Ambient Noise Analysis on Sound
For Use in Wireless Digital Transmission

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Abstract—Ambient noise is present everywhere in varying degrees of frequencies and amplitudes. This paper tries to analyse the ambient noises in various environments ranging from quiet room to busy public places to remote jungle type locations in order to study the impact of noise while using sound as a low frequency wireless carrier for digital data. We try to find the suitable frequency band for text transmission using sound by identifying the sound spectrum band least susceptible to ambient noise and do some test communication.

Keywords—noise analysis; ambient sound noise; digital transmission; wireless; data communication

I. INTRODUCTION

In response to the need for lower power wireless network signals, a proposal to evaluate use of sound as a network signal carrier was examined and we were able to successfully complete short rage communication between low powered smart devices using sound signals as the data carrier. However, even as the ubiquitous nature of sound makes it an adequate candidate for use as carrier signals, the same nature also presents a good amount of "noise", in the form of ambient sound present in various environments. This is a challenge with potential to become a strong obstacle in using sound as the wireless carrier signal in real life practical scenarios. This paper attempts to analyse the ambient noise conditions in different environments ranging from quiet office room, busy street, quiet streets (in-roads), busy shopping malls, market place, normal household, quiet jungle terrains, etc. It will first evaluate the possible effect of such noise over normal data communication and try to find a suitable frequency band for text transmission using sound by identifying the spectrum band least susceptible to ambient noise.

II. RELATED WORKS

Mathew and Issac proposed making use of sound as carrier for low bandwidth, low power communication in the ubiquitous paradigm [1]. The paper attempted ubiquitous data communication using existing hardware in smart devices and sound as the carrier signal. Successful data transfer was achieved as a proof of concept and future work on furthering this towards practical application was suggested. M Weiser, proposed in 1991 pervasive computing as technologies which disappear as they ubiquitously blend into everyday life so that they are indistinguishable [2]. The concepts called tabs, pads and boards were introduced, and also opened up the networking challenge the nature of the devices will present.

Madhavapeddy, Scott, and Tse worked on audio networking which was a forgotten technology [3]. They successfully sent and received data and over sound using common computing platforms to do high frequency (ultrasonic) communication.

Chen and Leesubmitted a bibliographic study on Ubiquitous Computing looking at inter-relationships among major research themes in ubiquitous [4].

Jurdak, Lopes and Baldi proposed an acoustic identification scheme for location systems [5] which uses acoustic signals to uniquely identify and locate a user.

Madhavapeddy, Scott, and Sharp presented context aware computing with sound [6]. A number of location aware applications, namely, pickup and drop interface, digital attachments in voice, etc. were analysed.

Mandalet et al. presented indoor positioning with 3D multilateration algorithms using audible sound [7]. It gave accuracy levels of about 2 feet in about 97% times using cheap consumer use hardware.

III. SOUND – THE NOISY SIGNAL

Close range transmission of data using sound as the carrier signal was tested to be possible in the real life scenario [1] and the transmission was accomplished using the Android smart devices with their standard built-in microphones and speakers.

Sound is a good choice in an attempt to identify a ubiquitous wireless signal, because of its low frequency, ubiquitous presence and low power requirements. The fact that sound is a ubiquitous signal also brings with it a challenge, that is, the good amount of sound present in most environments, which translates as noise when attempting data transfer. The challenge is to ensure successful data transmission even when noise is present.

The noise profiles in various environments are also expected to be different, which is analysed in this paper. We collected sound samples, from the Free Sounds website [9] from various environments including quite office, home, shopping mall, market, roadside, etc. and did a comparative
study, enumerated in the ensuing section. The white noise is included as the last case as control signal for reference.

IV. THE EXPERIMENT AND RESULTS

The following sections show the analysis of the various ambient conditions explored. It is not comprehensive, but is indicative areas of application. We look at the power spectrum and the spectrogram in order to view the frequency spread and power of the signal over time. Additional parameters analysed are the Standard Deviation (Sigma), Mean (Mu), Peak - crest (Q) and Dynamic Range (D), all computed from the sample signals using the Matlab tool using the equations 1 to 2.

The audio data was downloaded from the internet [12]. The downloaded audio samples were trimmed to about 5 second for standardisation of the profiling. Each of the scenes under analysis is as from figures 1-10 and Table 1.

A. The Quiet Office

We observe strong low frequency which weakens around 1 kHz and 17.5 kHz. The spread over time is fairly consistent.

B. The Quiet Home

We observe strong low frequency signal which weakens before 11 kHz. The spread over time is not consistent.

C. The Busy Cafeteria

We observe strong low frequency signal, weakens around 15 kHz. The spread over time is not consistent.

D. The Shopping Mall

We observe strong low frequency signal, weakens before 11 kHz. The spread over time is relatively consistent.

E. The Market

We observe strong low-mid frequency signal, weakens around 15 kHz. The spread over time is not consistent.
**F. The City Roadside in Traffic**

We observe strong low frequency which weakens around 14 kHz. The spread over time is not consistent.

**G. The Suburban Roadside**

We observe strong low frequency which weakens around 13 kHz. The spread over time is fairly consistent.

**H. The woods**

We observe strong low-mid frequency which weakens around 12 kHz. The spread over time is not consistent.

**I. A Rainy Day**

We observe low to high rollover as in a “pink noise”. The spread over time is fairly consistent.

**J. White Noise (control signal)**

We observe white noise as a control signal for referential comparison. White noise gives consistent strength throughout the spectrum & time.

The spectrogram was plotted using the built in spectrogram function in Matlab. To compute the power, we used the FFT function to calculate the values and plotted them against frequency. The Table 1 compares some of the other parameters of the clips that were generated using the Matlab tool on which the experiment was carried out. Standard deviation (Sigma), mean (Mu), peak-crest (Q) and dynamic range (D) was calculated as:

\[ \text{Use the norm fit function to compute } \text{Sigma} \text{ & Mu} \]

\[
\text{Peak (crest) factor Q} \quad \text{- (1)}
\]

\[
\text{Dynamic range D} \quad \text{- (2)}
\]
TABLE I. AMBIENT NOISE PROPERTIES COMPARISON

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Sigma</th>
<th>Mu</th>
<th>Q (dB)</th>
<th>D (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>0.03675</td>
<td>7.3327</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>B.</td>
<td>0.02589</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>C.</td>
<td>0.34569</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>D.</td>
<td>0.67890</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>E.</td>
<td>0.98001</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>F.</td>
<td>0.23245</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>G.</td>
<td>0.56789</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>H.</td>
<td>0.45678</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>I.</td>
<td>0.23456</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
<tr>
<td>J.</td>
<td>0.12345</td>
<td>7.3572</td>
<td>12.3581</td>
<td>43.2345</td>
</tr>
</tbody>
</table>

TABLE II. DATA TRANSMISSION OVER SOUND

<table>
<thead>
<tr>
<th>Transmission Text</th>
<th>Successful Transmission percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Success</td>
</tr>
<tr>
<td>1. Alphabets</td>
<td>100%</td>
</tr>
<tr>
<td>2. Random Characters</td>
<td>99%</td>
</tr>
<tr>
<td>3. Digits</td>
<td>100%</td>
</tr>
<tr>
<td>4. Short Text</td>
<td>96%</td>
</tr>
</tbody>
</table>

Transmission was done with a frequency gap of 10Hz between each character code.

Transmission using lower harmonic frequencies had hidden failures. So we shifted transmissions to a higher frequency band, using formula (3) for data encoding and was quite acceptable above 500Hz.

\[
\text{\textbf{- (3) }}
\]

where \( f = \text{frequency of the signal} \); \( asc = \text{ASCII value of the text} \); \( s = \text{frequency band shift factor} \); \( g = \text{frequency gap} \)

VI. CONCLUSION AND FUTURE WORK

The experiment reveals that the influence of the noise in a particular environment is not constant. The study detailed in this paper was carried out to identify quieter channels that are less susceptible to noise.

REFERENCES


