Then the model feeds the train and verification information using the generator. After the model was installed, we they used a confusing matrix to see how well our model worked. These are all applications. shown below.

```python
model = load_model('BrailleNet.h5')
acc = model.evaluate(val_data)[1]
print('model accuracy: {}'.format(round(acc,4)))
```

Code Fragement 2 Model Testing and Evaluation

5.4.2.2. Train and Validation Splitter

The creation of different samples and partitions in the dataset helps us to judge the true model performance. The partition coefficient of a data set depends on the data set and the number of samples in the model.

```
from keras.preprocessing.image import ImageDataGenerator
datagen = ImageDataGenerator(rotation_range=20,
                             shear_range=10,
                             validation_split=0.2)

train_data = datagen.flow_from_directory('./images/',
                                         target_size=(28,28),
                                         subset='training')

val_data = datagen.flow_from_directory('./images/',
                                       target_size=(28,28),
                                       subset='validation')
```

Code Fragement 3 Train and Validation Splitter.

5.5. Braille Image Classifier Implementation

In Chapter 4 we looked at the pre-process and model construction braille Image Classification Architecture. In this section, we have shown implementation details for each module.

5.5.1. Pre-processing Implementation

To get the most out of the data collection, we have implemented a variety of pre-processing techniques. Clearing and normalizing duplicate data as well Inconsistent values and behavior change are the main prerequisites for behavior selection. But to start with all the pre-processing steps, a data set must be installed to the work environment. Since we are working with Kolab, the data collection is from Google Drive can access the library using the google collab package. Retrieve the information and The installation application can be viewed as follows

CHAPTER SIX

6. RESULT AND DISCUSSION

6.1. Chapter Overview

So far we have seen the description of the problem, the method we use, the proposed solution Details of building integral Proportional, and functionality. Hand punched and machine punched braille sample and with various hyper parameter tunings Improving methods are described in detail and with various hyper parameter tunings Improving methods are described in detail. Also discuss the outcome and the overall discussion Comparing the proposed solution with expert evaluation and comparison Previous work has been posted.

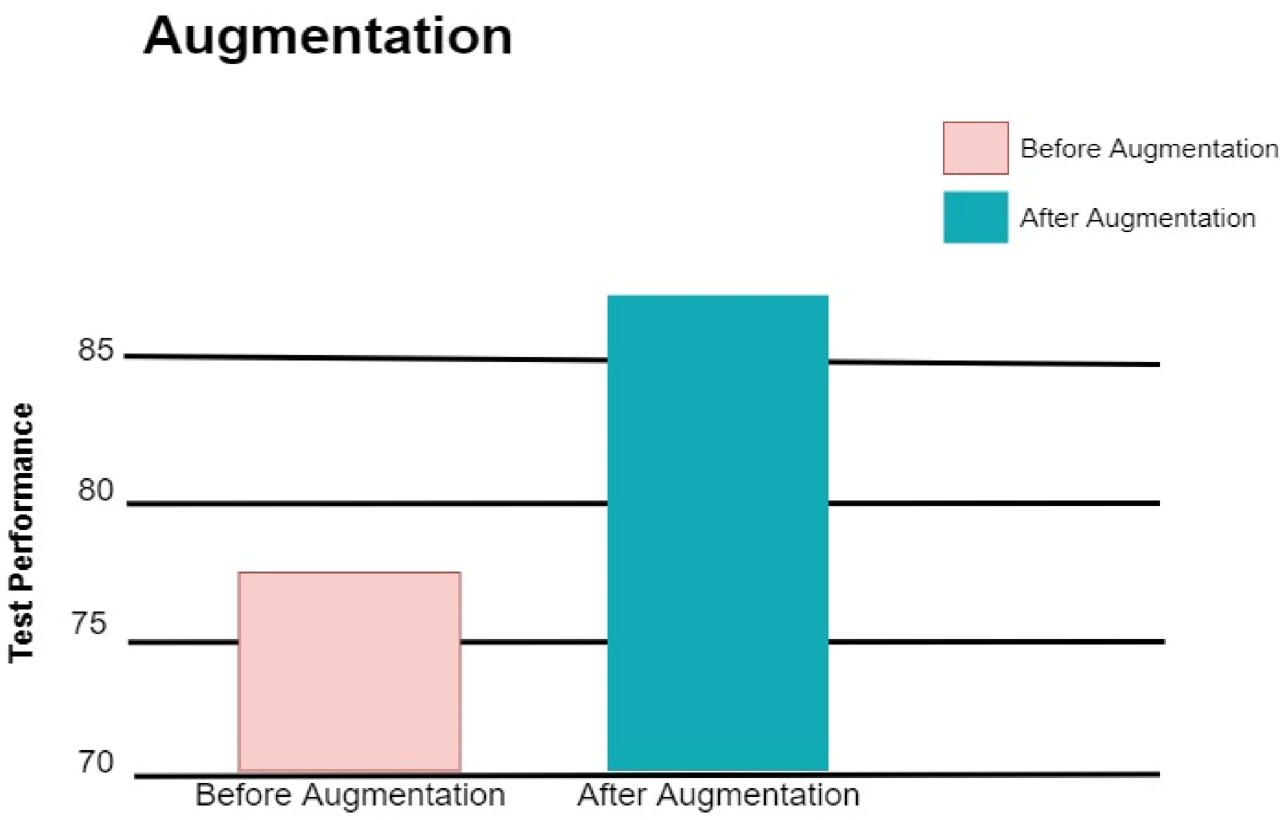
6.2. Braille Image prediction

Braille image forecasting is one of the areas in which in-deep learning is applied in text recognition. Of Prediction is a change of Afaan Oromo braille image to Afaan Oromo text. Classification Results from braille image as a sign or Behavior included with all braille character symbols information. It leads to a combination of all characteristics Prediction for well-defined braille recognition. The result from image It is the classification model, the Braille classification model, and the overall prediction performance. It is explained below.

6.2.1. Augmentation Results

Augmentation is applied using Roboflow library, the library takes a Braille Image file and corresponding annotation file in a multi-dimensional array format and outputs the determined Image together with enhanced or augmented data containing all the parameters used for deformation.

Augmentation with roboflow: As shown in the implementation below, a lot of different augmentation techniques are applied. Like 90-degree rotations, Rotation between 0 – 6 degree, Hue between -40^0 and $+40^0$ and Brightens between -12% and +12% is a powerful way to improve the performance of our computer vision models without needing to collect additional data.



6.2.2. Result for Segmentation

To evaluate the proposed CNN model, 80% of the data set is assigned to the training set And the remaining 20% is divided equally between the test and validation sets. After good training. The CNN model was able to predict images and classify them with 90% accuracy on the test set. A learning curve is plotted from full training and testing the model for overfitting. As shown in

Both training and certification losses are gradually lost as the plateau overtime and the certification disappear The loss does not suddenly increase beyond the training loss, which indicates that the model is learning. Instead of remembering the training subsection. To test the functionality of this AI system, the model and the proportional segmentation algorithm are included in two user interfaces; Flask web app and Android app. The web application contains one page It allows users to easily upload and submit a pre-cropped Braille image and receive Afaan Oromo.

As a companion, the Android app uses the uCrop API functionality provided by Yalantis (https://github.com/Yalantis/uCrop) to allow users to take a photo or select a braille image from your phone's gallery, crop the image and submit the image to the AI system to receive it instantly. Converting Afaan Oromo.

Table 7 Accuracy result for segmentation

Test Set	Total number of characters(A)	Incorrectly recognized Characters (B)	Segmentation Accuracy (%)
Test set 1(clean)	4500	**0**	**100**
Test set 2 (medium level noise)	15000	**130**	**98**
Test set 3 (High level noise)	24,480	**223**	**96**
Average		**161**	**98**

6.2.3. Training Result

Before testing our model, the training result for accuracy and loss performance is as follows

```
history = model.fit_generator(train_data,
                              validation_data=val_data,
                              epochs=666,
                              callbacks=[model_ckpt,reduce_lr,early_stop],
                              verbose=1)

/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:5: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future version
  """
Epoch 1/666
39/39 [==============================] - 4s 77ms/step - loss: 3.2875 - accuracy: 0.0441 - val_loss: 3.2400 - val_accuracy: 0.0929 - lr: 0.0010
Epoch 2/666
39/39 [==============================] - 3s 71ms/step - loss: 3.1427 - accuracy: 0.1066 - val_loss: 2.9250 - val_accuracy: 0.1378 - lr: 0.0010
Epoch 3/666
39/39 [==============================] - 3s 71ms/step - loss: 2.6859 - accuracy: 0.2260 - val_loss: 2.6298 - val_accuracy: 0.2532 - lr: 0.0010
Epoch 4/666
39/39 [==============================] - 3s 71ms/step - loss: 2.1854 - accuracy: 0.3686 - val_loss: 1.8555 - val_accuracy: 0.4679 - lr: 0.0010
Epoch 5/666
39/39 [==============================] - 3s 71ms/step - loss: 1.7611 - accuracy: 0.5048 - val_loss: 1.5252 - val_accuracy: 0.5833 - lr: 0.0010
Epoch 6/666
39/39 [==============================] - 3s 72ms/step - loss: 1.4402 - accuracy: 0.5769 - val_loss: 1.2874 - val_accuracy: 0.5865 - lr: 0.0010
Epoch 7/666
39/39 [==============================] - 3s 72ms/step - loss: 1.2674 - accuracy: 0.6074 - val_loss: 1.0841 - val_accuracy: 0.6571 - lr: 0.0010
```

```
39/39 [==============================] - 3s 71ms/step - loss: 0.0899 - accuracy: 0.9840 - val_loss: 0.2521 - val_accuracy: 0.9455 - lr: 1.0000e-06
Epoch 74/666
39/39 [==============================] - 3s 70ms/step - loss: 0.1013 - accuracy: 0.9808 - val_loss: 0.2759 - val_accuracy: 0.9455 - lr: 1.0000e-07
Epoch 75/666
39/39 [==============================] - 3s 73ms/step - loss: 0.0965 - accuracy: 0.9792 - val_loss: 0.2316 - val_accuracy: 0.9423 - lr: 1.0000e-07
Epoch 76/666
39/39 [==============================] - 3s 70ms/step - loss: 0.0909 - accuracy: 0.9840 - val_loss: 0.2720 - val_accuracy: 0.9391 - lr: 1.0000e-07
Epoch 77/666
39/39 [==============================] - 3s 71ms/step - loss: 0.0909 - accuracy: 0.9776 - val_loss: 0.2335 - val_accuracy: 0.9423 - lr: 1.0000e-07
Epoch 78/666
39/39 [==============================] - 3s 71ms/step - loss: 0.0806 - accuracy: 0.9872 - val_loss: 0.2590 - val_accuracy: 0.9391 - lr: 1.0000e-07
Epoch 79/666
39/39 [==============================] - 3s 73ms/step - loss: 0.1009 - accuracy: 0.9784 - val_loss: 0.2626 - val_accuracy: 0.9519 - lr: 1.0000e-07
Epoch 80/666
39/39 [==============================] - 3s 80ms/step - loss: 0.0875 - accuracy: 0.9880 - val_loss: 0.2069 - val_accuracy: 0.9551 - lr: 1.0000e-07
Epoch 00080: early stopping
```

Code Fragement 4 Accuracy and loss result for data training

6.3. Overall Prediction Results Based on Expert Evaluation

To evaluate the proposed CNN model, 80% of the data set is assigned to the training set and the remaining 20% is divided equally between the test and validation sets. After good training.

The CNN model was able to predict images and classify them with 92.95% accuracy on the test set. A learning curve is plotted from full training and testing the model for overfitting. As shown in fig

Both training and certification losses are gradually lost as the plateau overtime and the certification disappear The loss does not suddenly increase beyond the training loss, which indicates that the model is learning. Instead of remembering the training subsection. To test the functionality of this AI system,

The model and ratio partitioning algorithm are incorporated into two user interfaces; Flask web app and Android app. The web application contains one page It allows users to easily upload and submit a pre-cropped Braille image and receive the Afaan Oromo as a companion, the Android app uses the uCrop API functionality provided by Yalantis to allow users to take a photo or select a braille image from your phone's gallery, crop the image and submit the image to the AI system to receive it instantly. Afaan Oromo transcription.

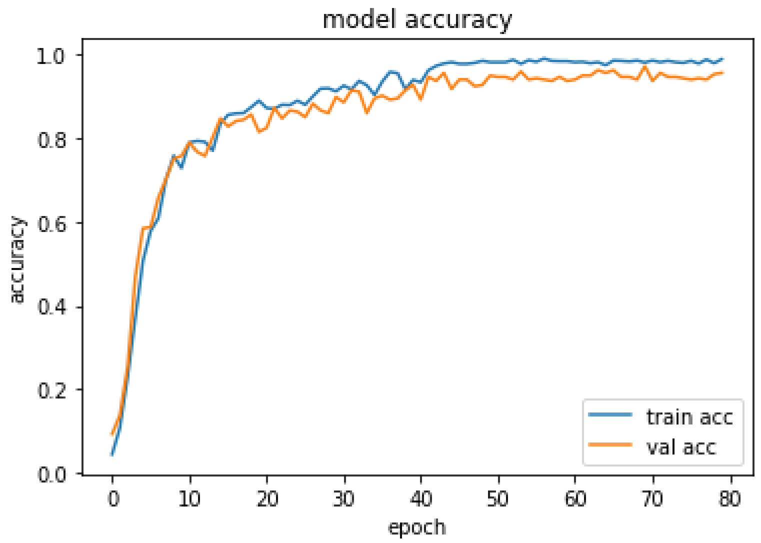


Figure 18 . Plot showing the training as a function of the number of training epochs

epoch

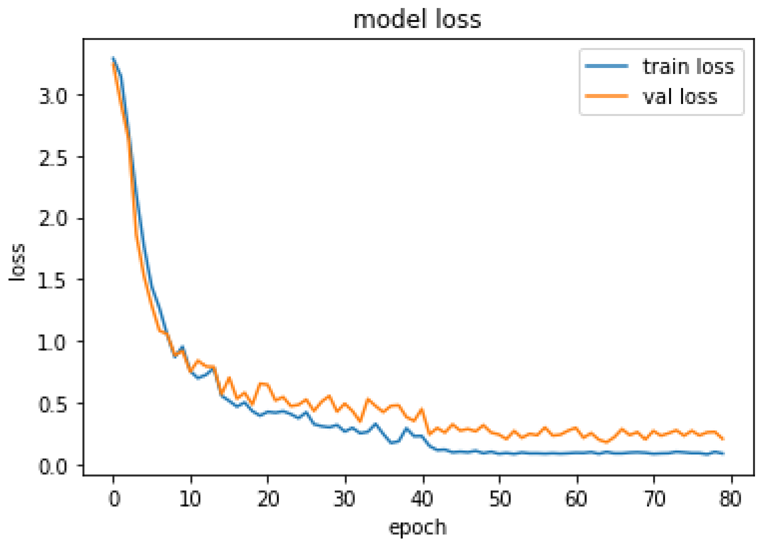


Figure 19 . Plot showing the validation loss as a function of the number of training epochs

```
model = load_model('BrailleNet.h5')
acc = model.evaluate(val_data)[1]
print('model accuracy: {}'.format(round(acc,4)))
```

```
10/10 [==============================] - 1s 31ms/step - loss: 0.2193 - accuracy: 0.9295
model accuracy: 0.9295
```

Code Fragment 5 Model result for testing

6.4. Discussion

There are many ways to get braille images, using scanners and document cameras; However, these devices are not as widely used as mobile phones, which they are It is portable and can easily carry one's daily observations. The proposed braille method Image acquisition uses mobile phones or camera devices that can capture Braille images and allow users to receive instant braille-text conversions. Although this approach can be more due to the inherent nature of camera images, which are prone to noise, this method can be used All real-world braille conflicts, not limited to braille. Therefore, by constructing information from a collection of different braille images, the task of recognition and It is able to predict blurry, out of focus and distorted images.

An initial approach to character separation was to model and use fewer layers instead. Incorporating edge detection to distinguish Braille character dots from their background. Edge detection It is a common machine learning technique used to find the boundaries of objects in an image. It allows extracting individual braille points from the image as indicated separated sealed Braille pages into different dots and background sections. However, it was decided not to use this method because it is based on knowledge Less effective brightness stops when the data contains background noise.

Additionally, although the standard approach to OBR is to divide each braille cell into a 3 by 2 grid. and consider the presence or absence of a point in a particular grid, it is known that The method may not be suitable for Braille images that are highly affected by camera angles. And lighting. A new approach was taken regarding the character division followed by the model Training on individual images. This approach allows the detection system to recognize It is not the presence or absence of individual dots in each braille, but the white space around the characters It has been proven to be equally efficient in detecting and distinguishing cell and individual Braille characters. However, this character segmentation approach relies on a ratio segmentation cropping algorithm. It is very sensitive to excess or lack of pad, so it needs an additional trimming step Image for convenient translations

An AI system has been implemented to recognize and translate characters and words Braille single line to Afaan Oromo text accuracy of 92 % This was achieved by connecting the A CNN model into recognition techniques: character and word recognition. They were single characters. Individual word recognition can be recognized using PCSA Adding a space character as one of the 37 symbols in the Braille dataset. A diagram showing this Progress is presented in Figure bellow.

This approach presents some limitations that could be sources of future research. Line-by-line It may not be the most efficient way to convert Braille to large lengths Afaan Oromo text. In the future, image segmentation should be included in this AI system, which will happen Provide the additional function of dividing the braille page image into multiple braille lines It can be translated and converted into English text by the current system. Optional approach is to extend proportional character segmentation techniques to line proportional segmentation, thus Segmentation of characters and Braille lines can be done simultaneously.

Eventually, 3 research questions are expected to be answered at the end of this research. Let us see how the research answered the indicated questions.

RQ1: - What are the effective constraints to improve the Braille image-to-Text translation?

As our research the main effective constraint for reducing generation gap between non visually impaired and visually impaired society.

Reusing a previously learned model on a new problem is known as transfer learning. It is currently popular in deep learning, especially because it can train deep neural networks with little data. As of now CNN mode is one of the best method for image in steady of this our proposed solution is done as follows.

RQ2: - What kind of preprocessing techniques are required to prepare the dataset for recognition?

The dataset includes Afaan Oromo braille symbols, especially Afaan Oromo 1st grade braille Uncontracted, meaning that there is a Braille symbol for each letter in the Afaan Oromo alphabet as well. Regarding punctuation. The preprocessing step is done with roboflow open source site and in four ways to enhance our input braille image 90^0 rotation, brightness/darkness image, Hue and random rotation are the basic for improve image quality. As there are enough datasets for speech to text recognition The data is exported as a csv file; Labels and source directories of images used for model training. including noise and filters Change the quality, quality, contrast, brightness and color of the images were added Not only to increase the size of the data set, but also to train the model better by allowing it to learn and Predicting imperfect Braille images. The database was created by clipping different Braille images. The images were not the same size. To solve this problem, all images in the database were resized. Up to 28 × 28 × 3 pixels. These dimensions were rescaled to 3 × 28 × 28 pixels before feeding. to the model.

RQ3: - Which classifier is suitable to design a general model that can enable Afaan Oromo Optical braille recognition system for better performance in real life braille Documents?

CNN Model is best for image type data recognition so the suitable classifier for Afaan Oromo Braille to text translation is Convolutional Neural Network is the best.

Further Afaan Oromo braille hand punched and machine punched they are the same but a little bit difference in some way. Hand punched braille mean the braille text written by manually and machine punched braille is by embosser machine. The braille punched by impaired person there is some less accuracy like over fitting, wrongly addressed and missing a dot and etc…in this research both hand punched and machine punched are used.

CONCLUSION AND FUTURE WORK

Conclusion

For people who are visually impaired, lack of vision can be a barrier to accessing printed content Also write their thoughts on paper. In a long effort to solve this important problem, Louis Braille invented a writing system called Braille, named after him. It's Braille. Effective writing and communication techniques for the blind. It has been widely accepted Different provinces to use their own language. One of the languages is Afaan Oromo. Received Braille.

The invention of Braille solved the communication problem of writing. For blind people and among blind people. However, using Braille for communication A visionary society requires vision for people to understand Braille. OBR is a technology with The answer to this problem. It is a system that converts hard-coded Braille documents. Machine-readable and editable text that humans can understand. In addition, it has OBR Keeping Braille works is allowed and is also an easy way to copy Braille.

Future Work

Future directions may include adding more characters to the Braille dataset to do the same. Integrating the entire braille system and further improving the accuracy of braille-to-text conversions. It is difficult to make comparisons with other research activities currently related to OBR. The datasets used between these works are inconsistent in terms of language and acquisition sources. However, it is worth noting that other OBR studies have also found high predictive performance.

Amanuel and Ebrahim achieved 96% accuracy using a printed scanner and MLP model Braille documents symmetry approach using a scanner and printed Braille yielded 98%. documents, except for the support vector machine model. Permanent achievements of the highest level The prediction accuracy between different OBR approaches is largely related to the similarity in Placement of braille dots Additionally, both user interfaces are in alpha testing to identify any potential. Issues that may arise during use and are intended to be made public after the test is completed. This will happen Allow error-free real-w (works, n.d.)orld conversion of Braille images to Afaan Oromo text.

sssReference

A. AlSalman, Y. A. (April 2012 Hammamet, Tunisia). "An Arabic Optical Braille Recognition System. ", . *ICTA"07,* , 2-14,.

A. Antonacopoulos and D. Bridson. (3BX, United Kingdom). "A Robust Braille Recognition System", Pattern Recognition and Image Analysis (PRImA) group, Department of Computer Science University of Liverpool. *Liverpool*, , 69.

A. Cheung, M. B. (n.d.). 'An Arabic optical character recognition system using recognition-based segmentation'. *Pattern Recognition, vol. 34, no. 2*, 33-40.

A. Papandreou and B. Gatos. (2015). 'A novel skew detection technique based on vertical projections'. *, Document Analysis and Recognition (ICDAR), International Conference on ,, , IEEE,* (pp. 384-388).

AbdulMalik Al-Salman, Y. A. (2007). "An Arabic Optical Braille Recognition System", . *Proceedings of the First International Conference in Information and Communication Technology and Access*, 81-87.

ALEMU, T. (2009). RECOGNITION OF AMHARIC BRAILLE. *Addis Ababa University*.

Ali, H. S. (2015). Recognition of Double Sided Amharic Braille Documents . *Addis Ababa University*.

B M.Hsu. (n.d.). "Braille Recognition for Reducing Asymmetric Communication b/n the Blind and Non-Blind,". *" Reducing Asymmetric Communication b/n the Blind and Non-Blind,"*.

Belay, B. a. (2020). Amharic ocr: An end-to-end learning. *Applied Sciences, 10*, 1117.

Berihun Girma, C. f. (1994). The Educational Situation of the Blind:. *Center for Educational Staff Development (CESD),* .

BLIND, T. C. (n.d.). *"TENNESSEE COUNCIL OF THE BLIND,"*. Retrieved 6 14, 2021, from [Online]. Available: https://tn-acb.org/join-tcb

C. Mackenzie. (1954). World braille usage. [Paris]: . *UNESCO,* , 33-55.

C. Ng and V. Lau. (1999). “Regular feature extraction for recognition of Braille”. *In Proceedings of third international conferance on computitional intelegence and multimedia applications*, 302-306.

C.M. Ng, V. N. (1999,). “Statistical Template Matching for Translation of Braille”, . *In Proceedings of the Spring Conference on Computer Graphics (SCCC 1999)* , , 197-200.

Chekol. (June 2010.). “Recognition of Amharic Braille documents”, . *M.Sc. Thesis, Faculty of Informatics, Addis Ababa University, Addis Ababa,.*

Chekol, E. (2010). Recognition of Amharic Braille Documents. *Addis Ababa University*.

Ebrahim Chekol. (June 2010). “Recognition of Amharic Braille documents”, M.Sc. Thesis, Faculty of Informatics, Addis Ababa University, Addis Ababa,.

F. Zahedi and R. Thomas. (1993). “Hybrid image segmentation within a computer vision hierarchy”,. *IJEEE,, 30*, .57-64.

H.Works. (n.d.). *History of Braille*. Retrieved 7 22, 2021, from https://en.wikipedia.org/wiki/Braille

Hassen, M. (2011). RECOGNITION OF AMHARIC BRAILLE USING DIRECTION FIELD. *Addis Ababa University*.

Hassen, Miftah. (2011). RECOGNITION OF AMHARIC BRAILLE USING DIRECTION FIELD.

Hsu, B.-M. (2020). Braille Recognition for Reducing Asymmetric Communication between the Blind and Non-Blind. *Symmetry, 12*, 1069.

Hsu, P. B.-M. (2020). Braille Recognition for Reducing Asymmetric Communication between the Blind and Non-Blind. *Symmetry in Artificial Visual Perception and Its Application*, 1 - 15.

I. G. Ovodov. (n.d.). "Optical Braille Recognition Using Object Detection CNN,".

J. Bhattacharya and S. Majumder. (2011). 'braille character recognition using a generalized featur vector'. *computer networka and intelligenct computing springer Berlin Heidelberg,*, 171-180.

J.Mennens, L. T. (1994). “Optical Recognition of Braille Writing Using Standard Equipment”, . *IEEE transactions of rehabilitation engineering,* , 207-212.

J.P. Dubus, M. B. (1988). “ Image Processing Techniques to Perform an Autonomous System to Translate Relief Braille into Black-Ink, Called: Lectobraille”,. *Proc. IEEE Engineering , 10*, 1584-1585.

Jie Li and Xiaoguang Yan. (, 2010). “Optical Braille character recognition with Support vector machine classifier”, International Conference on Computer Application and System Modeling. *(ICCASM 2010), vol.12*, 219-222.

K. Jithesh, K. G. (n.d.). *“Optical character recognition for Malayalam”,*. Retrieved 8 2, 2021, from :http://www.cdactvm.in/OPTICAL%20CHARACTER%20RECOGNITI

L. Wong, W. A. (August 2004.). “A Software Algorithm Prototype for Optical Recognition of Embossed Braille”, the 17th conference of the International Conference in Pattern Recognition, . *Cambridge, UK,* , 23-26, .

Li, R. a. (2020). Optical Braille Recognition Based on Semantic Segmentation Network with Auxiliary Learning Strategy. *IEEE*, 554--555.

M. Yli-heikkilä. (n.d.). “Data Science Languages,”. 2–5.

M. Yli-heikkilä. (n.d.). “Data Science Languages,”. pp. 2–5.

Mitiku, B. (2020.). "Braille Reading and Writing Skills of Students at Sebeta Primary School for the Blind,".

National Survey on Blindness, L. V. (2006). *Trachoma in Ethiopia.* Addis Abeba,Ethiopia: Ophthalmological Society of Ethiopia, and the Ethiopian Public Health Association.

Néstor Falcón, M. T. (2005.). “Image Processing Techniques for Braille Writing Recognition”, . *EUROCAST, LNCS3643*, 379 – 385.

Qing Chen. (2003.). “Evaluation of OCR algorithms for images with different spatial resolutions and noises”. *M.Sc. Thesis, School of Information Technology and Engineering Faculty of Engineering, University of Ottawa,*, 28-43.

R.T. Ritchings, A. A. (1995). A. Antonacopoulos and D. Drakopoulos, “Analysis of scanned braille documemnt". *Documetn Analysis System,*, 34-44.

Shreekanth. (2018). "A novel data independent approach for conversion of hand Punched kannada braille script to text and speach. *international journal of image and Graphics,T. a. D. M. a. K. K. R.*, Vol. 18,p.1850010.

Shreekanth, T. a. (2018). A novel data independent approach for conversion of hand punched Kannada braille script to text and speech. *International Journal of Image and Graphics, 18*, 1850010.

T. Agui and T. Nagao. (1994.). Computer image processing and recognition. . *Tokyo: Shoho-do,*.

T. Carneiro, R. V. (n.d.). “Performance Analysis of Google Colaboratory as a Tool for . pp. 1–6, 2018,.

TADESSE, S. (2011). FEATURE EXTRACTION AND CLASSIFICATION SCHEMES FOR ENHANCING AMHARIC BRAILLE RECOGNITION SYSTEM. *Addis Ababa University*.

TADESSE, SHUMET. (JUNE 2011). FEATURE EXTRACTION AND CLASSIFICATION.

Tahboub, S. I. (2015). A review of optical Braille recognition. *World Symposium on Web Applications and Networking (WSWAN), 2nd* .

Vision, A. G. (2018.). A Guide to Convolutional Neural Networks for Computer Vision. *Khan, S.; Rahmani, H.; Shah, S.A.A.; Bennamoun, M.; Medioni, G.; Dickinson, S.*, 5-12.

Wendmu, A. (2015). A Generalized Approach to Amharic Braille Recognition. *Addis Ababa University*.

Wendmu, A. (2015). A Generalized Approach to Amharic Braille Recogntion.

WENDMU, A. (june,2015). A GENERALIZED APPROACH TO AMHARIC . 37-39.

WHO. (n.d.). *W.H.Orginization*. Retrieved december 11, 2021, from https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment.

WHO. (n.d.). *world health* . Retrieved 10 1, 2021, from https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment.

works, H. (n.d.). *History Of Braille*. Retrieved 6 22, 2021, from https://brailleworks.com/braille-resources/history-of-braille/. [Accessed 12 2020].

YAN, C. L. (2019). Braille Recognition Using Deep Learning. *Auckland 1010*.

Yemane Berhane. (n.d.). *Prevalence and couse of blindness and low vision in ethiopia*. Retrieved 10 7, 2021, from https://www.google.comhttps://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwifyI_wuY_7AhXGSsAKHSPiCA4QgAMoAHoECAUQAg&url=https%3A%2F%2Fscholar.google.com%2Fscholar_url%3Furl%3Dhttps%3A%2F%2Fwww.ajol.info%2Findex.php%2loa

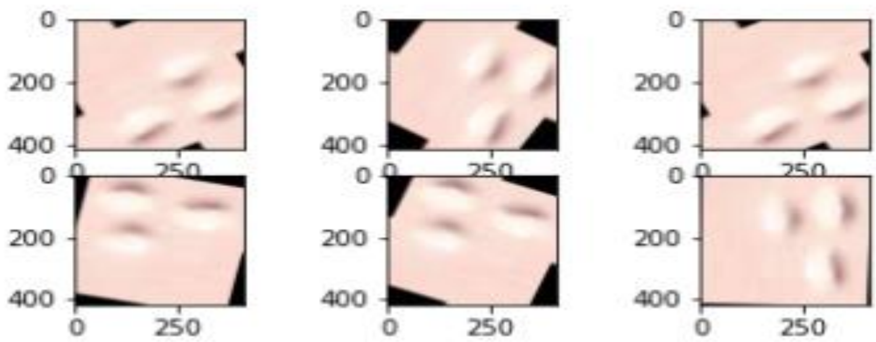
Yibeltal. (2012). "Braille in Ethiopia: Changes and Challenges," Addis ababa,. *Braille in Ethiopia*, 1-16.

APPENDIXES

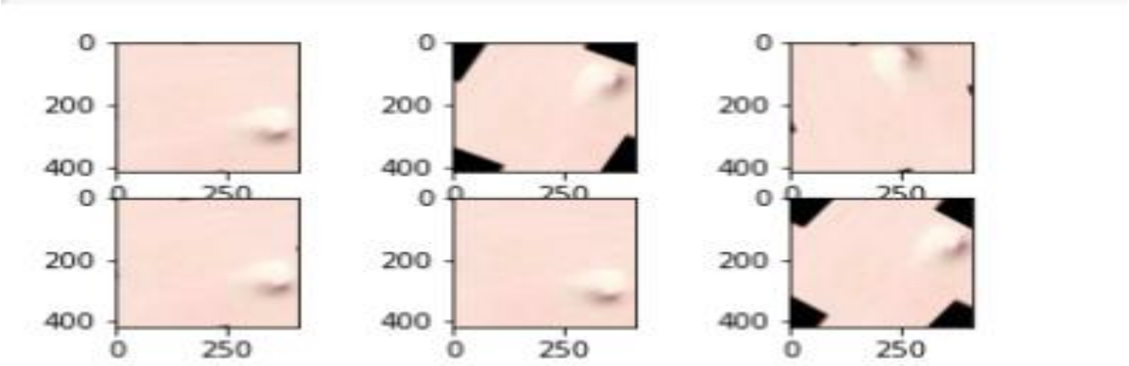
Appendixes A: - Sample data set with different position

```
from numpy import expand_dims
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array
from keras.preprocessing.image import ImageDataGenerator
from matplotlib import pyplot
# load the image
img = load_img('/content/AOB-with-Pun..-1/train/10_bmp.rf.0034c3fdc4dabaaacab46d034b86cc28.jpg')
# convert to numpy array
data = img_to_array(img)
# expand dimension to one sample
samples = expand_dims(data, 0)
# create image data augmentation generator
datagen = ImageDataGenerator(rotation_range=90)
# prepare iterator
it = datagen.flow(samples, batch_size=1)
# generate samples and plot
for i in range(6):
  # define subplot
  pyplot.subplot(330 + 1 + i)
  # generate batch of images
  batch = it.next()
  # convert to unsigned integers for viewing
  image = batch[0].astype('uint8')
  # plot raw pixel data
  pyplot.imshow(image)
# show the figure
```

Result for latter “F”



Result for Latter “A”

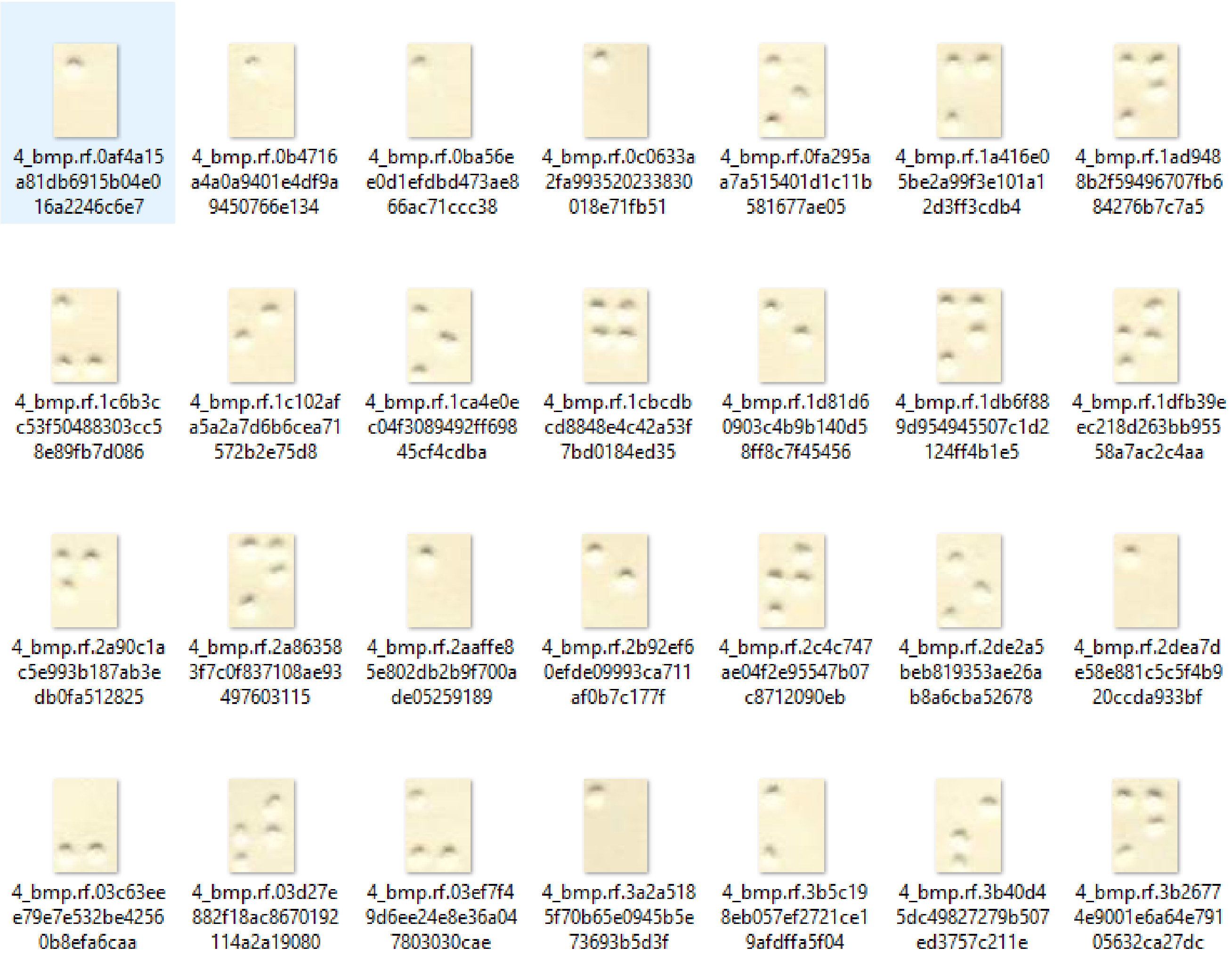


Appendixes B: - Training result for the given input of epochs

```
history = model.fit_generator(train_data,
                              validation_data=val_data,
                              epochs=666,
                              callbacks=[model_ckpt,reduce_lr,early_stop],
                              verbose=1)
```

```
Epoch 1/666
39/39 [==============================] - 4s 77ms/step - loss: 3.2875 - accuracy: 0.0441 - val_loss: 3.2400 - val_accuracy: 0.0929 - lr: 0.0010
Epoch 2/666
39/39 [==============================] - 3s 71ms/step - loss: 3.1427 - accuracy: 0.1066 - val_loss: 2.9250 - val_accuracy: 0.1378 - lr: 0.0010
Epoch 3/666
39/39 [==============================] - 3s 71ms/step - loss: 2.6859 - accuracy: 0.2260 - val_loss: 2.6298 - val_accuracy: 0.2532 - lr: 0.0010
Epoch 4/666
39/39 [==============================] - 3s 71ms/step - loss: 2.1854 - accuracy: 0.3686 - val_loss: 1.8555 - val_accuracy: 0.4679 - lr: 0.0010
Epoch 5/666
39/39 [==============================] - 3s 71ms/step - loss: 1.7611 - accuracy: 0.5048 - val_loss: 1.5252 - val_accuracy: 0.5833 - lr: 0.0010
Epoch 6/666
39/39 [==============================] - 3s 72ms/step - loss: 1.4402 - accuracy: 0.5769 - val_loss: 1.2874 - val_accuracy: 0.5865 - lr: 0.0010
Epoch 7/666
39/39 [==============================] - 3s 72ms/step - loss: 1.2674 - accuracy: 0.6074 - val_loss: 1.0841 - val_accuracy: 0.6571 - lr: 0.0010
Epoch 8/666
39/39 [==============================] - 3s 70ms/step - loss: 1.0518 - accuracy: 0.7003 - val_loss: 1.0558 - val_accuracy: 0.7019 - lr: 0.0010
Epoch 9/666
39/39 [==============================] - 3s 71ms/step - loss: 0.8698 - accuracy: 0.7572 - val_loss: 0.8853 - val_accuracy: 0.7500 - lr: 0.0010
Epoch 10/666
39/39 [==============================] - 3s 71ms/step - loss: 0.9543 - accuracy: 0.7276 - val_loss: 0.9192 - val_accuracy: 0.7564 - lr: 0.0010
```

Appendixes C: - Sample cropped braille sign image after augmentation



Appendixes D: - Challenges faced during data emplacement my occurred