DEVELOPMENT OF A PC-BASED ELECTROPALATOGRAPH SYSTEM FOR SPEECH THERAPY

(PEMBANGUNAN SISTEM ELEKTROPALATOGRAF UNTUK TERAPI PERTUTURAN BERASASKAN KOMPUTER)

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(Keywords: speech therapy, electropalatograph, contact pattern, word pronunciation)

People who have difficulties with speech can learn to pronounce word more clearly by using electropalatograph (EPG). The EPG is a device that uses an artificial palate worn against the roof of the mouth, which is able to detect tongue contact and enable the analysis of these contact patterns. The tongue contact is displayed on PC screen in tongue-palate contact pattern. By watching the tongue contact and comparing it with standard tongue positions, people with impaired speech can learn how to shape different sounds.

Thus, the aim of this study is to investigate the tongue-palate contact pattern of alphabets pronunciations in Malay. The patterns are then analyzed to classify the patterns obtained from the experiment. The tongue-palate contact patterns are modeled using 62 touch sensors which represent the contact points on the mouth palate (roof). The outcome of the work is applicable for individuals with speech difficulties. Results showed that the pattern can be acquired and compared using fast computing devices like the PC to display the contact patterns.

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PEMBANGUNAN SISTEM ELEKTROPALATOGRAF
UNTUK TERAPI PERTUTURAN BERASASKAN KOMPUTER

(Kata kunci:terapi petuturan, elektropalatograf, corak sentuhan,sebutan perkataan)

Orang yang mempunyai kesulitan untuk bertutur boleh belajar menyebut perkataan dengan lebih jelas menggunakan elektropalatograf (EPG). EPG adalah satu alat/peranti yang menggunakan plat gunaan yang dilekatkan di lelangit, dimana ia boleh mengesan sentuhan lidah. Ini membolehkan analisis dibuat ke atas corak sentuhan tersebut. Corak sentuhan lidah-lelangit pula dipaparkan dia atas skrin computer. Dengan melihat corak sentuhan lidah dan membandingkannya dengan kedudukan sentuhan lidah yang normal, seseorang yang bermasaalah bertutur boleh mempelajari bagaimana untuk membentuk bunyi yang berlainan.

Oleh itu, matlamat penyelidikan ini adalah untuk mengenalpasti corak sentuhan lidah-lelangit dalam konteks sebutan alphabet Melayu. Corak-corak sentuhan yang diperoleh dari eksperimen kemudian dianalisa untuk mengkelaskan corak-corak sentuhan tersebut. Corak sentuhan lidah-lelangit tersebut dimodelkan menggunakan 62 pengesan sesentuh yang mewakili titik sentuhan pada lelangit. Hasil dari penyelidikan ini boleh diaplikasikan untuk individu-individu dengan masaalah pertuturan. Keputusan menunjukkan corak sentuhan boleh diperolehi dan dibandingkan menggunakan peralatan canggih seperti komputer untuk memaparkan corak sentuhan lidah-lelangit tersebut.

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Introduction

1.0   Introduction

Speech station is used by the speech therapist in rehabilitation of a range of communication disorders. It is the combination of three types of speech therapy devices which are Laryngograph (also known as electroglottograph (EGG)), Nasal Airflow System and Electropalatograph (EPG). These devices used different concepts to detect and analyze the speech abnormalities of the speech difficulties patients. Laryngograph detect the vibration of the vocal fold as well as the simple movement of the glottis, nasal airflow measures both nasal and oral airflow, while EPG detect the contact pattern between the tongue and palate during speech. In assistance of the speech station, the effectiveness of speech therapy is much more improved.

Electropalatograph system detects and displays the dynamic motion of the tongue by using an artificial palate applied on the roof of the mouth. The tongue contacts are displayed in terms of tongue-palate contact patterns. EPG is an instrumental technique for determining tongue/palate contact pattern during speech which is an extremely useful tool when used in conjunction with conventional techniques for speech therapy. It also allows objective assessment

by enabling appropriate targeting during therapy, provides visual feedback which assists in therapy and can be extremely motivating for both therapist and patient.

The main applications of EPG are:

i-   training a person with articulation handicaps which might due to auditory and other sensory deficit,

ii-   due to motor coordination problems,

iii-   due to functional articulation difficulties, or

iv-   due to structural abnormalities of the tongue

Besides that, this study is also as a basic phonetic research into lingual articulatory motions and configurations. Both the therapist and patient can use the EPG. The general strategy in using the technique for diagnosis is to compare the patterns of tongue contact for a pathological speaker with the normal pattern.

The EPG used a series of electrodes as the sensors, i.e. when the tongue touches an electrode it completes an electrical circuit and a very low current flow. The grid of electrodes records the position of the tongue 100 times per second. This information is passed to a computer which displays the series of grids that match the arrangement of the electrodes and shows how consonantal stop and fricative articulations develop in time. The contact pattern also can be shown by the number of contacts at a particular area of the palate during the production of speech.

The artificial palate is divided to three zones: the alveolar, the palatal, and the velar area (refer to Figure 1). The EPG contact patterns reveal the stop,

fricative, or lateral approximant articulations in the alveolar region very clearly, as well as palatal and velar articulations. The contact patterns can be shown by the number of the contacts in a particular area of the palate as a function of time.
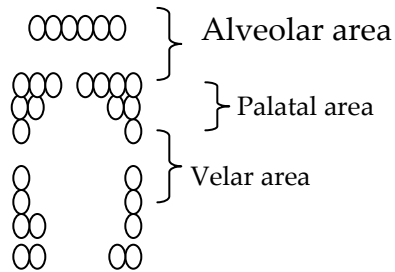

Figure 1 The zones of an artificial palate

1.1   The Tongue

The tongue is a muscular organ in the mouth. It is the primary organ of taste and important in the formation of speech and in the chewing and swallowing of food. The tongue which is covered by a mucous membrane, extends from the hyoid at the back of the mouth upward and forward to the lips. Its upper surface, borders and the forward part of the lower surface are free; elsewhere it is attached to the adjacent parts of the mouth. The extrinsic muscles attach the tongue to external points and the intrinsic muscle fibers, which run vertically, transversely and longitudinally allow it great range of movement. The upper surface is covered with small projections called papillae, which gave it a rough texture. The color of the tongue is usually pinkish-red but discolored by various diseases and this is an indication of health level.

The tongue acts together with the lips, teeth and hard palate to form word sounds. Different sounds require different tongue configurations. By altering tongue position and shape, the size of the oral cavity and therefore its resonating characteristics are changed. It is the most versatile of the articulators being involved in the production of all vowels and the vast majority of consonants.

The versatility of the tongue allows:
i.   horizontal anterior/posterior movement of the body, blade and tip
ii.   vertical superior/inferior movement of the body blade and tip
iii.   transverse concave/convex movement
iv.   spread/tapered contrast in the tongue blade and tip
v.   degree of central grooving

1.2   The Palate

The palate is the roof of the mouth, separating the mouth from the nasal cavities. The palate consists of two portions: the hard palate in front and the soft palate behind. The hard palate is formed of *periosteum*, a bony plate covered by mucous membrane and arches over to meet the gums in front and on either side. The soft palate is a movable fold of mucous membrane enclosing muscular fibers.

The condition called cleft palate is a birth defect that results from incomplete development of the palate. It is characterized by a hole or gap in the palate that may extend from behind the teeth to the nasal cavity.

1.3   The EPG

EPG is a device that uses an artificial palate applied to the hard palate to detect and display the dynamic motions of the tongue. Electropalatography is an instrumental technique for determining tongue/palate contact pattern during speech. EPG is extremely useful additional tool when used in conjunction with conventional therapy techniques. Electropalatography allows objective assessment and enabling appropriate targeting of therapy. It provides visual feedback, which assists in therapy and can be extremely motivating for therapist and patient. Besides, it gives an objective measurement of outcome, which is an increasingly important consideration for therapist.

Both therapist and patient can use EPG. The general strategy in using the technique for diagnosis is to compare the patterns of tongue contact for a pathological speaker with those of normal speaker and to interpret the differences in terms of lingual gestures.

1.4   Objectives of the Study

The objectives of the study to develop a model of EPG system and design a software that will display the tongue-palate contact pattern on PC screen.

1.5   The Scopes of the Study

i.   The study used Turbo C++ programming to map the tongue-palate contact pattern to the computer screen for comparison and analysis.

ii.   The artificial palate used 62 touch sensors to detect the tongue contacts.

Chapter 2

Paper Published

Modeling of Electropalatograph System for Speech Therapy

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Abstract

This paper presents a model of electro-palatograph (EPG) system for speech therapy. The aim of this study is to investigate the tongue-palate contact pattern of alphabets pronunciations in Malay. The patterns are then analyzed to classify the patterns obtained from the experiment. The tongue-palate contact patterns are modeled using 62 touch sensors which represent the contact points on the mouth palate (roof). This preliminary study is to collect some information on the contact pattern based on the Malay words pronunciations. The outcome of the work is applicable for individuals with speech difficulties. Results showed that the pattern can be acquired and compared using fast computing to display the contact patterns.

1. Introduction

Speech station is used by the speech therapist in rehabilitation of a range of communication disorders. It is the combination of three types of speech therapy devices which are Laryngograph (also known as electroglottograph (EGG)), Nasal Airflow System and Electropalatograph (EPG). These devices used different concepts to detect and analyze the speech abnormalities of the speech difficulties patients. Laryngograph detect the vibration of the vocal fold as well as the simple movement of the glottis, nasal airflow measures both nasal and oral airflow, while EPG detect the contact pattern between the tongue and palate during speech. In assistance of the speech station, the effectiveness of speech therapy is much more improved.

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The main applications of EPG are:
  i.   training a person with articulation handicaps which might due to auditory and other sensory deficit,
  ii.   due to motor coordination problems,

iii.   due to functional articulation difficulties, or

iv.   structural abnormalities (e.g.: cleft palate).

Besides that, this study is also as a basic phonetic research into lingual articulatory motions and configurations. Both the therapist and patient can use the EPG. The general strategy in using the technique for diagnosis is to compare the patterns of tongue contact for a pathological speaker with

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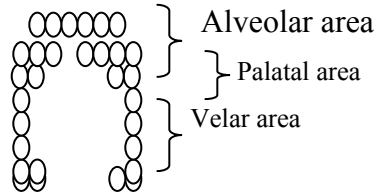
Figure 1 The zones of an artificial palate

2. Approach and Methods

When the tongue touches an electrode, it completes an electrical circuit and a very low current flow. The grid of electrodes records the position of the tongue 100 times per second. This information is passed to a computer which displays the series of grids that match the arrangement of the electrodes and shows how consonantal stop and fricative articulations develop in time. The contact pattern also can be shown by the number of contacts at a particular area of the palate during the production of speech.

In this work, the artificial palate is replaced with 62 touch sensors made of a conductor material which mapped to 62 points on the palate model as illustrated in Figure 2. The result of the contact pattern is also displayed on the computer screen and analyzed to recognize the pattern generated. Actual artificial palate is studded with 62 small electrodes in which each one is 1-2mm. The electrodes are arranged as in or touch sensor model.

The touch sensing input device senses contact from the user's hand, no pressure or mechanical actuation of a switch is necessary to trigger the touch sensor. The touch sensors are conductive surfaces on the exterior of the device

shell that are applied using conductive paint. The conductive paint is then connected internally to the touch sensing circuitry. The internal circuitry generates a 30 Hz square wave that is present on the conductive paint pad.

The D-latch in Figure 2 control the touch sensor and LED that represents the equivalent position of the sensor on the LED display. The display is arranged so that when the user touches the left-hand-side of the palate, LEDs on the right-hand-side of the display light up.

Some data files that contain the contact data for the tongue-palate contact patterns when alphabet is pronounced are created. The program read the data and compared them with the contact pattern acquired from the palate model. In this preliminary experiment, the contact patterns are created for alphabet 'a', 'c', 't', 's', and 'i'. Their contact patterns are stored individually. However, when the user of the system pronounces these alphabets continuously, the program will also display each contact pattern continuously. These illustrate the dynamic motions of the tongue movements. There are only 8 palates displayed on the screen, if there were 10 contact patterns generated, the first 8 patterns will be displayed on the first screen and the remaining 2 are displayed on the second screen.

3. Experiment Setup

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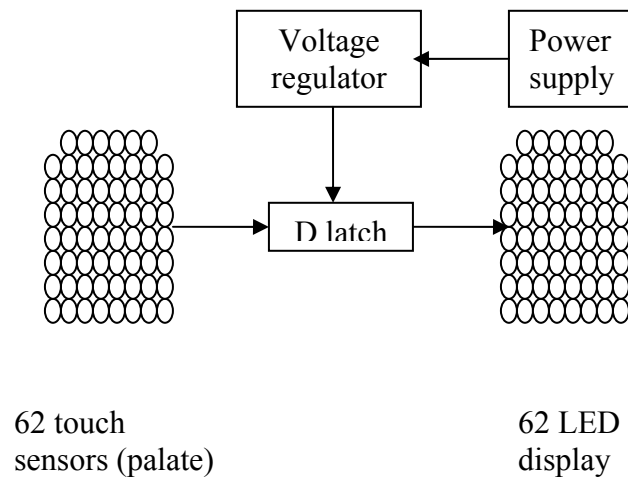
Figure 2 Block diagram of EPG model system

4. Results and Discussion

The expectation of this work is that when the touch sensors are pressed, the same pattern is displayed on the computer screen. This indicates that the circuit connections are working correctly and the interface between the model and GUI is properly established. In our experiment, the display is only for a touch pattern at a time. The same patterns are obtained from the experiments.

Hence, our modeling has successfully developed. An example of pattern obtained from our experiment is shown in Figure 3.

Palate   LED display
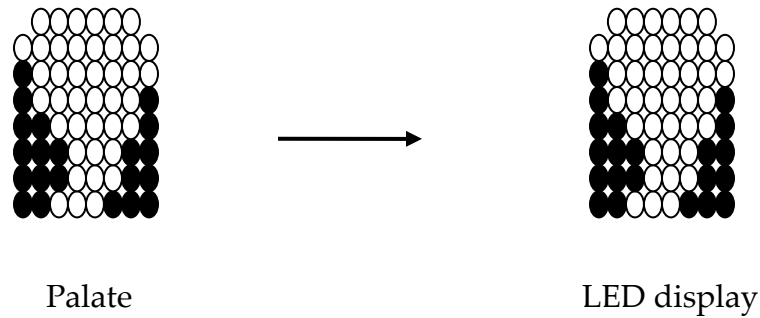
Figure 3 Output from touch sensors
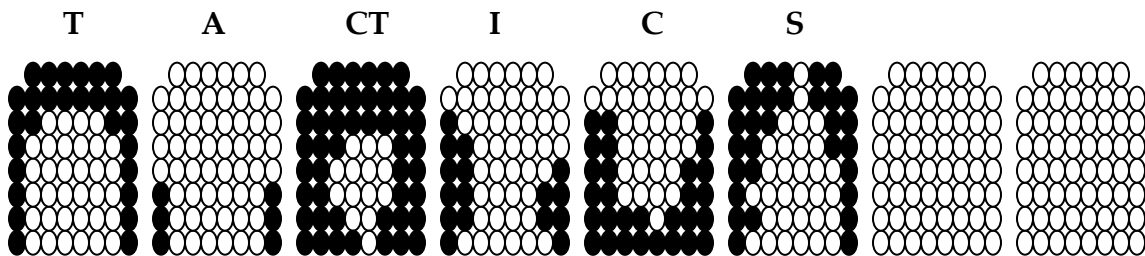
T   A   CT   I   C   S

Figure 4 Patterns of word 'tactics'

Along with the touch sensors that we designed, we also developed a computing system for the EPG. This software system requires the upload of data into the database system so that it can be use for comparison of the acquired pattern. The computing system of the EPG that we designed has few functions to process and analyze the data obtained from the device, they are: find mistakes, find match, and find correction functions. The 'find mistakes' function is to find if there was any mistake between the data from EPG and the reference file. The 'find match' function search the database files which has the same or the closest

pattern to the pattern being compared. The 'correction' function made suggestion on the contact points that has to be trained and corrected.

The contact patterns of word 'TACTICS' are displayed in Figure 4. This example is obtained from a simulation using the software system. The expected result from our experiments does not have any similarity to these patterns because the modeling only use touch sensors. A brief process flow in the EPG software is shown in Figure 5.

```
        ┌──────────────┐
        │  Enter user  │
        │     name     │
        └──────┬───────┘
               │
        ┌──────▼───────┐
        │ Obtain contact│
        │   pattern    │
        └──────┬───────┘
               │
            ╱──▼──╲
    no    ╱  Find  ╲
 ◄────────  matc    
          ╲        ╱
            ╲──┬──╱
               │ yes
    ┌──────────┐   ┌──────────────┐
    │ Suggest  │   │   Display    │
    │correction│   │ pattern & its│
    └────┬─────┘   └──────┬───────┘
         │                │
         └────────┬───────┘
                  │
               ╭──▼──╮
               │ end │
               ╰─────╯
```
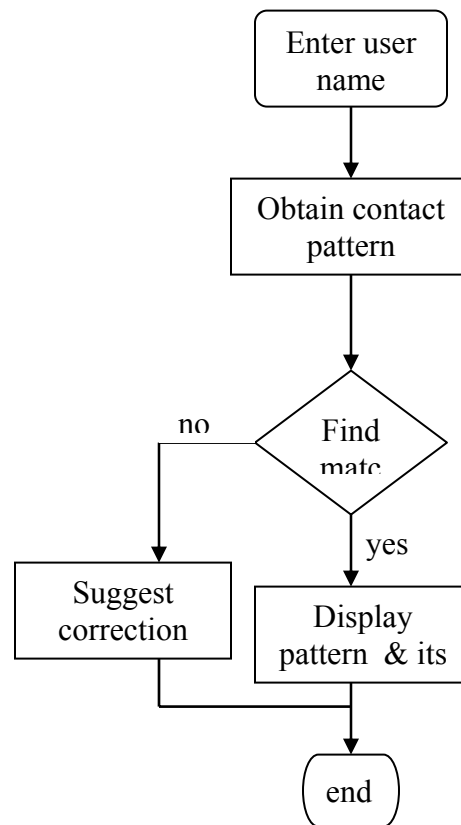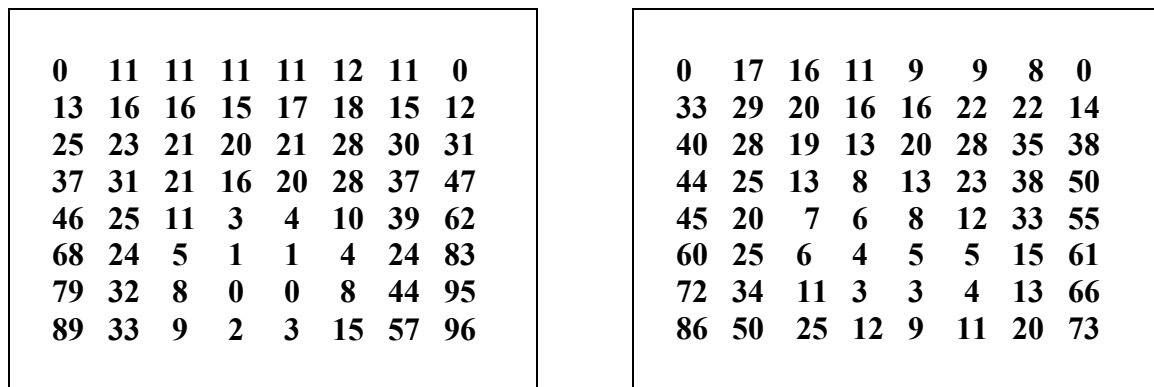
Figure 5 Flow process in EPG system

The EPG software system is designed to aid the therapies in selecting the right points of articulation to be corrected. The correction is done through training sessions with the therapist and parents as well.

The number of contacts for a given time is also recorded by the EPG system. It is called as the contact frequency. In Figure 6, the contact frequency of two speakers is shown to show that different speaker have different style of pronouncing a particular word in a particular given time. The number describes the number of contacts made at each contact points. This contact frequency is measured for a given period of time. If contact is obtained for single alphabet, then contact frequency only show a '1's on the contacts.

0	11	11	11	11	12	11	0
13	16	16	15	17	18	15	12
25	23	21	20	21	28	30	31
37	31	21	16	20	28	37	47
46	25	11	3	4	10	39	62
68	24	5	1	1	4	24	83
79	32	8	0	0	8	44	95
89	33	9	2	3	15	57	96

Speaker A

0	17	16	11	9	9	8	0
33	29	20	16	16	22	22	14
40	28	19	13	20	28	35	38
44	25	13	8	13	23	38	50
45	20	7	6	8	12	33	55
60	25	6	4	5	5	15	61
72	34	11	3	3	4	13	66
86	50	25	12	9	11	20	73

Speaker B

Figure 6 Contact frequency for Speaker A and B

5. Conclusion

Contact pattern depends highly on the articulator movements of the tongue. Studies of speech abnormality due to the tongue can be carried out using an integrated EPG system. Indeed the system can identify where the abnormalities occur and suggests the correction to be made so that the therapist can easily know how to train her patient speak correctly. Pronunciation of 'a', 'c', 't', 's', and 'i' individually produced the same contact patterns as when they are pronounced continuously. This research successfully designed the EPG system using the touch sensors and interfaced to the EPG software system.

6. Acknowledgement

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Chapter 3

Conclusion and Recommendation

3.1   Conclusion

The EPG model system is divided into two parts, which are hardware and software. The hardware part detects the human contacts and displayed the pattern on the LED display. The software part reads the contact data from data file and displayed them on the PC screen. In conclusion, the study has able to display the tongue-palate contact pattern on the PC screen for comparison and analysis.

3.2   Recommendation

Although the tongue-palate contact patterns can be displayed directly on the LED display, the performance and effectiveness of the system can be improved by interfacing the hardware with the software. The contact pattern can be displayed on the PC screen in real time. More features such as saving and

analyzing the tongue-palate contact pattern can be added to the software's GUI to make the system more user friendly.

The EPG model system is a single channel EPG, that means only one user can se the device at a time. For convenience of comparison between the abnormal tongue-palate contact pattern and the normal one, and improving the effectiveness of speech therapy using this device, the EPG model system could be modified to become a double channel system whereby two users can use the device simultaneously.

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