International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 5 (2015) pp. 13135-13153

http://www.ripublication.com

Finding the Aberration Spots of Intellectually Challengened Child – A Case Study

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Abstract

Acoustical measures are used in the assessments of stuttering children voice disorders and monitoring the child's improvement over the voice therapy. Even though many electronic devices are available, they have to speak and hear their own voice by this device. Even for this Speech Language Pathologist (SLP) help is required. To help the Speech Therapist, two Novel hybrid approaches were proposed to identify the acute spots in pathological speech signal [64,61]. In which, Hybrid Approach II using Support Vector Machines(SVM) and Fuzzy Inference System (FIS) was found to have a better performance than Genetic Algorithm (GA) [62]. To verify this result more practically, a case study was done for an intellectually Challenged Child suffering from mild mental retardation.

Key words: Genetic Algorithm (GA), Speech Language Pathologist (SLP), Support Vector Machines(SVM), Fuzzy Inference System (FIS).

1. Introduction

As the children with mild mental retardation are most likely to be involved with a therapist, a mild intellectually challenged female child's speeches were recorded for this case study using Hybrid Approach Model II.

Mental retardation is a developmental disability that first appears in children under the age of 18. It is defined as an intellectual functioning level (as measured by standard tests for intelligence quotient) that is well below average and significant limitations in daily living skills (adaptive functioning).

Mental retardation varies in severity. The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) is the diagnostic standard for mental healthcare professionals. The DSM-IV classifies four different degrees of mental retardation: mild, moderate, severe, and profound. These categories are based on the functioning level of the individual [66].

Mild mental retardation

Approximately 85% of the mentally retarded population is in the mildly retarded category. Their IQ score ranges from 50-75, and they can often acquire academic skills up to the 6th grade level. They can become fairly self-sufficient and in some cases live independently, with community and social support.

Moderate Mental Retardation

About 10% of the mentally retarded population is considered moderately retarded. Moderately retarded individuals have IQ scores ranging from 35-55. They can carry out work and self-care tasks with moderate supervision. They typically acquire communication skills in childhood and are able to live and function successfully within the community in a supervised environment such as a group home.

Severe Mental Retardation

About 3-4% of the mentally retarded population is severely retarded. Severely retarded individuals have IQ scores of 20-40. They may master very basic self-care skills and some communication skills. Many severely retarded individuals are able to live in a group home.

Low IQ scores and limitations in adaptive skills are the hallmarks of mental retardation. Aggression, self-injury, and mood disorders are sometimes associated with the disability. The severity of the symptoms and the age at which they first appear depend on the cause. Children who are mentally retarded reach developmental milestones significantly later than expected, if at all. If retardation is caused by chromosomal or other genetic disorders, it is often apparent from infancy. If retardation is caused by childhood illnesses or injuries, learning and adaptive skills that were once easy may suddenly become difficult or impossible to master.

Diagnosis:

There is no absolute measurement for retardation. At one time the different types were classified only according to the apparent severity of the retardation. Since the most practical standard was intelligence, the degree of retardation was based on the score of the patient on intelligence tests such as the intelligence quotient (IQ). The average person is considered to have an IQ of between 90 and 110, and those who score below 70 are considered mentally retarded.

Therefore, the dataset was collected from the normal and intellectually challenged female children (mild mentally retarded) within the age limit 6-10yrs. For normal data, 2 female children were utilized and for abnormal data one hundred and twenty five words were collected from 6-10 years old female children for the system to train and classify. The effective and functional communication is the goal of any speech-language treatment.

So, this case study follows with the

(i) Case Record,
(ii) Psychological Report and
(iii) discussion of the result.

This case study was implemented with the guidance of Speech Pathologist. Before implementation of process, let us discuss about the case record and Psychological report provided by the Special School, (for children with intellectually challenged).

For purpose of evaluation, the results have been categorized into
(1) Emotional and behavioural disturbances
(2) Personal habits
(3) Social attitudes
(4) Learning ability
(5) Other defects.

The children were carefully observed for therapeutic changes in behaviour, emotional reactions, sensory responses and their reactions to the compound. Subjective feelings of parents, near relations and teachers were also taken into account in judging the results of therapy. These were classified according to the degree of response as ‘Excellent’, ‘Marked’, ‘Moderate’ and ‘No Response’.

From Binet's work the IQ scale called the "Binet Scale," was developed. Sometime later, "intelligence quotient," or "IQ," entered our vocabulary. Lewis M. Terman revised the Simon-Binet IQ Scale, and in 1916 published the Stanford Revision of the Binet-Simon Scale of Intelligence (also known as the Stanford-Binet). The following scale resulted for classifying IQscores:

IQ Scale

Over 140	-	Genius or almost genius
120 - 140	-	Very superior intelligence
110 - 119	-	Superior intelligence
90 – 109	-	Average or normal intelligence
80 - 89	-	Dullness
70 - 79	-	Borderline deficiency in intelligence
Under 70	-	Feeble-mindedness

Normal Distribution of IQ Scores
50% of IQ scores fall between 90 and 110
70% of IQ scores fall between 85 and 115
95% of IQ scores fall between 70 and 130
99.5% of IQ scores fall between 60 and 140

Low IQ & Mental Retardation
An IQ under 70 is considered as "mental retardation" or limited mental ability. 5% of the population falls below 70 on IQ tests. The severity of the mental retardation is commonly broken into 4 levels:
50-70 - Mild mental retardation (85%)
35-50 - Moderate mental retardation (10%)

20-35 - Severe mental retardation (4%)
IQ < 20 - Profound mental retardation (1%)

Based on these measures, the case record and psychological report was prepared by the psychologist. The summary of the report is discussed below.

The rest of the paper is organized as follows, Mental retardation – case record and Psychologist Report in Section 2. The experimental setup is described in Section 3, Experiments Results is discussed in Section 4. Finally, Section 5 summarizes the approach.

2. Case Records

2.1 Mental Retardation – Case Record

Name : AAA [Name not mentioned for personal reasons.]
Age : 7 years
Date of birth : 24.1.2007
Sex : Female

History available on the date of registration:

Type of impairment	Present	Absent	Type of impairment	Present	Absent
Poor motor development		✓	Delayed milestones		✓
Dull		✓	Hyperactive		✓
Fits	✓		Physical handicaps		✓
Speech problems	✓		Scholastic backwardness		✓
Lack of self care	✓		Lack of social sense		✓
Others (Specify)					

Mother's health
1. Age at Pregnancy
2. During Pregnancy :

i) Ill nourishment
   i) Intoxication
   ii) Infection
   iii) Injury
   iv) Irradiation

ii) During delivery (Child Birth):
   i) Difficult labour
   ii) Delayed labour
   iii) Delayed birth cry
   iv) Signs of hypoxia
   v) Intoxication

iii) After Child Birth (for the child) :
- i) Poor nutrition
- ii) Fits
- iii) Infection
- iv) Head Injury

Development milestones	**Delayed**	**Normal**
Holding neck erect		✓
Sitting		✓
Standing		✓
Walking		✓
Speech	✓	

Physical Appearance:
i) Stunted growth / **Normal growth**
ii) Head - Small/Big/**Normal**
iii) Ears - Lowset/Big/**Normal**
iv) Eyes - Slanting / **Normal**
v) Abdomen - Protruding / **Normal**
vi) Genitals - Abnormal / **Normal**
vii) Limbs - Abnormal / **Normal**
viii) Skin - Abnormal / **Normal**

Associated Problems	**Present**	**Absent**
Behavioral Problems	✓	
Hyperactivity		✓
Physical Handicap		✓
Epilepsy	✓	

Provisional Diagnosis:
i) Mild M.R.
ii) Moderate M.R.
iii) Severe M.R.

Management:
i) Drugs Advised
ii) Counselling / Family therapy / Play Therapy / Behaviour therapy
iii) Type of rehabilitation advised

This is about the case record of the child named AAA. The summary of the Psychologist Report of that child given by Psychologist is presented below:

2.2 Psychologist Report

This report was referred by Anbalaya Special School. The following Test administration was done for the child:

1) Binet kamat test of Intelligence and
2) Vineland social maturity scale.

In this test it was found that, according to the Vineland social maturity scale, the child falls under Borderline deficit in social maturity and found that:

i) Social Age = 4 years 10 months
ii) Chronological Age = 7 years 2 months
iii) And also found IQ level = 67 for the child.

According to the Binet Kamat test of Intelligence, the child falls under the category mild mentally retarded and found that the mental age of the child is 3 years, terminal age = 4 years and IQ = 52.

The remaining points were also noted in the report:

- The Attention and concentration of the child was found inadequate by the Psychologist.
- The languages and Communication of the child was analyzed and report was given as, the child can speak in **word level** and there is a delayed language and speech disorder.
- Motor abilities were found to be: fine and gross motor abilities are not age appropriate.

Self-Help Skills	**Fully Dependent**	**Partially Dependent**	**Independent**
Eating			✓
Brushing			✓
Washing Face			✓
Toileting		✓	
Bathing		✓	
Dressing		✓	

Problem Behaviors Observed / Reported by the child:

i) Avoid eye to eye contact.

The summary of the report is:

The child has mental age of 3 years and her IQ was 52 and comes under **mild mentally retarded.** The recommendations given are:

- To continue her special education,
- To continue speech therapy
- Social skills training has to improve her socialization

As it was recorded in the Psychologist Report that the child can speak **word level** so, the one hundred and twenty five words were formed which covers most of

the syllables from ‘a’ to ‘z’. Many words like, wild animals, kingfisher, ball, eyes, analysis, dinosaurs, zebra, umbrella, etc were recorded by the stuttering children and normal children using Sony ICD-MX20 device.

3. Experimental Setup

3.1 DATA SOURCE

Dataset was collected from six to ten years old female children. Stuttering dataset was collected from

Anbalaya Special School,
(for children with intellectually challenged)
Thiruvotriyur, Chennai .
&
Normal dataset was collected from
Sri Ram Vidyalaya,
Koyambedu,
Chennai.

The same sets of one hundred and twenty five scripts were made to read by normal children and intellectually challenged children.

Sony ICD-MX20 was used to record children voice for the research work. The specifications of this device is shown below.

Specifications for ICD-MX20

System	
LPEC voice data compression	YES
Triple Rate Codec voice data compression	NO
Built-in flash memory	YES
Memory Stick medium	YES
Memory capacity (MB)	32.0
Frequency level (Hz)	ST 60 - 13,500 / SP 60-7000 Hz / LP 80-3500 Hz
PC link capability	YES
Sampling frequency LP mode (kHz)	8.0
Sampling frequency SP mode (kHz)	16.0
Recording time LP mode (hours)	705.0
Recording time SP mode (hours)	260.0
Recording time ST mode (hours)	85.0

The speech input is recorded at a sampling rate of 44.1 kHz. Their normal frequency range is from 20-4 kHz. This is shown below in Table 1:

Table 1

nSamplespersecond	44.1KHz
nAvgBytespersecond	176400
nBitspersample	16

It is already seen that using IQ the MR severity is diagnosed within the children. Fourteen features were extracted from these words and trained using SVM [61].

Around forty words was formed and made the child AAA to pronounce. These words were administered to this child and tested with this child. She managed to pronounce the small words like 'eye', 'ball' etc to an extent. She didn't find much difficulty in it.

But few words of around thirty was difficult for her to pronounce, as these were having more than three or four syllables like 'kingfisher', 'wildanimals', icecream', 'umbrella', dinosaurs, etc. These thirty words were applied in the software.As a first step, the speech signals were edited with the audio editor by removing the unnecessary portions in speech signals to extract the exact word signals and stored in ".wav" format.

3.2 To Identify the Aberration Spots

As per the comparison done between two Hybrid Approaches for finding the acute spots[62], the Hybrid approach with the combination of SVM and FIS was found better with accuracy of 98% when compared to the Hybrid approach with combination of NN and GA. So, **Hybrid approach system using SVM and FIS (Hybrid Approach II) was applied for the child's pronounced words**. Word by Word was inputted to this system. First, a word say "wildanimals" was inputted to this software. Before extracting the features, the signal was analyzed using (i) Mel frequency and (ii) ERB-rate. After this analysis, the fourteen features were extracted, (seven features from the original abnormal word and seven mfcc features of the abnormal word). A feature vector was generated for this word. This feature vector was classified with the aid of Support Vector Machines (SVM) by comparing with the SVM trained dataset. Fast Fourier Transform (FFT) has been obtained for the abnormal word to extract the number of peaks and the amplitude. These parameters are utilized for the Fuzzy Inference System (FIS) to optimize using the below said rules to identify the aberration spots.

4. EXPERIMENTAL RESULTS

4.1 Analysis

the signal was analyzed using (i) Mel frequency and (ii) ERB-rate.Its mel frequency analysis and ERB rate was analyzed and these values are shown in the Figure 1.[65]

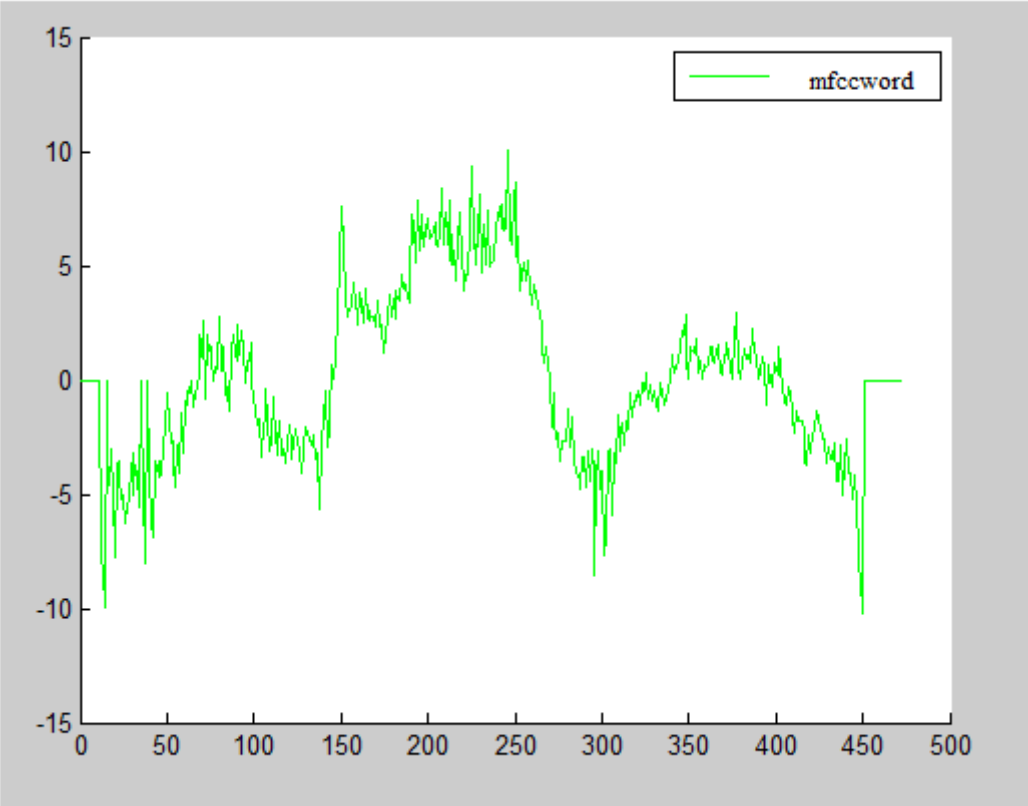

Fig 1. MFCC word signal for the word "umbrella" pronounced by the stuttering child

From the fig. 1, the amplitude of the MFCC word for this given word was found to be in the range of -10 to +10 dB. The amplitude for the MFCC word of the normal words which was trained was found to be in the range from -25 to +10 dB. The second analysis was done using ERB-rate of the signal. During this analysis it was found that the frequency in ERB-rate for this abnormal word was less than 120 and it is shown below in Table 2.

Table 2

Word pronounced by the stuttering child	ERB_rate
Umbrella	98.4261

4.2 Feature Extraction

After this analysis, the fourteen features were extracted, (seven features from the original abnormal word and seven mfcc features of the abnormal word). The values of the features extracted are shown below in Table 3.

Table 3

Features from MFCC words	
Sl. No.	**Feature Names**
1	MFCC-Mean = -2.8551e-15
2	MFCC-Standard Deviation = 2.4267
3	MFCC-Maximum amplitude value = 9.1337
4	MFCC-Maximum amplitude value's id = 729
5	MFCC-Minimum amplitude value = -10.7023
6	MFCC-Minimum amplitude value's id = 984
7	MFCC-length = 1482
From the original words	
Sl. No.	**Feature Names**
8	Mean = -0.0010
9	Standard Deviation = 0.1885
10	Maximum amplitude value = 0.8752
11	Maximum amplitude value's id = 37703
12	Minimum amplitude value = -0.9999
13	Minimum amplitude value's id = 37559
14	Original word length = 119072

4.3 Classification

A feature vector was generated for this word. This feature vector was classified with the aid of Support Vector Machines (SVM) by comparing with the SVM trained dataset. The output got was**"abnormal"**.

The word was categorized correctly by the SVM classifier in this stage. The result was verified by the SLP in this stage.

As the word was classified as abnormal correctly it was then optimized with the aid of Fuzzy Inference System to find the aberration spots where the child AAA stutters.

4.4 FFT RESULTS

Fast Fourier Transform (FFT) has been obtained for the abnormal word to extract the number of peaks and the amplitude [63]. The output of FFT is shown in fig. 2. These parameters are utilized for the FIS to optimize. The FIS is comprised of 3 phases that are Fuzzification, Rules Evaluation and Defuzzification. The process of fuzzy inference involves Membership Functions, Logical Operations, and If-Then Rules. In this FIS, the peaks of the abnormal words are used in order to identify the aberration spot.

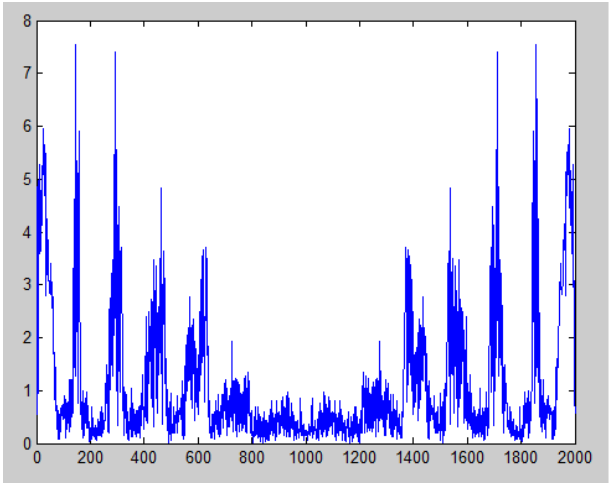

Fig. 2 FFT output for the word "umbrella" pronounced by the stuttering child

4.5 Identifying acute spot using FIS [61]

Few speech signals with the identified acute spots for few words are shown in the fig. 3 (a to f)

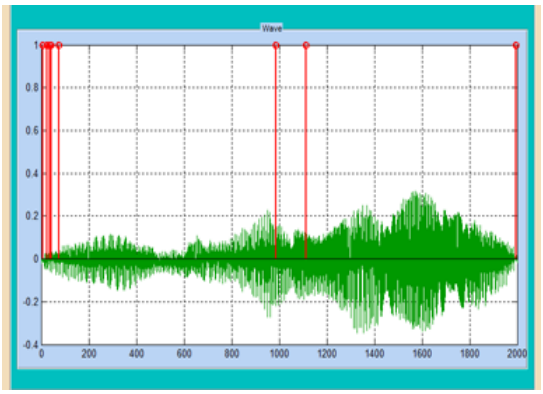

Fig. 3 (a) Wildanimals

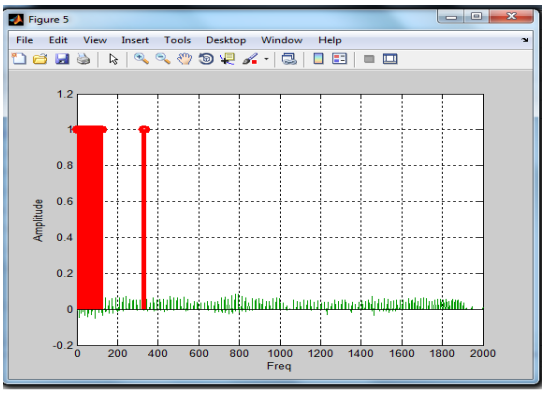

Fig. 3 (b) Violin

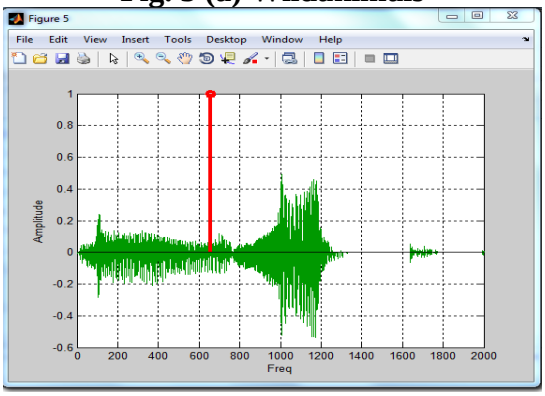

Fig. 3 (c) Lambent

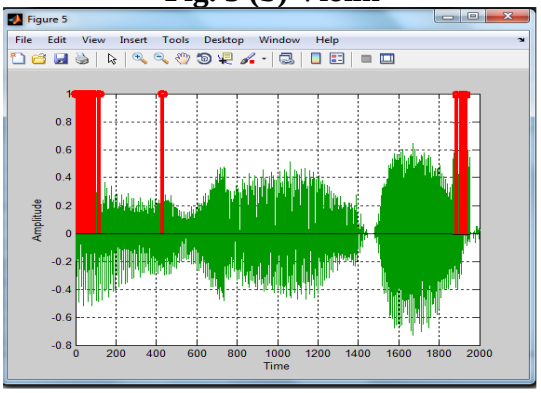

Fig. 3(d) analysis

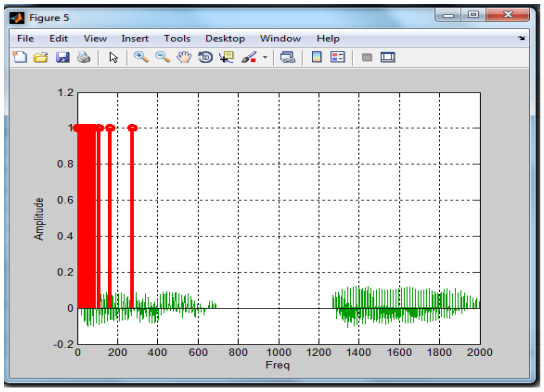

Fig. 3 (e) Peacock

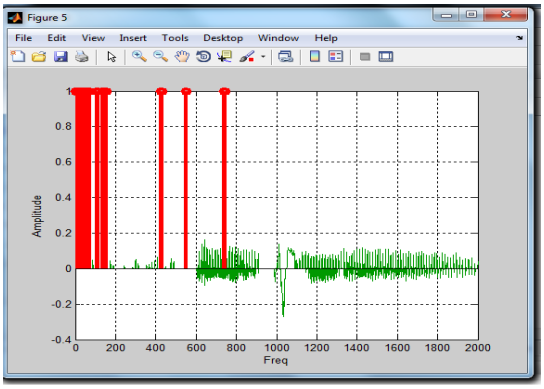

Fig. 3 (f) Umbrella

Analysis was done by the SLP from the result and found that,

- the child faced less problem for the words with less syllables when compared to the more syllable words.
- Syllable repetition noticed at the beginning of the word for this child.

Analysis done has been discussed with few examples here. The words taken here for discussion are

(i) wildanimals
(ii) Violin
(iii) lambent
(iv) analysis
(v) peacock and
(vi) umbrella.

(i) "wildanimals" speech shown in figure a)
Wi / l / d / a / ni / ma / l / s → split into Phonemes.
From the fig. a) it is understood that this child has problem in pronouncing sounds like,
'Wi' → 'y' sound,
'a' → ' a ' sound
'ni' → 'nee' sound in this word.

(ii) "Violin" speech shown in figure b)
Vi / o / li / n → into Phonemes
In this this it was found that child find difficult to pronounce the following sounds,
'Vi' → 'y' sound and
'o' → ' a ' sound.

(iii) From the word "Lambent" , shown in the figure c) it was found that the difficulty faced by the child was to pronounce 'm' → ' im ' sound.

(iv) "analysis" shown in figure d).
a / na / ly / si / s → into Phonemes
The child found difficult to pronounce the following sounds in this word.
' a ' → ' a ' sound
' na ' → ' na ' sound
' si ' → ' c ' sound
' s ' → ' ss ' sound

(v) "peacock" shown in figure e). In this word the child faced to pronounce the 'p' sound.
Pea / c / o / ck → into Phonemes
'Pea' →' p ' sound

(vi) "Umbrella" shown in Figuref). In this word the following sounds are found difficult to pronounce.
U / m / b / re / l / la → into Phonemes
'U' →' a ' sound
'm' → ' im ' sound
' b ' → 'ib' sound
're' → ' ra ' sound

Like this the phonic sounds where analysed and found that this child has to be mostly trained in the following sounds as she was lagging in these sounds.

'y' , sounds end with sound 'e', 'a', 'm', 's', 'p', 'ra'

Therefore, based on these phonemes or sounds, the words were formed by the SLP to train the child. Few words formed for training are as follows,
Violet → for 'y'sound/Phonemes
Wide → for 'y'sound
Wise → for 'y'sound
Wiper → for 'y'sound
Widen → for 'y' and 'a' sounds
Peas → for 'sounds ending with Phonemes 'e' and for 's'
Keys → for 'sounds ending with Phonemes 'e' and for 's'
Heap → for 'sounds ending with Phonemes 'e'
Sim → for 'sounds ending with Phonemes 'e' and for 'm'
Skim → for 'sounds ending with Phonemes 'e' and for 'm'

Like this words were formed and training was given with the help of SLP by making the child AAA to repeat these words to pronounce to overcome from stuttering of pronouncing 'y', ending with 'e', and 'm' syllables effectively.

Thus, the results indicate that this method could be used as a valuable tool for speech therapist in stuttering assessments.

5. CONCLUSIONS

The objective of the work is to provide efficient synthesizing techniques using soft computing techniques for finding the acute spots in the stuttering words. These acute spots likely to give the information to the Speech Language Pathologist (SLP) to find for which phonemes the child lags. So, that using these phonemes words could be formed and given practice to the child by the SLP. This is likely to be effective than giving a general practice.

In existing system, a general practice of speech is given for the children. Hence, this work concentrates to overcome from stuttering behaviour more effectively using optimization techniques to find the acute spots in each word.

The work contributes on an effective system to identify the child through which the speech correction process has been carried over. The child is motivated to pronounce the word and the signal is captured. A novel Hybrid Approach algorithm is applied for the screening the pathological voices and keenly identified the perceptive spots. The speech practitioner helps to know through the spots in which phoneme the child has to improve and need training. The work was implemented in the working platform of **MATLAB (version 7.11).**

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