A pitch extractor with larynx pick-up

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journal: STL-QPSR
volume: 5
number: 3
year: 1964
pages: 032-034

http://www.speech.kth.se/qpsr
III. AIDS FOR THE DEAF
I. A PITCH EXTRACTOR WITH LARYNX PICK-UP

Introduction

Efficient techniques for phonation and intonation training of the deaf and hard of hearing are strongly needed. Some attempts have been made to use electronic pitch extractors for this purpose\(^1\)(2)(4)(5). Few results are published, but it seems likely that a reliable and simple pitch extractor would be useful to those deaf school teachers who are engaged in advanced methods of speech training.

Sugimoto and Hiki\(^7\) and later on Porter\(^6\) have indicated a simple way to extract pitch pulses. They used a larynx microphone coupled to the throat by means of a small air cavity. These techniques allow extraction of pitch pulses comparatively free from the influence of articulation and at least 20 dB better S/N-ratio than when using the oral wave directly. Almost complete rejection of unvoiced sounds is also achieved. The increased S/N-ratio is an important feature when the background noise is appreciable as for example in a classroom. Another advantage is that the discriminating circuits in the pitch meter can be made relatively simple.

This principle has been adopted in our pitch extractor which displays a pitch frequency-time curve on an oscilloscope with long persistence screen. The device is primarily intended for speech training of deaf subjects but could also be valuable in any speech processing system that can be operated with a larynx microphone.

Microphone

The main difficulty of the larynx microphone is to find a suitable microphone which besides being cheap and mechanically robust has a good low frequency response, down to about 80 c/s. Many different microphones have been tested with respect to a stable reproduction of the voice fundamental. The one we found best was a small electrodynamic system made by Pearl\(^*\), (Type 3500). The microphone has been mounted in an aluminum case (see Fig. III-A-1) and is coupled to the throat via an air cavity. The problem is to get an airtight connection between microphone and throat, in

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LARYNX MICROPHONE

Fig. III-A-1.
order not to lose the low frequency response. This was solved by using a rubber ring which gave a reasonably satisfactory fit.

The most suitable microphone position was found to lie on the center line of the throat below the larynx (see Fig. III-A-2). This is about the same position as found by Sugimoto, Hiki and Porter. Samples of the tracheal signal directly from the microphone are shown in Fig. III-A-4.

Since the pitch meter is intended for speech training it was designed to be as flexible as possible with respect to readout possibilities. Besides the cathode ray tube display of pitch frequency versus time, the pitch frequency can be read directly on a meter. A third dimension is incorporated by pitch amplitude which is made visible on the monitor as a broadening of the pitch trace. This may be reduced to a simple amplitude-time display by disconnecting the frequency signal. Samples of such three-dimensional diagrams are shown in Fig. III-A-5. For pedagogical reasons a second channel has been added (for the teacher) and both channels are connected to the display by means of a time multiplex. The position of the two traces can be adjusted independently and thus can be made to coincide, even though the frequencies differ.

The pitch pulses can also be presented through earphones and the frequency may be divided by 2, 3 or 4, which might be useful if the subject has residual hearing in a very low frequency range only.

**Block diagram** (see Fig. III-A-3)

The amplified microphone signal is fed into a discriminating circuit consisting of two simple cascaded peak detectors. These have the advantage of an instantaneous pulse detection and a dynamic range of almost 40 dB without compression amplifier. Nor does the instrument require skilled manipulation, as there are no filters or volume controls to be adjusted. A voltage level sensor (Schmitt-trigger) shapes the pulses and a one-shot multivibrator gives the pulses uniform width. The signal is then integrated, logarithmated and connected to the oscilloscope via a time multiplex.
(a) Correct microphone position.

(b) Complete instrumentation.

Fig. III-A-2
BLOCK DIAGRAM FOR CHANNEL 1

FREQUENCY

AMPLITUDE

Pulse generator

Flip Flop

To channel 2

To display

Fig. III-A-3.
Fig. III-A-4. Larynx microphone signals for various vowels.
Fig. III-A-5. Intonation contour with superimposed voice amplitude width-modulation.
(a) Änden and (b) ånden, examples of Swedish one- and two-syllable tone accents.
The pitch meter may be regarded as the first step towards a simplified instrumentation for use in Schools for the Deaf. There remains, however, to find out how to present the data in the most meaningful way. This problem is now studied in an experiment at the State School for the Deaf in Stockholm.

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References:


(8) Tjernlund, P.: "Grundtonsindikator för dövundervisning", Thesis work at the Royal Institute of Technology (KTH), Speech Transmission Laboratory, November 1964.