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Telemonitoring of Four Characteristic Parameters of Acoustic Vocal Signal in Patients with Tumor or Inflammatory Chronic Dysphonia

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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 that we design an experimental protocol which consists of the recording and the archiving of the acoustic voice signal by means of the software environment Audacity which makes it possible to deliver a temporal signal under format WAVE. Our contribution consisted of the implementation, under the Visual Basic environment, of an algorithm that allows performing the analysis of a spectro-temporal acoustic voiced speech signal in this case the vowel "a" sustained for three seconds.*

We applied this algorithm on 10 healthy subjects and 10 pathological subjects of whose 7 with cancer of the larynx, one with chronic laryngitis and one presenting an inflammatory polyp of the vocal cords. The results obtained show a variability of spectro-temporal characteristics between healthy and pathological subjects and prone pathological between them according to the nature of the lesion in particular with regard to spectral content evaluated by Short-Time discrete Fourier Transform STD.FT, Disturbances in the medium term STD, Disturbance of short-term speech signal (jitter) and the fundamental frequency Fs averaged over several frames of the voiced signal.

Keywords: *STD, STD- FT, dysphonia laryngeal, voiced sound; jitter, fundamental frequency.*

I. Introduction

Assessing the quality of voice and perception of the causes of its degradation through various indices voice has always been the main concern clinical speech pathologists. However, the voice and speech is in essence made to be heard, the subjective evaluation "listening" to "clinical ear" of the expert remains the reference face of objective assessment methods. Today, the voice treatment is a fundamental component of the engineers sciences .it takes place between digital and language treatment i.e. (symbolical data treatment), since the 60’s, this scientific field has known a dazzling expansion linked to the development of the information and communication technical tools [1][4]. Among the voice treatment applications we distinguish [5] [6]:

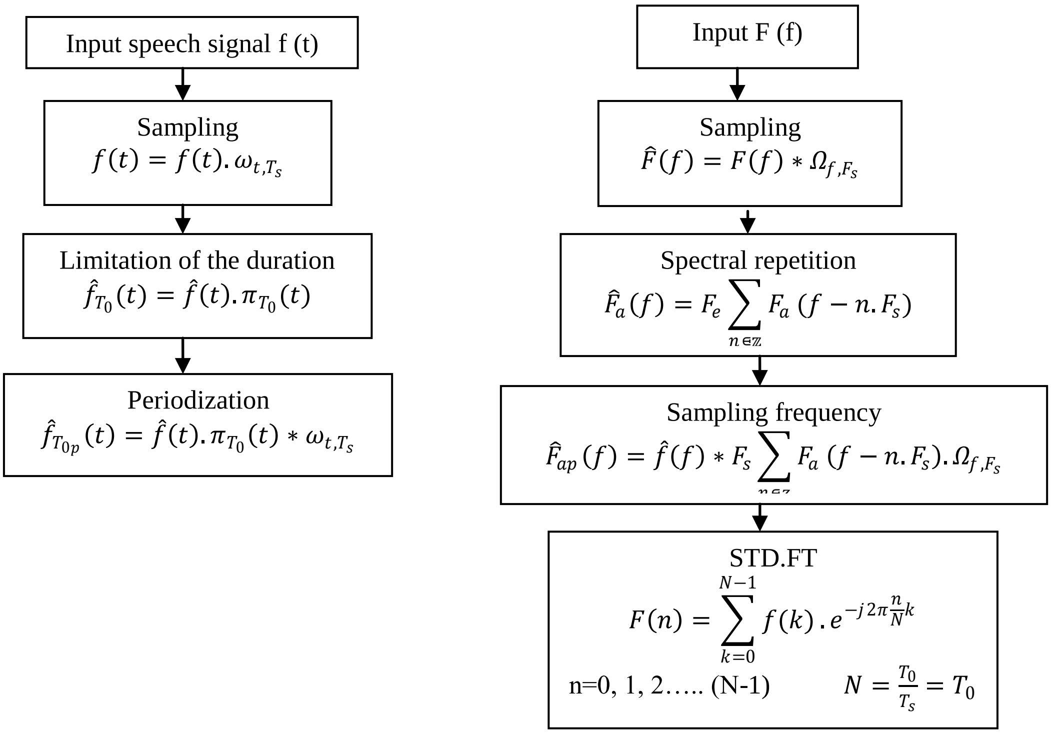
1) Temporal spatio-spectro analysis of the vocal signal observing the objective characterization of dysphonia of laryngeal origins [9] [10].
2) Quantitative estimation of characteristics parameters of the vocal signal during its acoustical representation especially the fundamental frequency of voiced sounds and its dispersion expressed by the factor STD, tones, formant, jitter and shimmer [7][11][12].

II. Materiel And Methodes

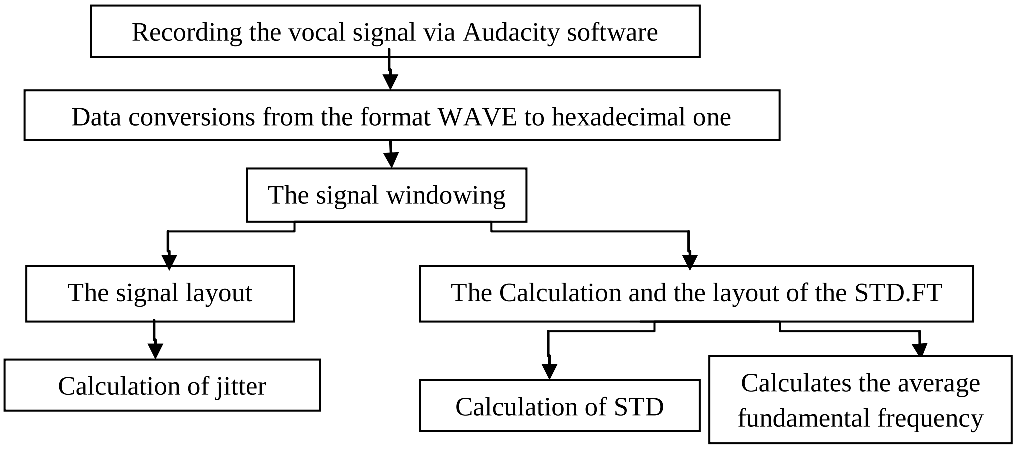
A telemedical plat-form was realized to the acquisition ,archiving and speech signals transfer also to construct an interactive data base in order to explore , observe the dysphonia of laryngeal origin and supervise the treatment especially tumors cases. According to this we’ve developed an algorithm that takes care of:

1. The transformation of the format WAVES to the HEXADECIMAL one coded upon the 16 bits with a sample frequency of 8KHZ.
2. The calculation of the discrete Fourier transform in reduced delay STD.FT according to the order 12 [13] [8].
3. The calculation of the averaged fundamental frequency on 6 selections (moving average), jitter and STD.
4. The adjustment of interactive data base of acoustical vocals signals physiological and pathological according to a clinical, epidemiological study for a best therapeutically taking charge.

2.1. Algorithm of the STD.FT[2][3]



2.2. Global algorithm of the application:



2.3. Sample presentation

The incoming corpus in the experimental protocol constitute of:

- The tenth subjects don't represent a particular laryngeal pathology (six subjects of masculine sex and tow one feminine sex aged from 40 to 60 years old)
- Tenth subjects of masculine sex patients aged from 40 to 80 years old (six subjects represent larynx cancer in the third and fourth stage, a three case of chronicle laryngitis and a case of inflamed polyps of vocal cords).

III. Results And Clinical Evaluation

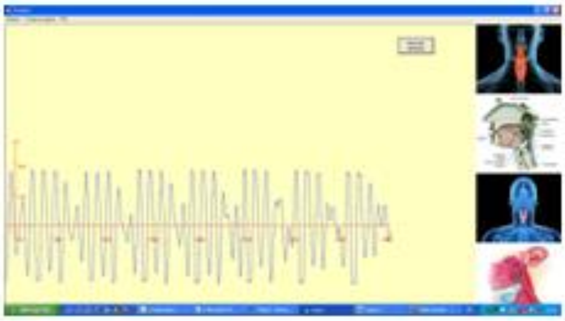


Fig.1: Temporal layout of vocal signal of a healthy subject

Fig. 2: Frequency layout of vocal signal of a healthy subject

The average fundamental frequency is: **200.60 HZ jitter: 069sec and STD: 13.94Hz**

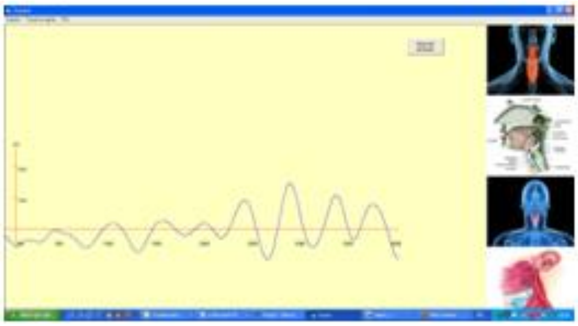


Fig.3: Temporal layout of vocal signal of a subject whose attains a larynx cancer

Fig.4: Frequency layout of vocal signal of a subject whose attains a larynx cancer

The average fundamental frequency is: **62.48 Hz,** jitter is**: 2.62sec** and STD is**: 4.5Hz**

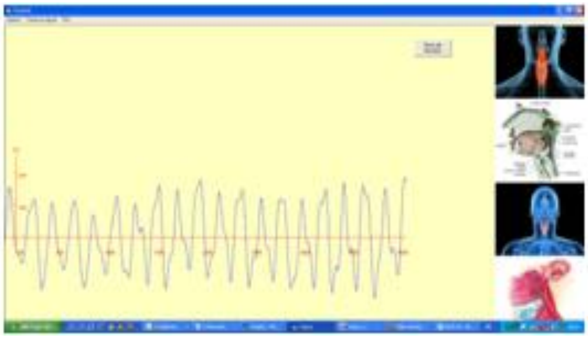


Fig.5: Temporal layout of vocal signal of a subject whose attains an inflamed polyps

Fig. 6: frequency layout of vocal signal of a subject whose attains an inflamed polyps

The average fundamental frequency is: **118.80 HZ.** Jitter is**: 1.59sec** and STD is**: 9.97Hz**

3.1. 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 could be distant sustained thank to platform implantation at near the health centers .And thank to the 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.

IV. Summary Of Results

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

Healthy 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*
	Male sexe								***Female sexe***	
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
STD (sec)	13.94	13.58	13.29	13.2	12.93	13.49	13.17	13.17	12.44	13.28

Table 2 : The jitter, STD 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	.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	1.03	2.69
STD (sec)	4.97	5.28	4.5	4.29	4.31	4.78	8.97	9.97	8.13	10.31

4.1. Results discussions:

This work was done in collaboration with doctors in ORL, ORL department of the University Hospital Tlemcen.

- In healthy subjects, the fundamental frequency was situated around 200 Hz, STD about 13Hz and Jitter extend to 0.7 sec Corresponding to the physiological frequency of vowel 'a'.
- In patients with the cancer of vocal cords, the fundamental frequency was significantly reduced to 60 Hz, while the STD was greatly decreased to 4Hz, and the jitter was increased to 2.5 sec.
- In the inflammatory polyp of vocal cords, fundamental frequency slightly decreased to 160 Hz, while STD was slightly decreased to 10 Hz. and jitter was slightly increased to 1.03sec.
- In patients with inflammatory disease (chronic laryngitis), the fundamental frequency was reduced to 120Hz, and STD decrease around 8 Hz and jitter was increased slightly to 1.5 Sec
- The spectral range was significantly diminished in cancer patients due to the total absence of vibration of vocal cords. This limitation of frequency range was also present but truncated in the case of chronic inflammatory disease of the larynx.

V. Conclusion

The analysis of the signal vocal treatment in accordance with screening and sustain of the vocals dysphonia stay a vast domain of research.

The aim of this work was to design and implement a human-machine interface dedicated to the objective evaluation of laryngeal dysphonia through the spectro-temporal characterization of the acoustic vocal signal.

For this we have developed:

- An acquisition system using the sound card-driven by environment software Audacity permitted in particular a passer-by sonorous bandaged extending from 0 to 4 kHz with a sampling frequency of 8 kHz and a voice signal recording format WAVE.
- A WAVE format converted to HEX format16-bit

- An experimental protocol based on the emission of a sustained voiced sound for 3 seconds in the occurrence the vowel 'a' the most commonly used in this kind of exploration of the voice. An application of digital treatment of the vocal signal by implementing an algorithm for calculating the Short-Time discrete Fourier Transform (STD.FT) and the detection of the jitter, STD and the fundamental frequency (Fs) averaged over 6 frames. This represents the frequency factor of the sound at around 200 Hz, the STD 13 Hz and the jitter at around 0.7 Sec in adult healthy subject.
- Results in concordance with those are found in the bibliography
- The jitter, STD and the fundamental frequency present a large variability in subjects with vocal cord pathology.
- This variability of parameters (Fs, jitter, STD) seems largely different depending on the type of disease that is inflammatory or tumor.
- These recordings performed in vivo and in situ at the ORL department of the University Hospital Tlemcen allowed us to start developing a database on classification of laryngeal pathologies as inflammatory or tumor type for an early detection of laryngeal cancer and its prevention by the epidemiological study of predisposing factors.

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