

# **‘Abhivrutti’ : A Multilingual Framework for Transliteration of Indian Speech into Bharati Braille.**

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## ABSTRACT

**Background:** Over the past few decades, one of the most common issues has been visual impairments. People with visual impairments typically ask for assistance from others in order to continue performing their everyday responsibilities. They struggle to function in unpredictable or strange circumstances. These difficulties restrict their freedom and increase the disparity between them and others who are typically sighted.

**Objectives:** This research seeks to bridge the gap by producing a real-time speech-to-text pipeline tightly integrated with accurate digital text-to-Braille patterns and low-cost tactile rendering devices.

**Methods:** This study uses a three-phase methodology: first, speech recognition uses Google's Speech API to record Gujarati audio input and translate it into text. Based on the input speech, a text processing module then prepares and cleans the recognized Gujarati script. Lastly, each Gujarati character is mapped to its Bharati Braille Unicode equivalent via the Braille translation module, producing usable Braille output for persons with visual impairments.

**Result Discussion :** Using one, two, and three-word Gujarati sentences, the experimental evaluation was carried out independently for male and female speakers. The overall recognition accuracy was 88.57%. For brief Gujarati utterances, male participants obtained 100%, 83.33%, and 80% accuracy, whereas female participants achieved 100%, 83.33%, and 83.33%, respectively...

**Keywords:** Braille Transliteration, Bharati Braille, Automatic Speech Recognition (ASR), Indian Languages, Speech-to-Braille.

## 1. INTRODUCTION:

The number of blind or visually impaired persons is increasing daily, according to data from the World Health Organization (WHO). According to the Who Report, there are an average of 285 million visually impaired persons, of which 217 million have limited vision and 39 million are blind.[1]

## 1.1 About Braille

The tactile phonetic alphabet system known as Braille was developed in the early 1800s by blind teacher ‘*Louis Braille*’.



.	.
(1)	(2)
.	.
(3)	(4)
.	.
(5)	(6)

[Figure 1 – Braille Symbol Structure]

Figure 1 illustrates how Braille creates letters, symbols, or contractions using a "cell" of six potential raised dots that are two columns wide by three rows tall.[6] Uncontracted braille, also known as alphabetic braille or Grade 1 braille, and contracted braille, also known as standard braille or Grade 2 braille, are the two primary types of braille. Each sign in Grade 1 Braille is used for beginners and represents one letter, whereas Grade 2 Braille is used for rapid reading and writing. [2].

India is a multilingual nation. Hindi, Marathi, Bangla, Punjabi, Rajasthani, Assamese, Gujarati, and other languages make up the family of 22 languages that make up India.[3] Vowels and consonants make up the vast character sets of these languages.[8] Gujarati is one of the many Indian languages that are derived from Devnagari scripts. The Gujarati alphabet consists mostly of 59 characters and 16 diacritical marks. Thirteen vowels, ten numerical digits, and thirty-six consonants make up these 59 characters. The consonants are referred to as "Vyanjan" and the vowels as "Swar."

**Vowel List (સ્વર):** Thirteen vowels make up the Gujarati alphabet: "અ, આ, ઇ, ઈ, ઉ, ઊ, ઋ, એ, ઐ, ઓ, ઔ, ઓ, ઔ. ઓ. ઔ. ઔ. ઔ. ઔ: અ."

**Consonant List (વ્યંજન):** According to Table 1, there are 36 consonants in Gujarati alphabets out of 59 characters. These are as follows.

[Table – 1 List of Gujarati Consonants]

ક	ખ	ગ	ઘ	ઙ	ચ	છ	જ	ઝ	ઞ	ટ	ઠ	ડ
ઢ	ણ	ત	થ	દ	ધ	ન	પ	ફ	ભ	ભ	મ	ય
ર	લ	લ	શ	ષ	સ	હ	ળ	ક્ષ	ઙ્			

Gujarati Numbers (અંક) List: Table 2 lists the specific numerical symbols used in the Gujarati language.

[Table – 2 List of Gujarati Numbers]

૦	૧	૨	૩	૪	૫	૬	૭	૮	૯
૦	૧	૨	૩	૪	૫	૬	૭	૮	૯

In Gujarati, each vowel has an own set of modifier symbols called "Maatras," which are applied to consonants to change how they are pronounced. Table 3 is a list of Gujarati matraas.

[Table – 3 List of Gujarati Matraas]

Vowel (સ્વર)	Matra (માત્રા)	Example with ક	Pronunciation
અ	— (no matra)	ક	ka
આ	ા	કા	kaa
ઇ	િ	કિ	ki
ઈ	ી	કી	kee
ઉ	ુ	કુ	ku
ઊ	ૂ	કૂ	koo
ઋ	ૃ	કૃ	kri
એ	ે	કે	ke
ઐ	ૈ	કૈ	kai
ઓ	ૌ	કૌ	ko
ઔ	ૌ	કૌ	kau
અં	ં	કં	kam (nasal)
અઃ	ઃ	કઃ	kah (visarga sound)

The Bharati Braille system, a uniform code for Indian languages, is the foundation of Gujarati Braille. Hindi "क" and Gujarati "ક" have the same Braille design. The

National Institute for the Visually Handicapped (NIVH), Dehradun, and the Indian government have officially standardized Bharati Braille as the standard Braille system for Indian languages. It ensures that the Braille code is the

same for all Indian languages that utilize characters identical to Devanagari, such as Hindi, Marathi, Gujarati, etc.[5]

[Table -4 Braille Dots used for Gujarati સ્વર (Vowels)]

Gujarati	Dots	Braille Symbol
અ	1	⠠
આ	1-3	⠠⠠
ઇ	1-2	⠠⠡
ઈ	2-4	⠠⠢
ઉ	1-3-6	⠠⠠⠠
ઊ	1-6	⠠⠠⠠
ઋ	1-2-3-5	⠠⠠⠠⠠
એ	1-2-6	⠠⠠⠠
ઐ	2-4-5	⠠⠠⠠
ઓ	1-3-5	⠠⠠⠠
ઔ	1-3-5-6	⠠⠠⠠⠠
અં	4-6 (nasal)	⠠⠠
અઃ	2-5-6	⠠⠠⠠

Braille structure dots can be used to represent Gujarati characters.[4] The dot number displayed in Table 4 represents the Gujarati vowels. The same holds true for Gujarati consonants, which are displayed in Table 5.

[Table -5 Braille Dots used for Gujarati વ્યંજન (Consonants)]

\Gujarati Letter	Dots Used	Braille Symbol
ક	1	⠠
ખ	1-3	⠠⠠
ગ	1-2	⠠⠡
ઘ	1-2-4	⠠⠢
ઙ	1-2-4-5	⠠⠠⠠
ચ	1-5	⠠⠠⠠
છ	1-5-6	⠠⠠⠠

જ	2-4	⠠
ઝ	2-4-5	⠠⠨
ઞ	1-2-4-6	⠠⠨⠨
ટ	2-3-4	⠠⠢
ઠ	2-3-4-6	⠠⠢⠨
ડ	1-4-5	⠠⠣
ઢ	1-4-5-6	⠠⠣⠨
ત	2-3-5	⠠⠴
થ	1-2-3-6	⠠⠴⠨
દ	1-4-5	⠠⠤
ધ	1-4-6	⠠⠤⠨
ન	1-3-4-5	⠠⠥
પ	1-2-3-4	⠠⠦
ફ	1-2-3-4-6	⠠⠦⠨
બ	1-2	⠠⠧
ભ	1-2-4	⠠⠧⠨
મ	1-3-4	⠠⠨
ય	1-3-4-5-6	⠠⠨⠨⠨
ર	1-2-3-5	⠠⠢⠢
લ	1-2-3	⠠⠣
લ	1-2-3-6	⠠⠣⠨
શ	1-4	⠠⠤
ષ	1-4-6	⠠⠤⠨
સ	2-3-4	⠠⠴
હ	1-2-5	⠠⠢⠢
ક્ષ	-	⠠⠢⠢⠢
જ્ઞ	-	⠠⠢⠢⠢⠢
ટ્ઠ	-	⠠⠢⠢⠢⠢

Halant (◌̣)	4	⠠
Anusvara (◌̣̣)	4-6	⠠⠨
Visarga (◌̣̣̣)	2-5-6	⠠⠢⠢
Comma	2	⠠
Full stop	2-5-6	⠠⠢⠢
Question mark	2-3-6	⠠⠢⠢

Braille structure dots can be used to represent Gujarati numbers are displayed in Table 6.

[Table -6 Braille Representation using Dots for Gujarati Numbers (અંક)]

Gujarati Digit	Braille Representation	Dots (after ⠠)
૦	⠠⠠⠠	2-4-5
૧	⠠⠠	1
૨	⠠⠢	1-2
૩	⠠⠢⠢	1-4
૪	⠠⠢⠢⠢	1-4-5
૫	⠠⠢⠢⠢⠢	1-5
૬	⠠⠢⠢⠢⠢⠢	1-2-4
૭	⠠⠢⠢⠢⠢⠢⠢	1-2-4-5
૮	⠠⠢⠢⠢⠢⠢⠢⠢	1-2-5
૯	⠠⠢⠢⠢⠢⠢⠢⠢⠢	2-4

## 2. Design Methodology

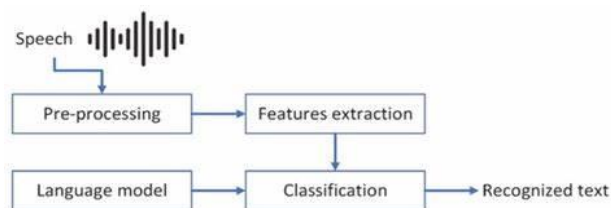
Gujarati voice is converted to text using algorithmic procedures, which are then translated into Braille. The aforementioned tables list Braille characters for the Gujarati language that include vowels, consonants, ‘matraas’, and numerical digits according to American Grade 0 standard Braille translation guidelines. In Gujarati, there are no such capital letters.[8] Algorithm steps are described in a number of steps, including:

Step – 1 Speech Recognition Layer



[Figure 2 – Speech-to-Text conversion]

Above figure – 2 demonstrate that input can be categorized as either take speech at runtime or gathered pre-recorded different audio datasets, including lecture recordings, classroom Q&A, public announcements, and conversational speech as a corpus. Analogue signals are transformed to digital signals after speech input.



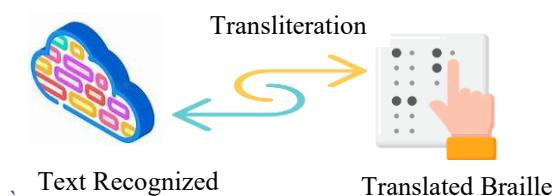
[Figure 3 – Speech-to-text conversion process]

Figure – 3 explains the various process used to transform speech to text. The.wav (Waveform) extension is used to save the prerecorded speech. Spoken words are first recorded using a microphone, and the input is analog audio impulses that need to be processed before comprehension. Pre-processing of analogue signals comprises volume control, noise reduction (i.e., eliminating background noise), silence removal (i.e., disregarding silent portions), and segmenting continuous speech into short connected frames.[7]

MFCC (Mel Frequency Cepstral Coefficients), LPCC (Linear Predictive Cepstral Coefficients), and Spectrogram or Mel-Spectrogram features are common features that are obtained by pre-processing the analogue signals and converting the speech waveform into a set of numerical features that represent speech characteristics.

Language models are employed for contextual understanding to improve recognition accuracy once the features have been extracted. If two words sound similar, N-gram, RNN, and LSTM can be used. The features can be classified into text symbols using the Hidden Markov Model and Convolutional Neural Network. The spoken words are transformed into text as the final product. These identified terms can be applied to additional transliteration tasks.

#### Step – 2 Transliteration Layer



[Figure 4 – Text-to=Braille translation]

Gujarati text is taken from the speech after input voice is transformed to text using the Google Speech Recognition API. For transliteration, use Bharati braille mapping rules based on Unicode. Every Indian script has been standardized to a single representation. Braille Unicode is created from the extracted text.

#### Step – 3 Output Generation Layer

Each Gujarati letter is represented by a 6-dot binary code in the extracted text that has been translated to Braille. Braille symbols can be used to display the generated braille output on the screen once each character has been converted into a 6-dot pattern.

### 3. Experimental Setup and Result Discussion

The Python programming language environment is utilized to implement Speech-to-Text-to-Braille. To translate spoken Gujarati words into text, import the Speech Recognition library. Google's Speech API is utilized for precise multilingual identification. The "pyaudio" module is used to record the audio from the microphone.

Every Gujarati alphabet is mapped to its equivalent Braille using the Bharati Braille standard.[6] A dictionary featuring the Gujarati alphabet and its transliteration into Braille is kept up to date. The software uses this dictionary to determine the Braille equivalent of a Gujarati letter. Additionally, the code will show the default placeholder if any characters are not mapped.

Following the creation of a braille dictionary, a microphone is utilized as an input source and a recognizer object is constructed to handle speech input. When the program asks the user to talk in Gujarati, input will be recorded.

The Gujarati language code (gu-IN) will be used to send the recorded audio to the Google Speech Recognition API. The identified text is returned in Gujarati script by this Google Speech Recognition API. The recognized text will then be translated into Braille. When an Internet connection fails or the voice is unclear, the exception handler mechanism will handle the exception.

A dictionary is used to map recognized text to the appropriate Braille symbols for each character. The final output will be a string that is created by concatenating all recognized braille characters. The output for the following sample data will be produced after the aforementioned processes are finished

[Table -7 Sample Data corpus for One Word, Two Words, and Three Words]

One word			Two Words			Three Words		
S	ગુજ	Eng	S	ગુજ	Eng	S	ગુજ	Eng
r	રાતી	lish	r	રા	lish	r	રા	lish
N	શબ્દ	Mea	N	તી	ning	N	તી	Mea
o		ning	o	શ		o	શ	
				બ્દ			બ્દ	
1	ભાઈ	Brot	1	ધીમે	Spe	1	હું	I
	(Bhā	her		બો	ak		શા	will
	ī)			લો	slo		ભા	go
					wly			to
								scho
								ol

						જઈ શ	
2	બહેન (Bahen)	Sister	2	ધ્યા ન આ પો	Pay atten tio n	2 મા રે પા ણી જોઈ એ	I nee d wat er
3	પાણી (Pāṇī)	Water	3	પા ણી પી વો	Drin k wat er	3 પ પ્પા કામ કરે	Dad is wor king
4	ખોરાક (Khorāk)	Food	4	દર વા જો ખો લો	Ope n door	4 હું ગુજ રા તી શી ખું	I lear n Guj arati
5	સૂર્ય (Sūrya)	Sun	5	ચા લો જઈ એ	Let's go	5 હું ધરે જઈ શ	I will go hom e
6	ચંદ્ર (Chandra)	Moon	6	કામ કરો	Do wor k	6 ચા લો બજાર જઈ એ	Let's go to mar ket

```

In [1]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): પિત્ત
# ગુજરાતી ટેક્સ્ટ: પિત્ત
# ભેષ આઉટપુટ: પિત્ત

In [2]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): બાઈ
# ગુજરાતી ટેક્સ્ટ: બાઈ
# ભેષ આઉટપુટ: બાઈ

In [3]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): બહેન
# ગુજરાતી ટેક્સ્ટ: બહેન
# ભેષ આઉટપુટ: બહેન

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[Figure – 5 Gender-wise Single Word Speech-to-text into Braille transliteration]

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In [10]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): પ્યાન આપો
# ગુજરાતી ટેક્સ્ટ: પ્યાન આપો
# ભેષ આઉટપુટ: પ્યાન આપો

In [12]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): પાણી પીવો
# ગુજરાતી ટેક્સ્ટ: પાણી પીવો
# ભેષ આઉટપુટ: પાણી પીવો

In [13]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): દરવાજો ખોલો
# ગુજરાતી ટેક્સ્ટ: દરવાજો ખોલો
# ભેષ આઉટપુટ: દરવાજો ખોલો

```

[Figure – 6 Gender-wise two words Speech-to-text into Braille transliteration]

```

In [17]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): હું શાળા જઈશ
# ગુજરાતી ટેક્સ્ટ: હું શાળા જઈશ
# ભેષ આઉટપુટ: હું શાળા જઈશ

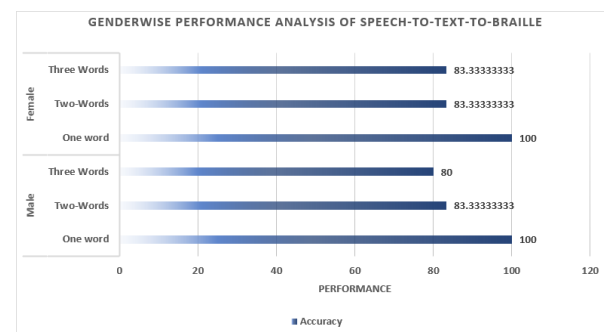
In [18]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): મને પાણી જોઈએ
# ગુજરાતી ટેક્સ્ટ: મને પાણી જોઈએ
# ભેષ આઉટપુટ: મને પાણી જોઈએ

In [19]: runfile('D:/Research Work/2025/Braille/untitled0.py', wdir='D:/Research Work/2025/Braille')
# બોલો (Speak now in Gujarati)...
# ઓળખાયેલું ટેક્સ્ટ (Recognized Text): પપ્પા કામ કરે
# ગુજરાતી ટેક્સ્ટ: પપ્પા કામ કરે
# ભેષ આઉટપુટ: પપ્પા કામ કરે

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[Figure – 7 Gender-wise three words Speech-to-text into Braille transliteration]

According to the experimental setting described in above figure-5,6, and 7, gender-wise input is collected for testing. Gujarati one-word, two-words, and three-words sentences must be spoken by both men and women.



[Figure – 8 Performance analysis of Speech-to-text into Braille transliteration gender-wise]

Figure – 8 shows the identification of proper and incorrect speech, the accuracy is 100%, 83.33%, and 80% for one, two, and three words, respectively, for the male group and 100%, 83.33%, and 83.33% for one, two, and three words, respectively, for the female category. 88.57% performance accuracy was attained overall.

#### 4. Challenges of the Proposed Work

The characters in Braille are made up of cells, each of which has six dots. It is therefore possible to write 64 characters in total. Gujarati has seventy-five characters.

In Gujarati, some characters are identical. Some presumptions are made, such as the idea that the digits 0–9 correspond to specific vowels or consonants.

In Braille, several Gujarati characters are written as a combination of many characters.

The way words are constructed in Braille depends on how they are pronounced. It is pronounced precisely as it is spelt.

The meaning of the text might change if the above-described issues are fixed.

At the moment, this system relies on Google's online Speech Recognition API, which necessitates a reliable internet connection.

Background noise and gender-specific accent differences in Gujarati pronunciation can affect recognition accuracy.

Punctuation rules and complex conjuncts (જ્ઞ, ઙ્ગ, ઞ) are not yet included in the Braille mapping, which primarily covers basic letters and matras.

## 5. Conclusion

Visually challenged people can access digital information through tactile reading thanks to the Gujarati Speech-to-Text-to-Braille System, which offers an effective way to translate spoken Gujarati language into Braille text.[5] Using Python and Google's speech recognition API, the system combines three main stages: text processing, speech recognition, and Bharati Braille translation.

According to experimental findings, the system correctly recognizes Gujarati speech and uses a pre-established Unicode mapping to translate it into Braille using dictionary approach. Other Indian languages that adhere to the Bharati Braille standard can be readily added because to the modular design, which guarantees flexibility.

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