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Objective evaluation of chronic laryngeal dysphonia by spectro-temporal analysis

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ABSTRACT

In this paper we develop a system dedicated to the objective characterization of dysphonia chronic laryngeal origin. The purpose of this system is threefold: diagnosis, treatment and monitoring of patient. . For this we proceed initially to the remote recording and archiving of an acoustic speech signal voiced in this case "a" sustained for three seconds. We then apply at the Otorhinolaryngology (ORL) department of the University Hospital of Tlemcen, different algorithms of objective assessment of three parameters in this case the fundamental frequency, Disturbance of short-term speech signal (jitter) and Short-Time discrete Fourier Transform (ST.DFT) that allow experts to assess the development of chronic dysphonia of tumor or inflammatory origin (larynx cancer, inflammatory polyp of the vocal cords, chronic laryngitis).

Keywords: Telemedicine; ST.DFT; Chronic dysphonia; Voiced sound; Jitter; Fundamental frequency.

1. INTRODUCTION

The voice is a spectacular indicator of physical and mental health of a person. The technology of voice pathology has been a marked increase over the past two decades, the voice processing is now a fundamental component of engineering [13] [1]. The special importance of voice processing in the more general framework is due to the privileged position of the speech as a vehicle of information in our human society. [11] The voice is indeed produced by the vocal tract, continuously monitored by the motor cortex [8] [4]. Among the voice treatment applications we distinguish [5] [6]:

1) Temporal spatio-spectro analysis of the vocal signal observing the objective characterization of dysphonia of laryngeal origins [9][10].

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2) Quantitative estimation of characteristics parameters of the vocal signal during its acoustical representation including the Fundamental Frequency and the jitter of voiced sounds [7] [12].

2. MATERIEL AND METHODS

The slide that we have implemented is composed of an interface for acquiring the acoustic speech signal consists of a dynamic microphone to reproduce sound in analog form and sound card for digitization and an environment software to archive the signal in Wave format in order to perform the calculation of different indices and we had to implement an algorithm for converting Wave format to decimal format in Visual Basic environment. The experimental protocol includes the following steps:

- Pronunciation of a voiced sound in this case 'a' sustained for three seconds.
- The division of the signal into 6 frames each 0.5 seconds
- The calculation of the three indices (spectral content, fundamental frequency and jitter) averaged over six frames.
- The correlation between the indices themselves and the balance sheet and para-clinic of patients.
- The implementation of an interactive database of physiological and pathological acoustic voice signals for a clinical and epidemiological study and better therapeutic management.

2.1 Global Algorithm of the application

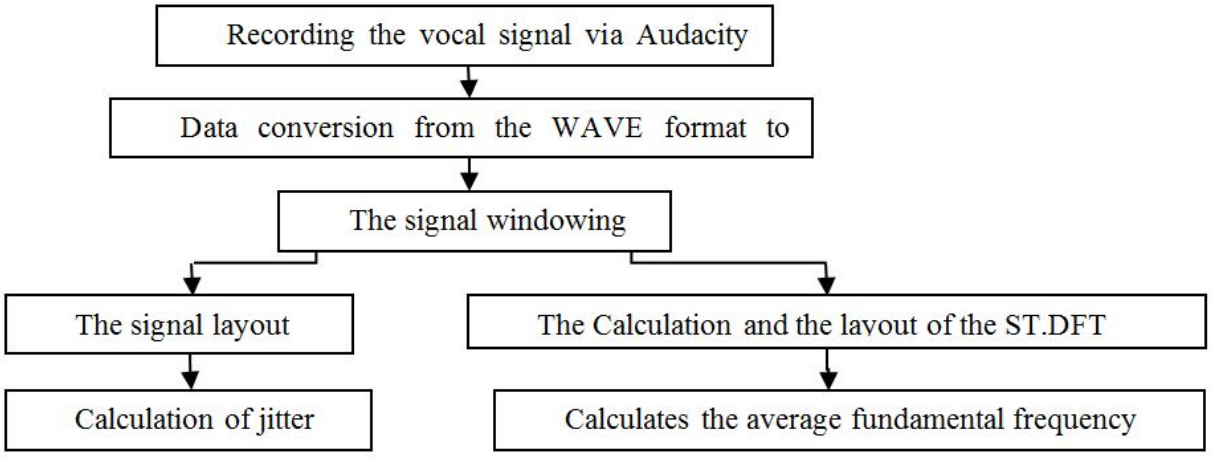

Figure 1: The algorithm

3. CLINICAL EVALUATION

3.1 Healthy subject study

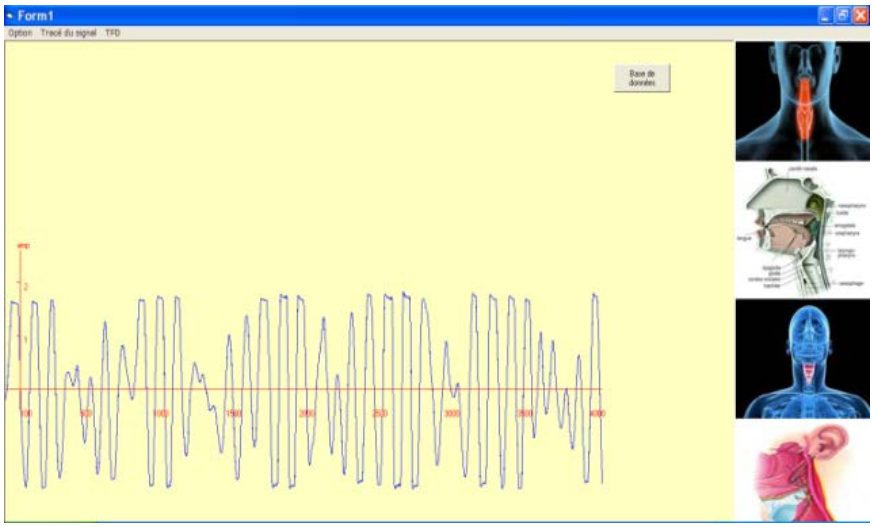

Figure2. Temporal layout of vocal signal of a healthy subject

Figure 3. Frequency layout of vocal signal of a healthy subject

The average fundamental frequency is: **200.60 HZ** and jitter is**: 0.69Sec**

The fundamental frequency established by gliding average method and jitter [3] is given by following equations:

$$F_0 = \frac{1}{N}\sum_{i=1}^{N} F_0^{(i)}$$

$$\text{jitter} = \frac{\frac{1}{N-1}\sum_{i=1}^{N-1}\left|T_s^{(i)} - T_s^{(i+1)}\right|}{\frac{1}{N}\sum_{i=1}^{N} T_s^{(i)}}$$

When N is the selection number (N=6).

3.2 Sick subjects

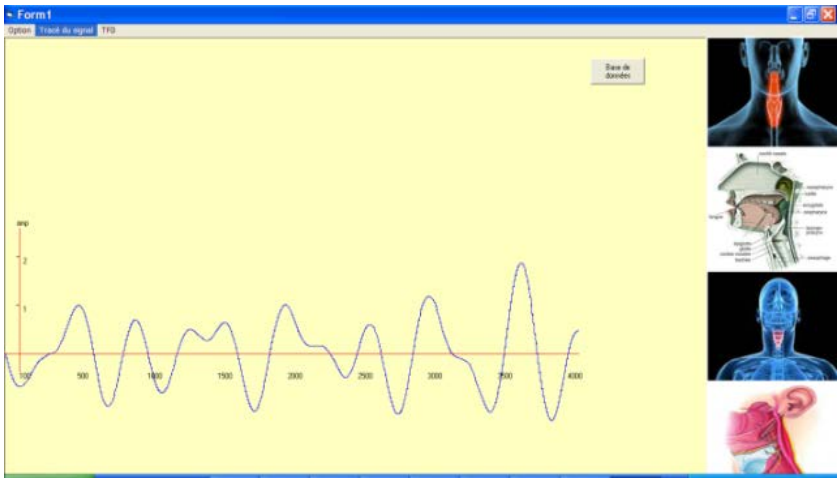

Figure 4: Temporal layout of patient attains a larynx cancer

Figure 5: Frequency layout of vocal signal of a patient whose attains a larynx cancer

The averaged fundamental frequency is: **62.48 HZ** and jitter is: **2.62.**

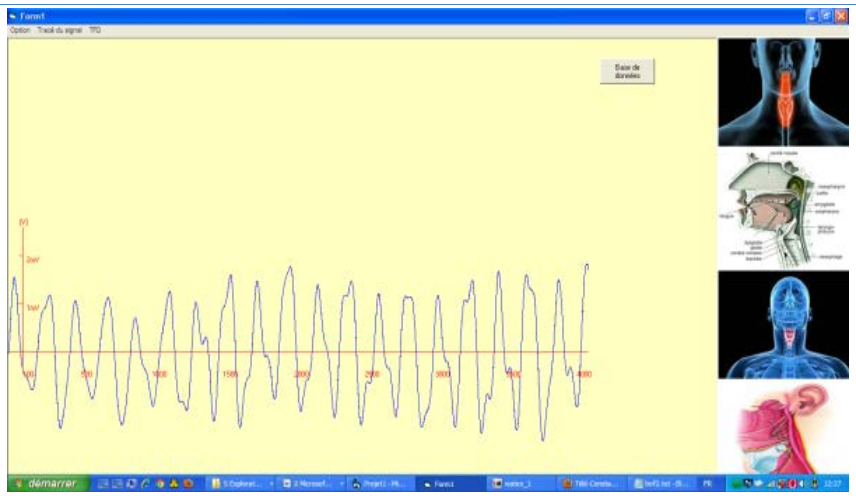

Figure 6: Temporal layout of patient attains an inflammatory polyp

Figure 7. Frequency layout of vocal signal of a patient whose attains a larynx cancer

The average fundamental frequency is: **118.80 HZ** and jitter is: **1.59 Sec**

3.2 Distant sustained of the patient:

The patient treated by the radiotherapy (persons suffering from cancer) or by medical treatment (a patient presents a clinical inflamed syndrome) and whose living in isolated area especially the north polar can be monitored remotely through the implementation of a platform at health centers proximities through periodical recording of the acoustical signal vocal according to the precedent described protocol and its O.R.L department of University Hospital accordance with the architecture client-server hold up by the component Winsock compatible with the protocol TCP/IP which permitted the transmission of the data toward intranet or internet thus the patient avoiding the inutile movement a condition that he responds favorably to the instituted treatment.

4. RESULTS

Table 1 : The jitter and the average fundamental frequency of healthy subjects

Healthy subjects										
Fundamental frequencies F0(HZ)	1st subject	2nd subject	3rd subject	4th subject	5th subject	6th subject	7th subject	8th subject	9th subject	10th subject
	Male								Female	
1st selection	227.05	200.65	190.09	184.81	216.49	205.93	184.81	211.21	200.65	190.09
2nd selection	184.81	211.2	184.8	211.21	184.81	179.53	205.93	190.09	211.2	184.8
3rd selection	184.81	184.8	184.8	179.53	200.65	221.77	227.05	195.37	184.8	184.8
4th selection	227.05	184.8	216.49	184.81	221.77	205.93	211.21	216.49	184.8	216.49
5th selection	195.12	211 .4	184.81	211.21	200.65	184.81	195.37	179.53	184.81	184.81
6th selection	184.8	195.37	211.21	184.8	184.81	205.93	195.37	195.37	195.37	211.21
The average fundamental frequencies (HZ)	200.6	198.03	196.68	192.72	201.53	200.65	203.29	198.01	193.59	195.36
Jitter (sec)	0.69	0.67	0.68	0.67	0.77	0.68	0.61	0.79	0.7	0.68

Table 2 : The jitter and the average fundamental frequency of sick subjects

Sick subjects										
Fundamental frequencies Fs (HZ)	1st subject	2nd subject	3rd subject	4th subject	5th subject	6th subject	7th subject	8th subject	9th subject	10th subject
	Larynx cancer						Inflammatory pathology			
1st selection	73.92	58.08	68.64	47.52	47.52	50.52	105.6	121.44	105.6	174.25
2nd selection	73.92	47.52	47.52	52.8	63.36	67.36	147.85	105.6	137.29	163.69
3rd selection	52.8	47.5	47.52	52.8	47.52	50.52	126.73	110.88	126.73	142.57
4th selection	73.92	42.24	68.64	47.58	58.08	58.08	142.57	100.32	110.88	174.81
5th selection	63.36	42.24	68.64	58.08	63.36	68.64	105.6	137.29	121.44	163.69
6th selection	73.92	47.52	73.92	58.08	68.64	47.52	110.88	137.29	105.6	142.57
The average fundamental frequencies (HZ)	68.64	47.51	62.48	52.81	58.08	57.10	123.20	118.8	117.92	160.17
Jitter (sec)	2.64	2.22	2.62	2.4	2.69	2.65	1.5	1.59	1.55	1.03

5. DISCUSSIONS

We notice that for the healthy subjects the fundamental frequency is about 200 Hz corresponding to the value of the physiological fundamental frequency of the vowel 'a' [14] and jitter is around 0.7 Sec. On the other hand it's reduced in the persons suffering from cancer it's situated around 60HZ and jitter extend to 2.5Sec. This diminution of the fundamental frequency and the augmentation of jitter are also present in the case of chronicle inflamed diseases of the larynx but a lower degree F_s around the interval 100-160 HZ and jitter around the interval 1-1.6 Sec .Even the extended spectral is lower in cancerous patients because of an important reduction notice Even the extended spectral is lower in cancerous patients because of an important reduction with a total absence of the vibrations of vocals cords . This limitation of the

content of the frequency is also present but with a truncated manner in the case of chronicle inflamed diseases of larynx.

6. CONCLUSION

Characterization and objective assessment of chronic dysphonia were studied using three parameters. The fundamental frequency was around 120 Hz and the jitter was around 1.2 sec in cases of inflammatory disease, while the frequency was low at around 60 Hz and the jitter increased to 2.5 sec in larynx cancer, where the jitter was three times higher than healthy subjects. The clinical and para-clinical examinations, notably the pathological diagnosis, were in perfect agreement with the evolution of their indices. Clinical validation of the results is still subject to much larger samples supported by a rigorous statistical support.

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