

# Comparison of Cough, Wheeze and Sustained Phonations for Automatic Classification between Healthy subjects and Asthmatic patients

Shivani Yadav, Kausthubha NK, Dipanjan Gope, Uma Maheswari  
Krishnaswamy, Prasanta Kumar Ghosh

**SPIRE LAB**  
Electrical Engineering,  
Indian Institute of Science (IISc), Bangalore, India





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- 1** Introduction
- 2 Motivation
- 3 Dataset
- 4 Proposed Method
- 5 Experimental Setup
- 6 Results
- 7 Conclusion and Future work

# What is Asthma??

- 1 Asthma is an **inflammatory disease** of the airways resulting in a number of symptoms including **obstruction of the airways**, chest discomfort or pain, cough, and wheezes or other peculiar sounds during breathing.

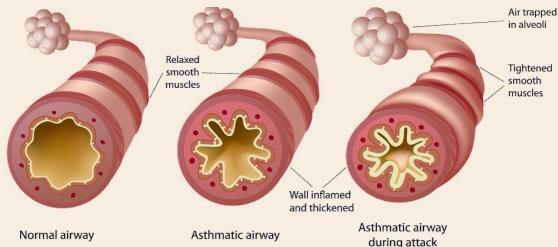


Figure: Healthy and Asthmatic Bronchioles <sup>1</sup>

<sup>1</sup> <http://ib.bioninja.com.au/options/option-d-human-physiology/d6-transport-of-respiratory/asthma.html>



# What is Asthma??

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- 2 334 million is global burden of asthma<sup>2</sup>.

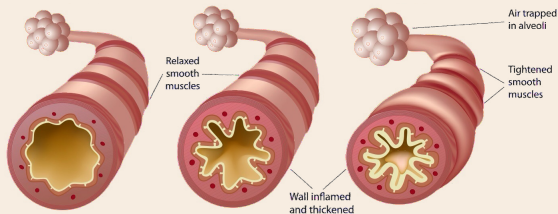


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<sup>2</sup> <http://www.globalasthmareport.org/burden/burden.php>

## Traditional diagnostic tool: Spirometry

- A lung function test that **measures how much and how fast a person can exhale air.**
- Helps in **diagnosis** and **monitoring** asthma in hospital.
- Drawbacks of spirometry
  - 1 Very strenuous
  - 2 More training required
  - 3 More time required to screen large population

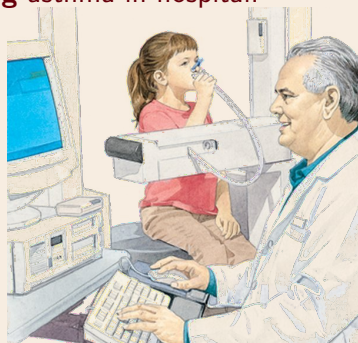


Figure: Spirometry <sup>1</sup>

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**Is there a simpler approach for asthma diagnosis?**

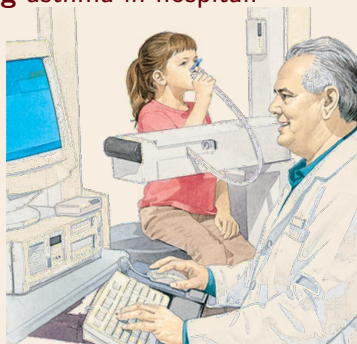


Figure: Spirometry <sup>1</sup>

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# Voice based analysis

- 1 Less training required.
- 2 Less timing required to screen large population.
- 3 Less strenuous.
- 4 Easy for the aged and children.





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**Does human voice encode cues to detect asthma??**



# Voice based analysis is possible!

- **Key finding:** Acoustics are different between healthy and asthmatic subjects<sup>1</sup>.
- **Stimuli used:** Sustained phonations
  - /ɑ:/ (as in 'Father')
  - /i:/ (as in 'See')
  - /u:/ (as in 'Blue')
  - /oʊ/ (as in 'Go')
  - /aɪ/ (as in 'Eye').

<sup>1</sup> Batra, Khushboo, Swati Bhasin, and Amandeep Singh. "Acoustic Analysis of voice samples to differentiate Healthy and Asthmatic persons." International Journal of Engineering and Computer Science 4.7 (2015): 13161-13164.



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## What are the other possible stimuli?

<sup>1</sup> Batra, Khushboo, Swati Bhasin, and Amandeep Singh. "Acoustic Analysis of voice samples to differentiate Healthy and Asthmatic persons." International Journal of Engineering and Computer Science 4.7 (2015): 13161-13164.

# Illustration

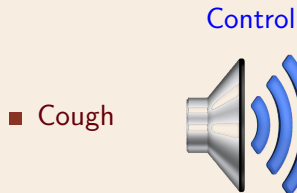
■ Cough



■ Wheeze



# Illustration



# Illustration

■ Cough

Control



Patient



■ Wheeze

Patient



Control



# Illustration

■ Cough

Control



Patient



■ Wheeze

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Control



**How well do the different stimuli encode cues to detect asthma?**



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# Dataset

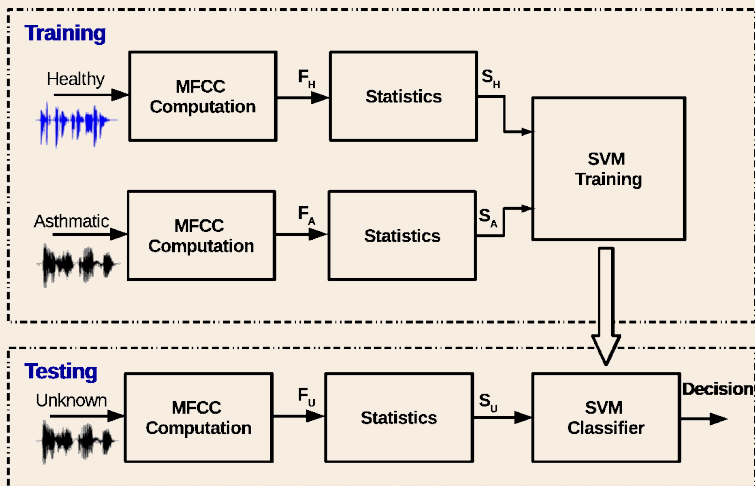
- **35 Patients**- 18 male, 17 female.
- **36 Controls (healthy)**- 18 male, 18 female.
- The age range of controls are between 19-42 years and average age of 24 years. The age range of the patients are 19-78 years with an average age of 43 years.
- **Stimuli:**
  - 1 Cough
  - 2 Wheeze
  - 3 Sustained phonations: /ɑ:/ (as in 'father'), /i:/ (as in 'See'), /u:/ (as in 'Blue'), /e:/ (as in 'Say'),/ou/ (as in 'Go').
- Average number of recordings per stimuli per subject is **5**.



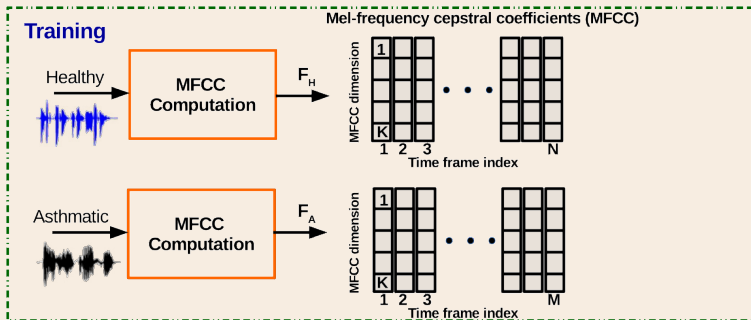
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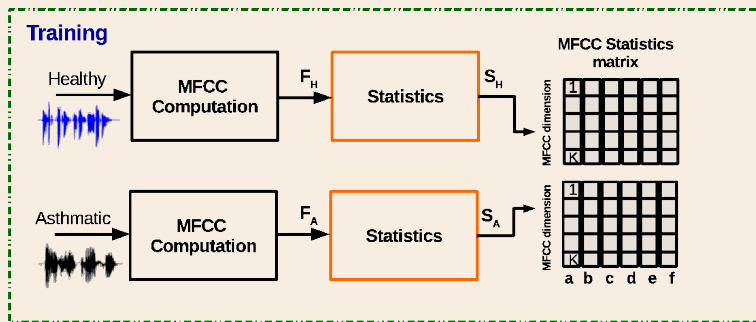
# Schematic Diagram



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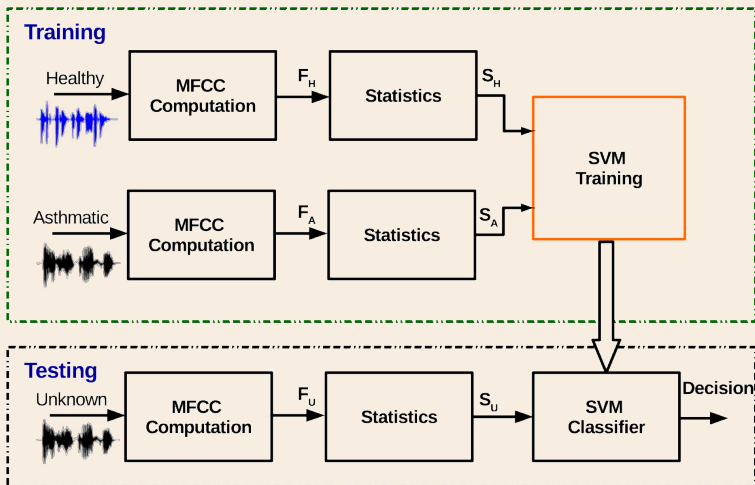


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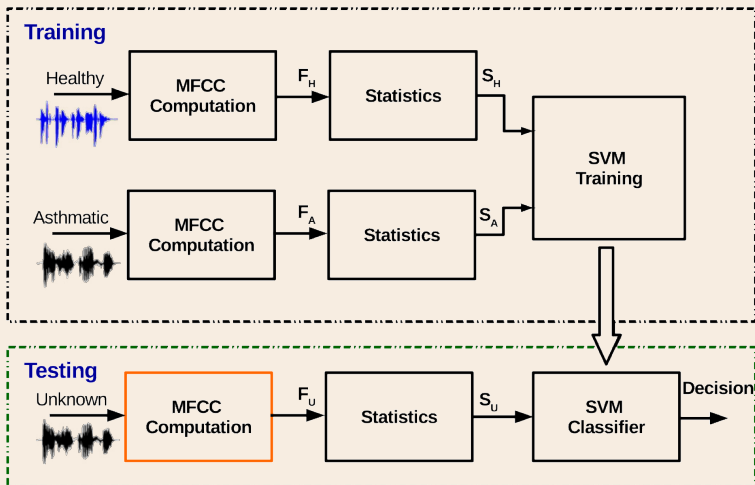


- a. Mean
- b. Median
- c. Mode
- d. Root mean square (RMS)
- e. Variance
- f. Standard Deviation (SD)

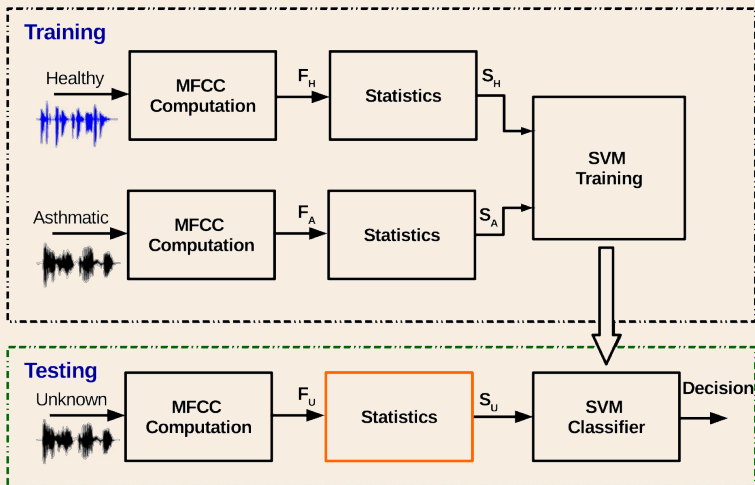
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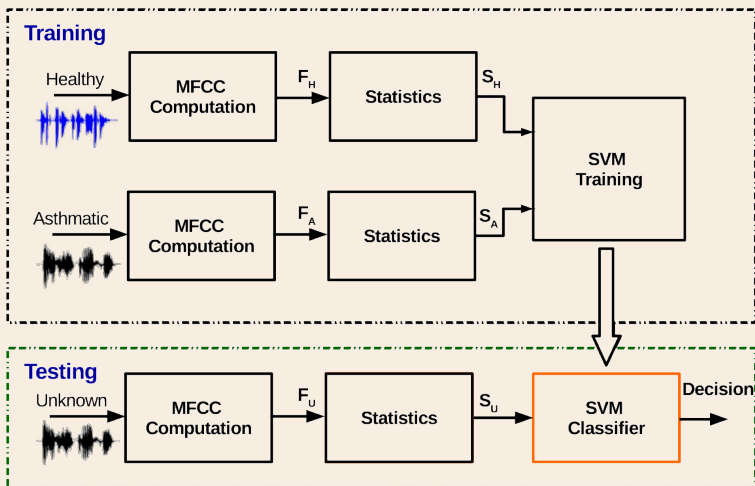


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# Experimental setup

- Sampling rate of: 48 kHz, analysis window : 20ms, shift : 10ms.
- Support vector machine (SVM) used with 4 fold cross-validation setup.
- Evaluation metric
  - Total classification accuracy

$$TCA = \frac{TP + TN}{TP + TN + FP + FN}$$

where, TP (True Positive), TN (True Negatives), FP (False Positives) and FN (False Negatives).



## Key questions addressed

- 1 **Which stimuli** (cough, wheeze and sustained phonation) are better for classification?
- 2 What is the **effect of including  $\Delta$  (velocity) and  $\Delta\Delta$  (acceleration) coefficients** on the classification results?
- 3 To **what degree do individual MFCCs** encode asthma related information for the best performing stimuli?
- 4 **Which among the 6 statistics** are more discriminant in the best performing stimuli for the classification task?



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# Classification Results

Table: Mean (Standard deviation) of Total classification accuracy (TCA%) using static,  $\Delta$  (velocity) and  $\Delta\Delta$  (acceleration) coefficients.

Stimuli	Total classification accuracy (TCA) %		
	$K = 12$	$K = 24$	$K = 36$
/a:/	54.7( $\pm$ 8.8)	61.7( $\pm$ 6.9)	66.1( $\pm$ 9.0)
cough	77.3( $\pm$ 6.1)	81.0( $\pm$ 2.5)	78.7( $\pm$ 3.7)
/i:/	74.3( $\pm$ 3.2)	76.8( $\pm$ 9.0)	80.8( $\pm$ 7.3)
/ou/	72.3( $\pm$ 10.7)	75.8( $\pm$ 5.3)	75.2( $\pm$ 7.4)
/u:/	74.5( $\pm$ 4.3)	73.9( $\pm$ 2.2)	75.6( $\pm$ 3.9)
<b>wheeze</b>	<b>89.8(<math>\pm</math>8.2)</b>	<b>90.5(<math>\pm</math>6.9)</b>	<b>90.2(<math>\pm</math>5.9)</b>
/ei/	69.4( $\pm$ 12.8)	74.0( $\pm$ 8.6)	73.6( $\pm$ 10.3)

- Which stimuli (cough, wheeze and sustained phonation) are better?
  - **Wheeze is the best stimuli** for classification.
  - **Sustained /i:/** performs the best among all sustained vowels.



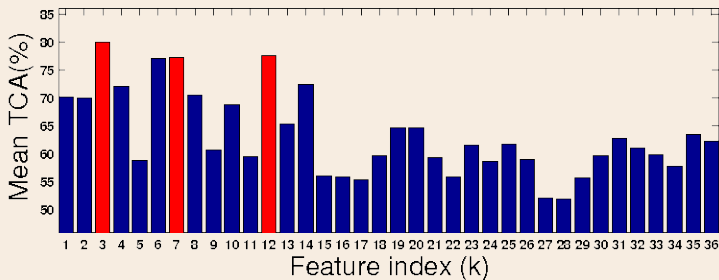
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- Which stimuli (cough, wheeze and sustained phonation) are better?
  - Wheeze is the best stimuli** for classification.
  - Sustained /i:/** performs the best among all sustained vowels.
- What is the effect of including  $\Delta$  and  $\Delta\Delta$ ?
  - Stimulus dependent.

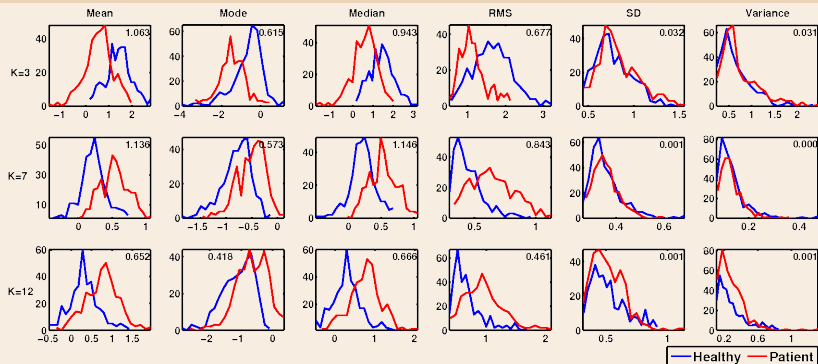
## Role of Individual MFCC in Wheeze



- 3 To what degree do individual MFCCs encode asthma related information for the best performing stimuli?
- **3<sup>rd</sup>, 7<sup>th</sup> and 12<sup>th</sup> Static MFCC** capture cues of asthma better than  $\Delta$  and  $\Delta\Delta$  coefficients.



# Role of each statistics in Wheeze



4 Which among the 6 statistics are more discriminant in best performing stimuli for classification task?

- Mean, Median, Mode and RMS.

- Fisher discriminant ratio (FDR) was used.



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# Conclusion and Future work



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# Conclusion and Future work

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- 3 FDR values shown suggests** that the **mean, mode, median and RMS** statistics are relatively more discriminative compared to the variance and SD statistics.

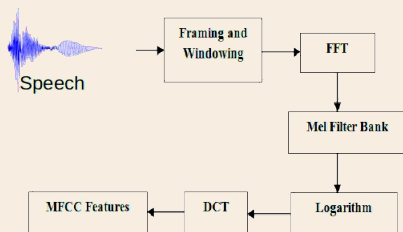


# Conclusion and Future work

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- 3 FDR values shown suggests that the **mean, mode, median and RMS** statistics are relatively more discriminative compared to the variance and SD statistics.
- 4 As the best performing stimuli is wheeze where there is no voicing, future plan includes investigation of **fricatives** as stimuli for asthma classification task.

**THANK YOU**

# Mel-frequency cepstral coefficients(MFCC)





# Support vector machine (SVM)

