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A PRELIMINARY REPORT ON THE TONGUE DYNAMICS OF DYSARTHRIC PATIENTS

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The tongue shape and its dynamics during speech production have been observed using mainly the X-ray technique . Because of the unfavorable side-effects of X-rays , quantity as well as quality of the data gathered by this method is limited. To overcome this limitation, we have been utilizing the ultrasonic method.[1,2,3] The ultrasonic visualization method can provide a large series of data without any side-effect. In addition, using this method, the dynamic image of the tongue can be displayed on a CRT screen without delay (real time display). This means that the ultrasonic visualization technique can be applied not only for observation purposes, but also as a training tool for dysarthric individuals or for studying foreign language.[4]

Since the ultrasonic device detects the timing delay between the emission of ultrasonic pulses and the reception of the echo reflected at the tongue surface, the visualized image of the tongue is greatly dependent on the angle and the position of the ultrasonic probe (the emitter and the receiver). However, surrounding structures, such as the hard palate, cannot be visualized.

In genral, it is preferable to have a palatal configuration which can serve as a reference for measurement and can provide an indication of the vocal tract shape. We have reported on a system which enables us to observe the superimposed image of the hard palate and the tongue.[5] In order to get the configuration of the hard palate, a specially designed palatal prosthesis was made and photographed. The photo and the ultrasonic tongue image were superimposed by the aid of a computer. For this processing, any movement of the probe was monitored by a Position Sensing Device (PSD), and the coodinates which represented the position and the angle of the probe were entered in the computer. The system is illustrated in Fig.1.

The purpose of present study is to investigate the tongue shape and its dynamics in some dysarthric patients as well as normal subjects. In this paper, the validity of this system and the possibility of its application to evaluate the dysarthric state will be discussed.

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Method and Subjects

A normal adult male and three dysarthric patient (two amyotrophic lateral sclerosis cases and one spinocerebellar dystrophy case) served as the subjects for this study. During the recording session, the ultrasonic probe was held relatively firm on the subjects' skin beneath their submandibular triangle by means of head gear. The position and the angle of the probe were monitored as described above. Prior to the recording session, in order to know the palatal configuration (hard palate), a specially designed palatal prosthesis was made. A subject was asked to put on the prosthesis and photographed laterally.

Result

1. Observation of a normal subject

Figure 2 shows the tongue configurations for the five Japanese vowels uttered by a normal subject. The tongue surface was extracted from the ultrasonic image by an image-processing technique[6)] which is available at the RILP.

The dynamic patterns of the tongue movements were shown in Fig.3. Each line represent the tongue shape recorded at a rate of 12 fields per second. The fields were selected from /e/ to /a/ in the test word /aea/ uttered at a comfortable speaking rate. The numbers attached to each line correspond to consequent fields. It can be clearly seen that the /e/ articulation pattern changes to the /a/ articulation target smoothly and regularly.

2. Observation of pathological cases

Two amyotrophic lateral sclerosis (ALS) and one spinocellebral dystrophy (SCD) cases were studied.

a) ALS

The two cases of ALS discussed here were judged acoustically by a speech pathologist to have almost the same degree of distorted speech. Ultrasonic observations were made for the second vowel in test words which consisted of three vowel syllables, such as /aea/, /aia/ and so forth.

Tongue shapes from the second vowel articulation are shown in Fig.4. In case 2, although the tongue dorsum does not show much difference between the different vowels, the contour of the tongue root has a unique pattern for each of the target vowels. On the other hand, in case 1, the unique articulatory gesture for each target vowels can be seen around the tongue dorsum area and not at the tongue root.

b) SCD

Figure 5 illustrates the movement of the tongue in the transition from /e/ to /a/ for the test word /aea/. The subject was asked to utter the test word at a comfortable speaking rate. The numbers which are attached to each line represnt the consequent fields (12 fields / sec). Comparing the normal case, it can be observed that the duration of the transition is longer and consistecy during a vowel is poor.

Discussion

Although the ultrasonic method has advantages, such as its harmlessness and instant imaging, there are some shortcomings. One of them is that the palate cannot be visualized. We superimposed the hard palate shape and the ultrasonic image of the tongue. In order to superimpose two independent images, positional information is essential. The PSD system, we used in this study, enables us to get the superimposed images of the tongue and hard palate in real time. In this study, the system was used to evaluate the articulatory gesture of the tongue in some pathological cases.

a) ALS

The speech symptoms of this pathology are characterized by slowness in speaking rate and distortion of syllables.[7] Although an auditory judgment of the two ALS cases in this study indicated almost the same degree of distortion, their tongue gestures were different each other. It could be suggested that different methods of speech training for different dysarthric patients should be designed based on an evaluaton of these articulatory dynamics.

b) SCD

It has been reported that uncoordinated movement and dysmetria are the main clinical symptoms of SCD. As far as the tongue is concerned, inconsistent articulatory gestures and irregular movements of the tongue were observed in this particular patient. These observations indicate that uncoordinated movements and dysmetria are reflected in the tongue movements during speech.

In conclusion, the ultrasonic technique combined with the PSD system can be used to evaluate pathological articulation and can be used as a training tool for dysarthric patients.

References

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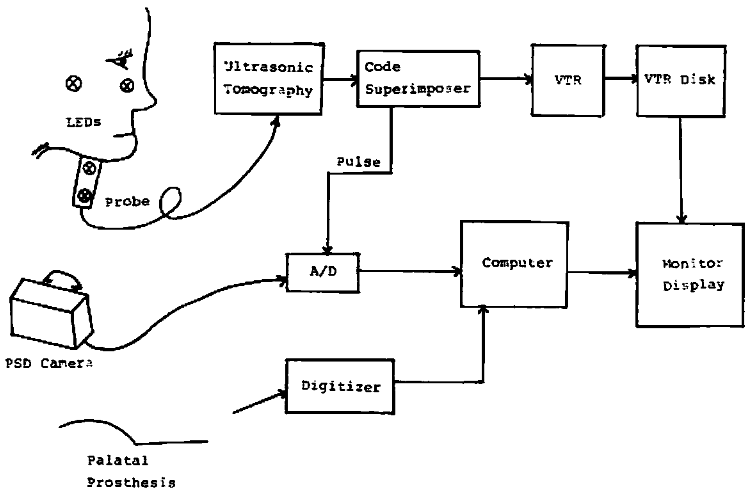


Figure 1. A block diagram of the system.

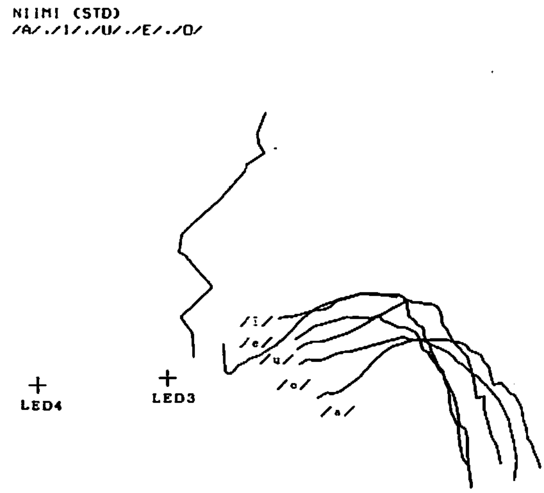


Figure 2. The tongue configurations for the five Japanese vowels.

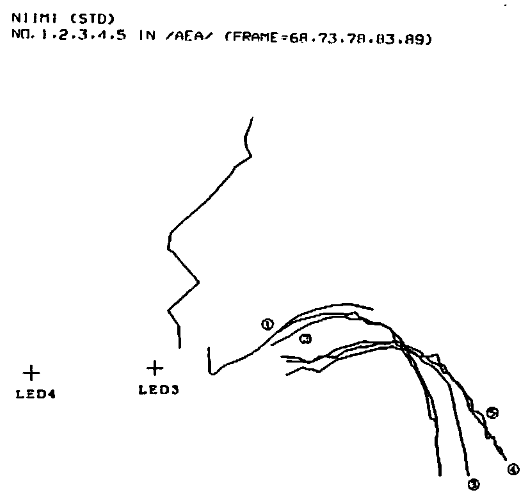
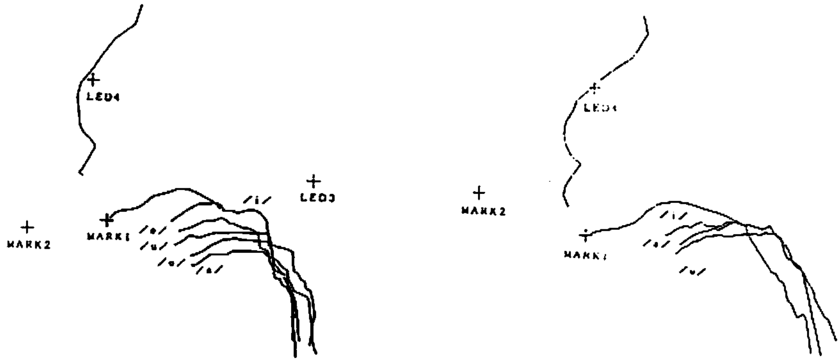


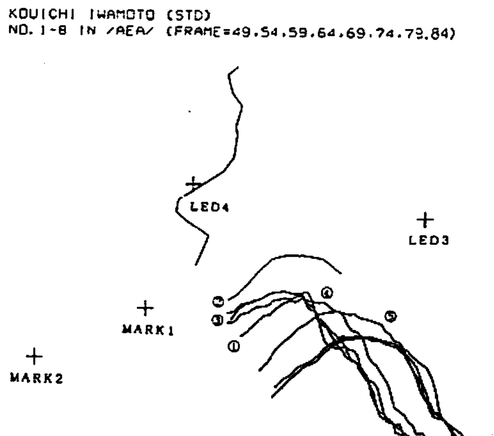
Figure 3 Sequential tongue configurations from /e/ to /a/ in a test word /aea/.



ALS: 1

ALS: 2

Figure 4. The tongue configurations for the Japanese vowels uttered by two ALS patients.



SCD

Figure 5. Sequential tongue configurations from /e/ to /a/ in a test word /aea/ uttered by a SCD patient.