

# Chapter 10

## Bangla Speech Analysis, Synthesis, and Vowel Nasality

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### ABSTRACT

*The chapter provides an overview of the theory of speech production, analysis, and synthesis, and status of Bangla speech processing. As nasality is a distinctive feature of Bangla and all the vowels have their nasal counterpart, both Bangla vowels and nasality are also considered. The chapter reviews the state-of-the-art of nasal vowel research, cross language perception of vowel nasality, and vowel nasality transformation to be used in a speech synthesizer.*

### 1. INTRODUCTION

In this section a brief overview of Bangla language is given. Then the importance of Bangla speech processing is discussed. The aim of this chapter is pointed out in Section 1.4.

#### 1.1. Brief Description of Bangla

Bangla, one of the more prominent Indo-Iranian languages, is the sixth-most popular in the world and spoken by a population that now exceeds 250 million. Geographical distribution of Bangla-speaking population percentages are as follows: Bangladesh (over 95%), and the Indian States of Andaman & Nicobar Islands (26%), Assam

(28%), Tripura (67%), and West Bengal (85%). The global total includes those who are now in diaspora in Canada, Malawi, Nepal, Pakistan, Saudi Arabia, Singapore, United Arab Emirates, United Kingdom, and United States. Bangla has two literary styles: one is called *Sadhubhasa* (elegant form) and the other *Chaltibhasa* (commonly used form). The differences between the two styles are not huge and involve mainly forms of pronouns and verb conjugations.

The origin of modern Bangla derives from Vedic Sanskrit (1500 BC – 1000 BC). Bangla writing system evolved from the Brahmi script, which is closely related to the *Devanagari* alphabet, from which it started to diverge in the 11th century AD. The current printed form of Bangla

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alphabet first appeared in 1778 when Charles Wilkins developed printing in Bangla. Its script includes two types of symbols, the letters (Var-nas) and signs (Cinhas). The letters are vowels, consonants and conjunct consonants. The signs used are vowel signs and prosodic signs. When the vowel is used with the consonant except in the first position, it is written in sign symbols. Among prosodic signs Chandrabindu [◌̣] and Hasant [◌̣̣] are noticeable. Chandrabindu or moon dot is a graphic sign for nasalization and is written on top of a letter when the vowel following immediately is to be expressly nasalized. The writing system is more syllabic than phonemic as there is an inherent vowel [◌̣] with all the consonant phonemes except three consonants. It has the ambiguity of being phonetic, syllabic or alphabetic in nature (Hai, 1985; Chaudhury, 1984). When Hasant is appended to a consonant, the pronunciation is consonantal alone, so the inherent vowel [◌̣] is not functioning anymore. Bangla is an intonation language having no tone, accent or stress (Shaw, 1996). Normal Bangla speech is heard more or less on a monotone with slight rise and fall of pitch and loudness within the sentence. Just as the written form of a language is a sequence of elementary alphabet, speech is also a sequence of elementary acoustic sounds or symbols known as phonemes that convey the spoken form of a language (Hai, 1985). Bangla is heard more or less in monotone. But the interesting point in Bangla is nasality. All the 7 vowels in Bangla have their corresponding nasal counterparts. Nasalization of vowel changes meaning of some words in Bangla. The contrast lies in the spectrum of nasal and oral vowels as shown in Figure 1. Besides, there are 29 simple consonants, 19 diphthongs and two semivowel phonemes as shown in Table 1. There are monosyllabic to seven syllabic words in Bangla. Vowel is the nucleus of a syllable. Some vowel itself has meaning and is treated as a word. The general syllable structure of Bangla is:

(C)(C)(C)V(V)(C)

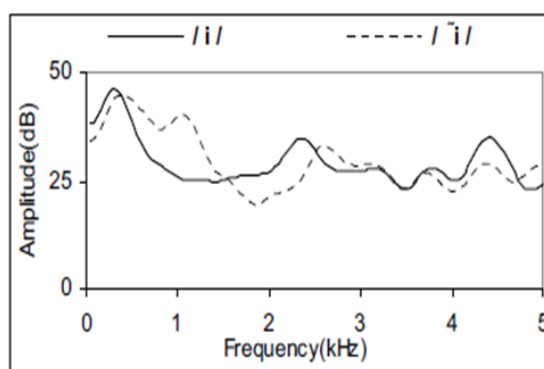
where C and V stand for consonants and vowels. When two or more consonants occur consecutively without any vowel in between they are written in cluster form. The second consonant is written below the first consonant, and the third consonant below the second. These consonant clusters are called double and triple consonant, respectively.

## 1.2. Nasality in Bangla

The nasality feature is found in many of the world's languages. 96.5% of the 451 languages from UPSID database (UCLA Phonological Segment Inventory Database) use this feature in their consonantal system. It is also the most frequent secondary dimension used in vocalic systems (22.4% of UPSID languages), on a par with the dimension of length.

Vowel nasality has differing prosodic properties across languages. In many languages vowel nasalization is strictly local, i.e. it does not spread to an adjacent segment, even if vocalic, as in French /oseã/ which surfaces as [oseã] 'ocean.' In other languages, vowel nasality, inherent or from an adjacent nasal consonant, may spread onto and across adjacent segments. In Apurinã, all vowels adjacent to a nasal vowel are obligatorily nasalized. Directionality of nasal spread

Figure 1. Spectrum of oral Bangla vowel /i/ and its nasal counterpart /ĩ/



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