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STUDY OF TONES CHARACTERISTICS IN THAI, CHINESE LANGUAGES AND SOME ANIMAL SOUNDS USING FAST FOURIER TRANSFORM (FFT)

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ABSTRACT:
The Thai and Chinese languages are tonal languages. Tones are core of the language. Tones distinguish the meaning of one word from another. Thai and Chinese languages are two of the languages that use tones for communication. To speak Thai or Chinese correctly in terms of meaning the tones of the words must be pronounced correctly. This research work was to study the tone characteristics of Thai and Chinese languages using Fast Fourier Transform (FFT) to analyze the frequency patterns of the 5 tones in Thai language and 4 tones in Chinese language. Apart from the tone characteristics of these language, some animal sounds were also studied. Fast Fourier Transform takes a time-varying input signal and transforms it into a frequency spectrum. The voice signals of the various tones are recorded and analyzed. Each syllable is pronounced with one of five distinct tones – Mid, Low, Falling, High and Rising. There are 5 tones in Thai language. But there are only 4 tones in Chinese Language: Mid, Low, Falling, and Rising. From experiments, it was found that each animal species gives obviously different sound spectrum. Some animal sounds are compared between real animal sounds and imitating sounds of animals.

Keywords:- Tonal Language, Phonetic Communication, Consonant Sound Symbols, Fast Fourier Transform (FFT), Bandwidth.

INTRODUCTION :

Spoken language communication is the most important activity that distinguishes humans from animals. While many animal species communicate and exchange information using sound, humans are unique in the complexity of the information that can be conveyed using speech, and in the range of ideas, thoughts and emotions that can be expressed.

Various languages for oral communication in the world have different structures and patterns. The characteristics or structures and patterns of oral language will be the major factor for effective communication of information. The important structure of many languages in the world are the tones of the language. Different tones of the words in the oral language may have different meanings. Thai and Chinese languages are two of the languages that use tones for communication of information. Thai language uses consonant sound symbols to indicate how the words should be pronounced correctly. To speak Thai or Chinese correctly in terms of meaning the tones of the words must be pronounced correctly. This may be different from English language. This research work was to study the tone characteristics of Thai and Chinese languages using Fast Fourier Transform (FFT) to analyze the frequency patterns of the 5 tones in Thai language and 4 tones in Chinese language. Apart from the tone characteristics of these language, some animal sounds were also studied.

The paper by **Young (2008)** describes about the of speech sounds in the auditory nerve of the central nervous system, focusing especially on vowel sounds.

The paper by **Moore (2008)** reviews basic aspects of auditory processing. The frequency selectivity of the auditory system refers to the

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ability to resolve the sinusoidal components in complex sounds and is closely related to the tonotopic representation described by Young.

The paper by **Diehl (2008)** considers further the robust nature of speech perception. Diehl considers how the acoustical and auditory properties of vowels and consonants help to ensure intelligibility.

Quantal theory **Stevens (1989)** is because nonlinearities exist in the mapping between articulatory (i.e., vocal tract) configurations of talkers and acoustic outputs. Given these regions of acoustic stability and instability, quantal theory is based on the idea that preferred sound categories are selected to occupy the stable regions and to be separated by unstable regions. Dispersion theory **Liljencrants & Lindblom (1972),** like quantal theory, is based on the idea that speech sound inventories are structured to maintain perceptual distinctiveness.

Typically, frequencies in the range of 50Hz and upwards are generated in human speech. Most of the energy is concentrated between 300Hz and 3kHz. The human ear, on the other hand, can detect sounds over a range of frequencies from around 20 Hz to 20 kHz. with most sensitivity in the region between about 300Hz. and 10kHz. With the account of these factors along with functional testing the frequency range of 300Hz to 3.4kHz has been found to be the most important for speech intelligibility and speech recognition. It is therefore used in our everyday telephone system. This range of bandwidth provides exceptionally understandable speech and has been the basis of our society's telephony equipment for many decades. (Nortel Networks 2001).

METHODS AND RESULTS:

Pronouncing the Tones in Thai, Chinese Languages and Linguistic Analysis

In Thai, every syllable is pronounced in one of five tones: **Mid, Low, Falling, High and Rising** but for Chinese four tones: **Mid, Low, Falling, and Rising.** To analyze the frequency characteristics of these 5 tones, the word "KA" will be pronounced with different tones. But in Chinese case there are only 4 tones: **Mid, Low, Falling,** and **Rising,** the word "GA" will be pronounced. Software Audio tools from Studio Six Digital, U.S.A. to analyze the audio signals was used. FFT, or Fast Fourier Transform takes a time-varying input signal and transforms it into a frequency spectrum.

The results of FFT analyzer are shown in the figure 1. The voices of different persons will give different frequency spectrum. But the patterns of voice spectrum are the same only the variations of the frequency set. The figure 1. Shows a typical set of voice spectrum of the five tones.

: Normal vocal range. Do not vary the pitch as the syllable is pronounced. Mid tone gives a peak frequency of about 113 Hz, equivalent to music note of A2 in the piano keyboard.

: Falling lower pitch, starting at a pitch lower than normal vocal range. Low tone gives a peak frequency of about 93 Hz, equivalent to music note of F#2 in the piano keyboard.

: Falling tone gives a frequency band ranging from about of 128 Hz to 88 Hz, equivalent to music notes of C3 to F2 in the piano keyboard.

: High tone gives a peak about 138 Hz, equivalent to music note of C#3 in the piano keyboard.

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: Rising tone gives a frequency band ranging from about of 91 Hz to 145 Hz, equivalent to music notes of F#2 to D3 in the piano keyboard.

Typically, the frequency difference between Mid and Low tones is about 20 Hz. The frequency difference between Mid and High tones is about 25 Hz. The frequency difference between Low and High tones is about 45 Hz. The frequency bandwidth of Falling tone is 40 Hz. The frequency bandwidth of Rising tone is 54 Hz.

From the experiments, the voice tone of each word in Thai and Chinese languages from different persons, especially male and female, may be different. The whole set of voice tone of male may be lower than the one from female. The voice tone from each person will be shifted in the form of whole set of tones like musical sounds on piano keyboard.

Analysis of Sounds from Some Animals.

Sounds from some animals like hen, gecko, cat etc. were recorded as a function of time. From these sound signals, the frequency spectrum of each kind of animal was analyzed again by using Fast Fourier Transform. We also tried to imitate sounds of some animal using a paper cup and string to generate sound imitating the real sound of that animal as shown in figure 2. The imitating sounds of animals like a hen, a gecko, or a cat sound very similar to the real ones. It will be interesting to see the FFT frequency spectrum of some animal sounds, comparing the real ones to the imitating ones. The results of the comparison are shown in figure 2.

CONCLUSION:

The Thai Chinese languages are tonal languages. Tones are the core of the language. They are essential as important as any vowel or any consonant. Tones distinguish the meaning of one word from another.

Each syllable in Thai language is pronounced with one of five distinct tones – **Mid, Low, Falling, High** and **Rising**, the middle tone starts at a middle pitch level of about 113 Hz (typically). The low tone starts low about 93 Hz. The falling tone starts high and falls to a low pitch, from 128 Hz to 88 Hz. The high tone rises at 138 Hz. The rising tone starts at low-level and gradually rises from 91 Hz to 145 Hz. Figure 5 shows a more technical analysis of the pitch (frequency) of over time. Chinese language has only four distinct tones - **Mid, Low, Falling,** and **Rising.**

Comparing Thai and English, prosody is used for different functions. In Thai, tone has a semantic function; words which are similar but pronounced with different tones have different, unrelated meanings. English generally does not use tone in this way, but for illustration it may be useful to examine a different type of prosody in English. In other languages like Chinese, they are also tone languages. Like many languages created in early civilizations, Chinese started out as pictures and symbols to represent certain objects and ideas. There is no phonetic radical to help with pronunciation.

From experimental measurements of the sound spectrum of animals, it was found that each animal species such as mammal, amphibian, aquatic and birds give obviously different sound spectrum. Some FFT frequency spectrum of animals are compared between real sounds of animals and imitating sounds of animals look very similar.

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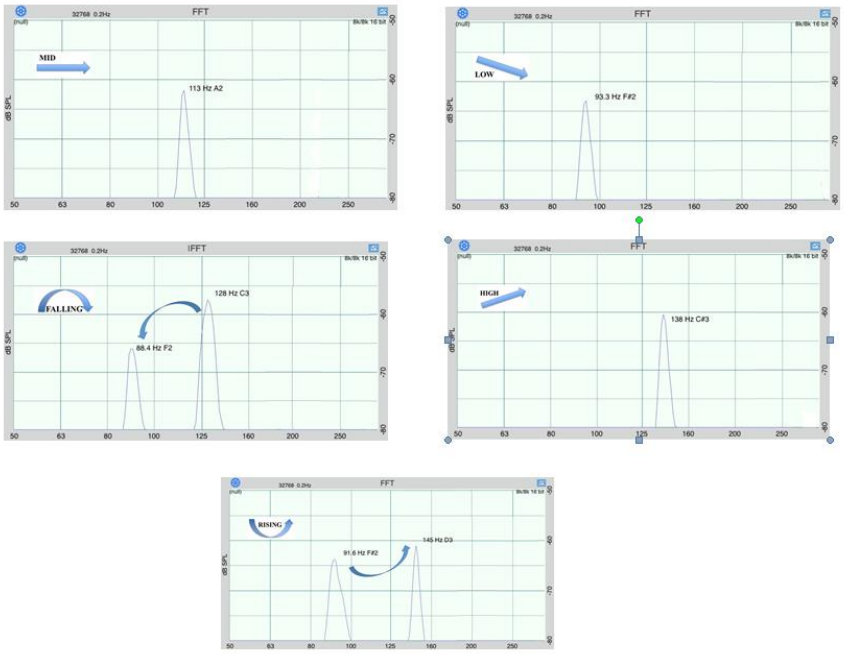

Figure 1. FFT frequency (typical) spectrum of the 5 tones in Tonal languages

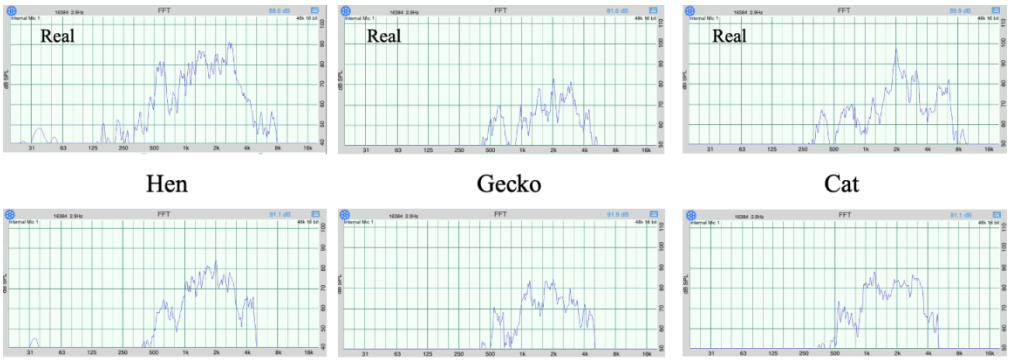

Figure 2. FFT frequency spectrum of some animal sounds, comparing the real ones to the imitating ones.

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