The mechanism of voice production and hints to vocal-music research

C. Julian Chen

Columbia University, jcc2161@columbia.edu

Abstract

In 1957, French physiologist Philippe Fabre invented the electroglottograph, which can accurately determine the closing and opening instants of the glottis *in vivo*. In 1984, Donald Miller and Harm Schutte further placed two pressure sensors immediately above and below the glottis, measured the air pressures across the glottis. The experimental evidence enabled a scientific understanding of human voice production. A refined version of the transient theory of human voice production, the timbron theory, initially proposed by Leonhard Euler in 1727, is established. In this lecture, experimental facts and the timbron theory of human voice production are presented using graphics with little mathematics. According to that theory, the time between two adjacent glottal closing instants accurately defines the pitch period, and the sound waveform in each pitch period contains full information on the timbre. A method of extracting glottal closing instants from sound waves and a graphical display, the pitch-synchronous spectrogram, are presented. Among the samples of human voice, the sound recordings of Luciano Pavarotti are analyzed. Some characteristics of the master singer are shown, and hints of how to improve the quality and volume of voice are presented. Finally, the theory and parametrization method for human voice developed in early 20th century, the source-filter theory and linear prediction coefficients (LPC), are outlined. Comparing with the more accurate timbron theory and pitch-synchronous parametrization method, the deficiencies of the source-filter theory and the LPC method are discussed.

Biography

C. Julian Chen received a PhD in Physics from Columbia University in 1985, then joined IBM Research Division as a Research Staff Member. In 1993, He published *Introduction to Scanning Tunneling Microscopy*, a recognized "bible" of nanoscience. In 1994 he switched research focus to human voice, received an Outstanding Innovation Award from IBM in 1998 for breakthroughs in speech technology. In 2007 he joined Department of Applied Physics of Columbia University, continuing research on human voice by collaborating with Donald Miller of Groningen Voice Research Laboratory. In 2016 he published a monograph *Elements of Human Voice*. By degree and profession, he is a physicist. Nevertheless, he was a private student in music composition of Professor Cheng Maojun, the composer of the Anthem of the Republic of China (Taiwan). In leisure time, he often directs amateur choirs and accompanies singers.