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Effect of Noise Part on Synthesis of Elephant Call Using HNM Technique

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Abstract—Acoustic communication is most important among other forms of communication used by elephant as they can generate both very high and very low frequency signals. In this research paper, elephant calls are synthesized using harmonic plus noise model (HNM) technique. Five different calls of elephant are recorded with high quality recording system which is used as source signal for synthesis process. Quality of the synthesized elephant calls has been tested using perceptual evaluation of speech quality (PESQ). Also effect of noise on the quality of synthesized elephant calls has been investigated. Various levels of the noise ranging from 1% to 10% and constant voice part of 10% is taken. Result shows that the PESQ score of the synthesized calls at lower noise part have higher magnitude.

Keywords— HNM, PESQ, Voice, Noise.

I. INTRODUCTION

Voice signal is an important means for communication in all kinds of mammals, including humans. The mammalian sound generator exhibits a wide variety of oscillatory behaviour, including non-linear phenomena. Elephants are the largest terrestrial mammals. Their vocal communication is characterized by a rich repertoire of distinct sounds, spanning a fundamental frequency range from ten to several hundred hertz. Acoustic signals are omni directional and short-lived. Due to reflection, refraction and absorption these signals are degraded by the surrounding in ways that are often very much greater for high frequency sounds than for low frequency sounds. Elephants are capable producing low frequency sound which can propagate to very long distance [1-4].

Elephant produced sound by expelling air from the lungs which is passed over the vocal chords or larynx, a structure in elephants some 7.5 cm long. The moving air causes the vocal chords to vibrate at a particular frequency. A wide range of frequencies are produced by elephant by lengthening or shortening the vocal chords. The column of air vibrates in the elephant's extended vocal tract or resonating chamber and, depending upon how the elephant holds the various components of this chamber which includes trunk, mouth, tongue, pharyngeal pouch, larynx.

Fig. 1. Elephant with long trunk.

Elephants are able to produce very low frequency sounds because they are large bodied shown in Fig. 1. Also, being a large bodied animals, elephants have several adaptations that allow them to make their resonating chamber even larger and their vocal chords even longer and thus produce even lower sounds than we might expect. The most frequently produced sounds made by elephants fall in the category referred to as rumbles. First, the lowest components of these elephant calls are between one and two octaves below the lower limit of human hearing. And second, because lower frequency sound travels farther than higher frequency sound, elephants use the more powerful of these calls to communicate over long distances [6-7].

In this research paper elephant calls are synthesised using HNM technique [8-10]. Analyses of the synthesised calls are carried out using PESQ score obtained with respect to the originally recorded elephant calls. Also, investigations are carried out evaluate the effect of level of noise part on the synthesized calls.

II. METHODOLOGY

Research work is carried out to synthesize and analyses elephant calls using HNM technique. Also the effect of the level of sound part on synthesised elephant call is investigated. Perceptual Evaluation of Speech Quality (PESQ) test is used for the comparison of the original and synthesized elephant calls. The block diagram of the methodology is shown in Fig. 2. A high quality sound recording system is used to record the sound produced by Asian elephant. Four sound signals are taken are source to be synthesized the calls using HNM techniques. Also a range of voice level from 1 to 10 was taken with constant noise level to evaluate the effect on the synthesized calls.

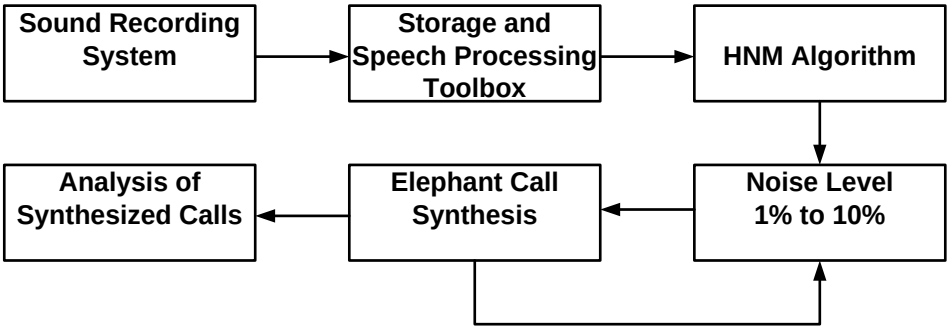

Fig. 2. Schematic of methodology.

III. RESULTS AND DISCUSSION

Figure 3 (a)-(e) shows the normalized recorded elephant calls and their respective spectrogram. These calls were used as source for synthesizing calls using HNM technique. Figure 4 shows the PESQ score of the synthesized elephant calls at 10% of voice and noise part. After synthesizing the calls effect of voice part on the call generation is investigated. The computed PESQ score of five synthesized elephant calls with various level of voice part with constant noise part are given in Table I. Figure 5 shows the pictorial view of the PESQ score of synthesized elephant calls with different voice level in synthesis process. In the graph x-axis represents the noise to voice level in HNM ranging from 1% to 10% and y-axis is the magnitude of the PESQ score. The inference drawn from the results is that at lower noise level, the PESQ score obtained is above 2 which represent good quality of synthesized call. As the noise level is increased the PESQ score reaches a magnitude of approximately 2.5 at unity ratio of voice and noise level, which is acceptable range of PESQ. This provides evidence that HNM model works well with elephant call generation. The quality of the elephants calls obtained shows a gradual increase until the ratio of voice and noise part approaches unity.

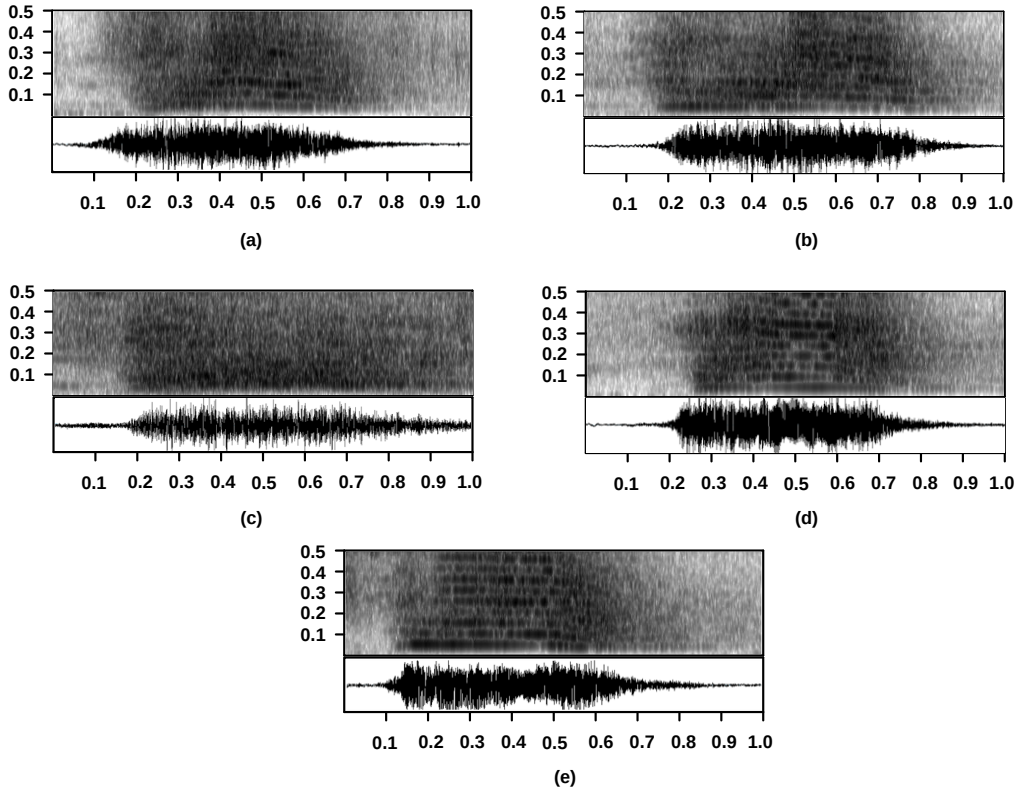

Fig. 3. (a)-(e) Normalized signal and spectrogram of five different calls of Asian elephant.

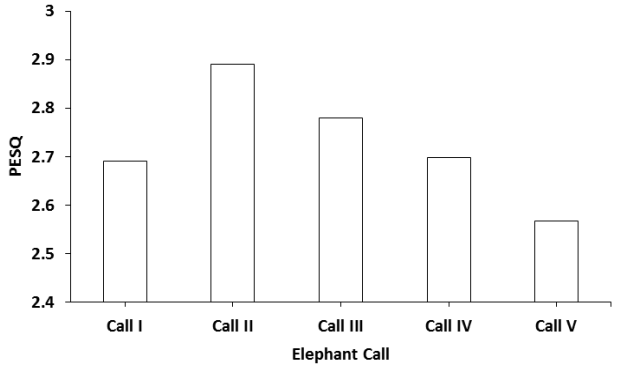

Fig. 4. PESQ score of five different synthesized calls w.r.t original call.

TABLE I COMPUTED PESQ SCORE FOR DIFFERENT CALLS

Voice: Noise Part Ratio	**PESQ Score**				
	Call I	**Call II**	**Call III**	**Call IV**	**Call V**
v1n10	2.4238	2.7445	2.7722	1.9858	2.2530
v2n10	2.4234	2.7427	2.7709	1.9853	2.2436
v3n10	2.465	2.6890	2.6644	2.0702	2.2288
v4n10	2.4001	2.7821	2.7017	2.0271	2.3299
v5n10	2.4084	2.7584	2.7867	2.1643	2.1887
v6n10	2.3462	2.7774	2.7373	2.2132	2.1533
v7n10	2.3742	2.7889	2.7374	2.3326	2.2056
v8n10	2.4160	2.7830	2.7187	2.4951	2.3776
v9n10	2.5623	2.8063	2.7358	2.5380	2.4097
v10n10	2.6901	2.891	2.7791	2.6972	2.5670

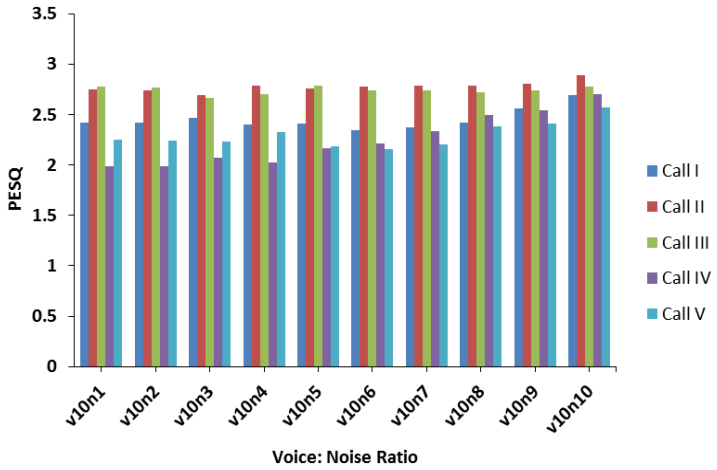

Fig. 5. PESQ score of five different synthesized calls w.r.t original call.

IV. CONCLUSIONS

Research work is carried out to synthesized elephant calls using HNM technique. The effect of the proportion of noise part on the synthesized elephant call quality has been discussed. PESQ is used as the evaluation method for the quality elephant calls. The quality of the synthesized call obtained shows a gradual increase until the value of voice part is 10% and noise part is 10%. From the results it is quite apparent that HNM model is an efficient model for synthesizing elephant calls.

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