International Journal of Luminescence and Applications (ISSN: 2277-6362)
Vol. 7, No. 3-4, October - December 2017. Article ID: 261. pp.519-520.

A Heart Speech Model Based on Correlation between Heart Parameters and Speech Features Extracted from Speech Signal Analysis

Kavita Thakur and **Anjali Deshpande**

Abstract— *This paper presents the heart speech model with the mathematical modeling of speech production for acoustical monitoring of human cardiac functioning. The speech production mechanism is analogous to the vacuum tube oscillator in that it converts a direct current flow into pulsating flow. The modeling of speech production mechanism is based on Webster's equation in the modified form which provides the mathematical model of vocal tract. The modeling of heart is done. The electrical activities of heart are analysed through Electrocardiogram. A correlation exists between speech features like pitch, Formant frequencies and important heart parameters. Based on this a heart speech model has been proposed in this work.*

VOCAL TRACT MODELING

The vocal tract model is assumed to have three main blocks: an oral cavity, a glottal source, and an acoustic impedance at the lips.

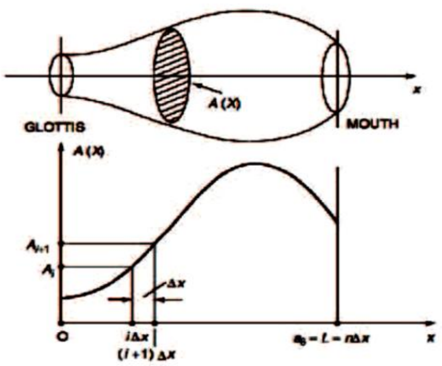

Fig. 1

We shall consider them singly first and then in combination. As is commonly done, we assume that the behavior of the oral cavity is that of a lossless acoustic tube of slowly varying (in time and space) cross-sectional area, A(x), in which plane waves propagate in one dimension. [Sondhi] and [Portnoff] have shown that under these assumptions, the pressure, p(x, t), and volume velocity, u(x, t), satisfy

$$-\frac{\partial p}{\partial x} = \frac{\rho}{A(x,t)}\frac{\partial u}{\partial t}$$

$$-\frac{\partial u}{\partial x} = \frac{A(x,t)}{\rho c^2}\frac{\partial p}{\partial t} \quad (1)$$

which express Newton's law and conservation of mass, respectively. In above stated equation ρ is the equilibrium density of the air in the tube and c is the corresponding velocity of sound. Differentiating (eq:1) and (eq:2) with respect to time and space, respectively, and then eliminating the mixed partials, we get the well-known Webster equation [Webster] for pressure,

$$\frac{\partial^2 p}{\partial x^2} + \frac{1}{A(x,t)}\frac{\partial p \partial A}{\partial x \partial x} = \frac{1\partial^2 p}{c^2 \partial t^2} \quad (2)$$

The eigenvalues of (eq:3) are taken as formant frequencies. It is preferable to use the Webster equation (in volume velocity) to compute a sinusoidal steady-state transfer function for the acoustic tube including the effects of thermal, viscous, and wall losses. So we let p(x, t) = P(x,ω) & u(x, t) = U(x,ω), where ω is angular frequency. When p and u have this form, (eq:1) and (eq:2) become (cf. [Rabiner, L.R.and Schafer, R.W.]) and p(x, t) = P(x,ω)

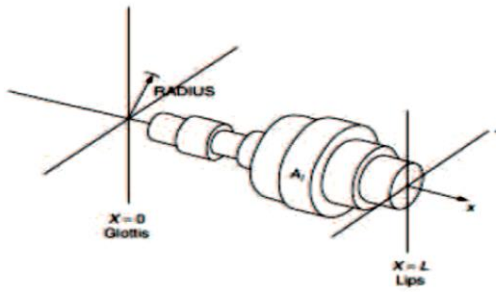

Fig. 2

u(x, t) = U(x,ω) (5)

respectively. In order to account for the losses we define Z(x,ω) and Y(x,ω) to be the generalized acoustic impedance and admittance per unit length, respectively. Differentiating (eq:5) with respect to x and substituting for−dp dx and P from (eq:4) and (eq:5), respectively, we obtain

$$\frac{d^2U}{dx^2} = \frac{1}{Y(x,\omega)}\frac{dU}{dx}\frac{dY}{dx} - Y(x,\omega)Z(x,\omega)U(x,\omega) \quad (6)$$

This is recognized as the "lossy" Webster equation for volume velocity. The sinusoidal steady-state transfer function of the vocal tract can be computed by discretizing (eq:6) in space and obtaining approximate solutions to the resulting difference equation for a sequence of frequencies. By considering the boundary conditions & the fact that the spectral envelope decreases as the square of frequency. It is convenient to solve (eq:6) with its boundary conditions For the boundary condition at the mouth, the well-known [Portnoff] and [Rabiner and Schafer] relationship between sinusoidal steady-state pressure and volume velocity, is used.

$$P(L,\omega) = Zr(\omega)U(L,\omega) \quad (19)$$

Here the radiation impedance Zr is taken as that of a piston in an infinite plane baffle, the

behavior of which is well approximated by

$$Z_r(\omega) = \frac{j\omega L_r}{\left(\frac{1+j\omega L_r}{R}\right)} \quad (20)$$

Values of the constants which are appropriate for the vocal tract model are given by [Flanagan] s

$$R = \frac{128}{9\pi^2} \quad (21)$$

nd

$$L_r = 8\,[A(L)/\pi]^{\frac{1}{2}}\,/3\pi c \quad (22)$$

t is convenient to solve (eq:6) with its boundary conditions (eq:19) and (eq:20) by solving a elated initial-value problem for the transfer function

$$H(\omega) = U(L,\omega)/U(0,\omega) \quad (23)$$

$$-\frac{dU}{dx}|_{x=L} = \frac{A(L)}{\rho c^2}(j\omega)P(L,\omega) \quad (24)$$

rom which the frequency domain difference equation is

$$-\frac{U_n^k - U_{n-1}^k}{\Delta x} = jk\Delta\omega\frac{A_n}{\rho c^2}P_n^k \quad (25)$$

been derived. Let it be noted from (eq:21), finally, the vocal track output is obtained by (eq:26)

$$\xi(x,t) = e^{1/2\frac{\left(-b+\sqrt{b^2-4k(x)M}\right)t}{M}} + e^{-1/2\frac{\left(b+\sqrt{b^2-4k(x)M}\right)t}{M}} - \frac{1}{\sqrt{b^2-4k(x)M}}$$
$$-\left(\int p(x,t)e^{1/2\frac{\left(b+\sqrt{b^2-4k(x)M}\right)t}{M}}dt\right)e^{-1/2\frac{\left(b+\sqrt{b^2-4k(x)M}\right)t}{M}}$$
$$+\left(\int p(x,t)e^{-1/2\frac{\left(-b+\sqrt{b^2-4k(x)M}\right)t}{M}}dt\right)e^{1/2\frac{\left(-b+\sqrt{b^2-4k(x)M}\right)t}{M}}\left(e^{-\frac{bt}{M}}\right) \quad (26)$$

Here, p represents pressure, $k(x)$ - Damping coefficient, M - Mass of speech, $\xi(x,t)$ - resultant Value. [NRR]

2. HEART - SPEECH MODEL

Heart – speech model has been developed based on the following facts-

1. Cardiovascular system is to continuously pump blood through the body, to supply the oxygen needed to function.
2. The heart rate is the heart beat/ minute to pump the blood into the body (65 – 75 / min. in adults).
3. The respiratory system is made of lungs and fibrous tubes that carry oxygen and carbon-di-oxide in and out of the body. Breathing or respiratory rate is the number of breaths taken per minute (10 -20 / min.).
4. With the workload the body tissue requires more oxygen. To meet the requirement heart speeds up. Heart rate increases and more oxygen is needed to meet this breathing rate increases to supply extra oxygen.
5. Speaking, talking also increase workload on the system. Thus the phenomena of speech energy can be represented by a closed control loop model as shown in the Figure 3.

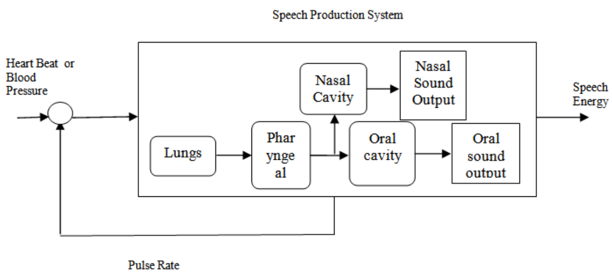

Fig. 3: Heart speech model