

# A MICRO-EMBOLIC ENERGY DETECTOR BASED ON SUB-BAND DECOMPOSITION

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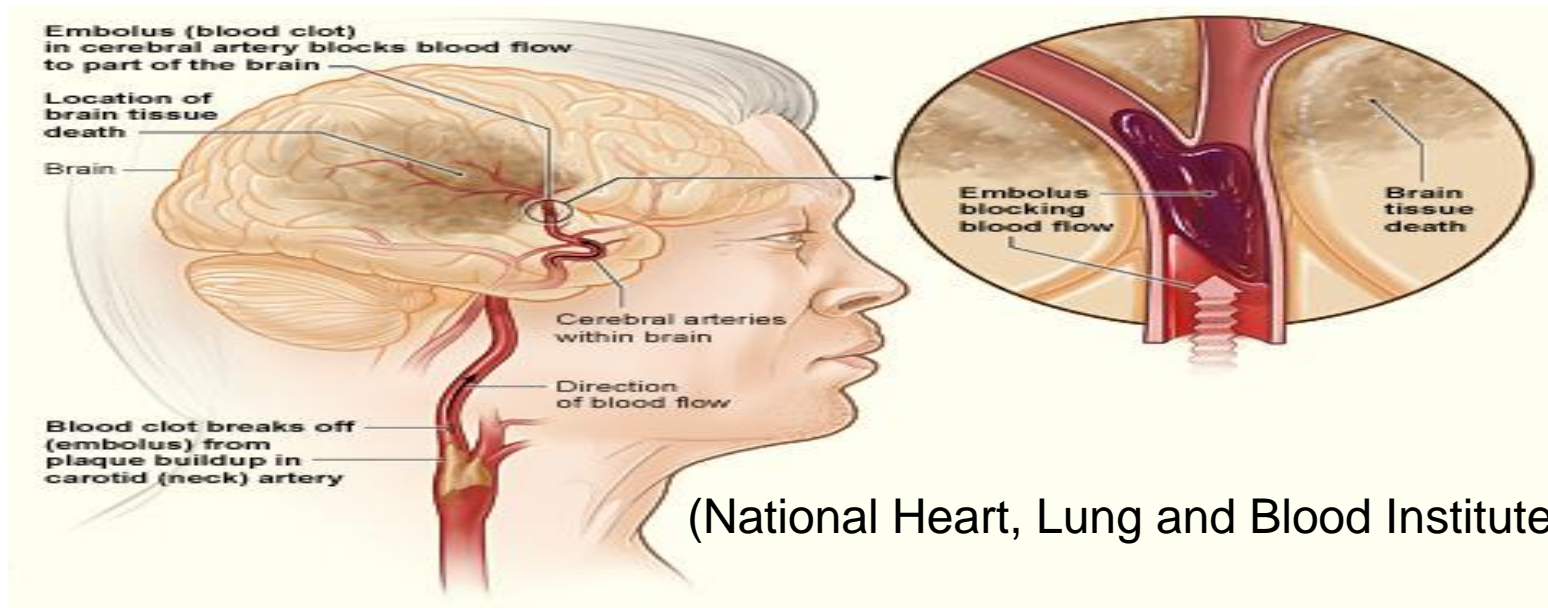
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## The importance of our research study

- Cerebrovascular Accidents
  - Blockage of blood flow in a cerebral artery
  - Second cause of mortality
  - 2,000 death in Lebanon
- Cerebral Embolism is responsible for 14% of all CVAs



(National Heart, Lung and Blood Institute).

## Instrument of Detection : Transcranial Doppler Ultrasound- Holter TCD

- TCD: Measures the velocity of blood flow through the brain's arteries
  - Inconveniences
    - Lengthy probe positioning procedure
    - Decreased confidence in automatic detection
    - Insufficient examination duration
- The Holter system by Atys Medical (Soucieu en Jarrest, France)
  - Automatic ultrasound probe positioning
  - Long term recordings extending up to 5hours
  - Naturalistic monitoring conditions



## The Objective of our Work

- Performance of available detection systems
  - Robust detection of high intensity embolic signals
  - Underachieving and imperfect for the detection of small micro-emboli
  
- Objective
  - Propose robust techniques for the automatic detection of the smallest micro-emboli
  - Reduce risk on patients

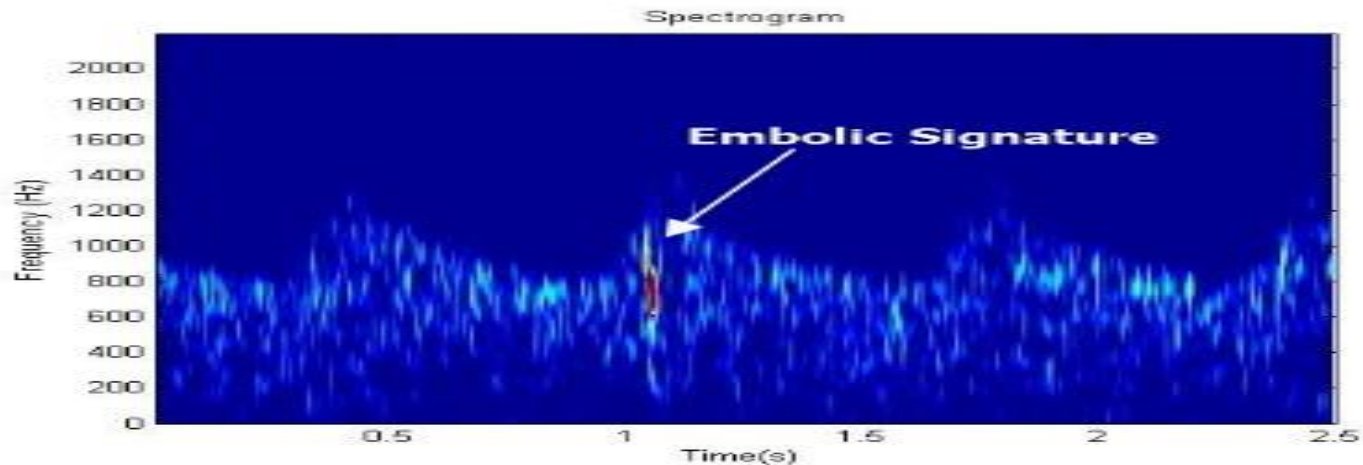
## The Ultrasonic Experimental Setup



- Emitted Ultrasound wave frequency: 1.5 MHz
- Pulse repetition frequency (PRF) : 6.4 kHz
- Ultrasound power is 50 mW/cm<sup>-2</sup>
- Principle idea: Energy of the backscattered Doppler signal is proportional to the size of the scatterer to power of 6 (Rayleigh Scattering)

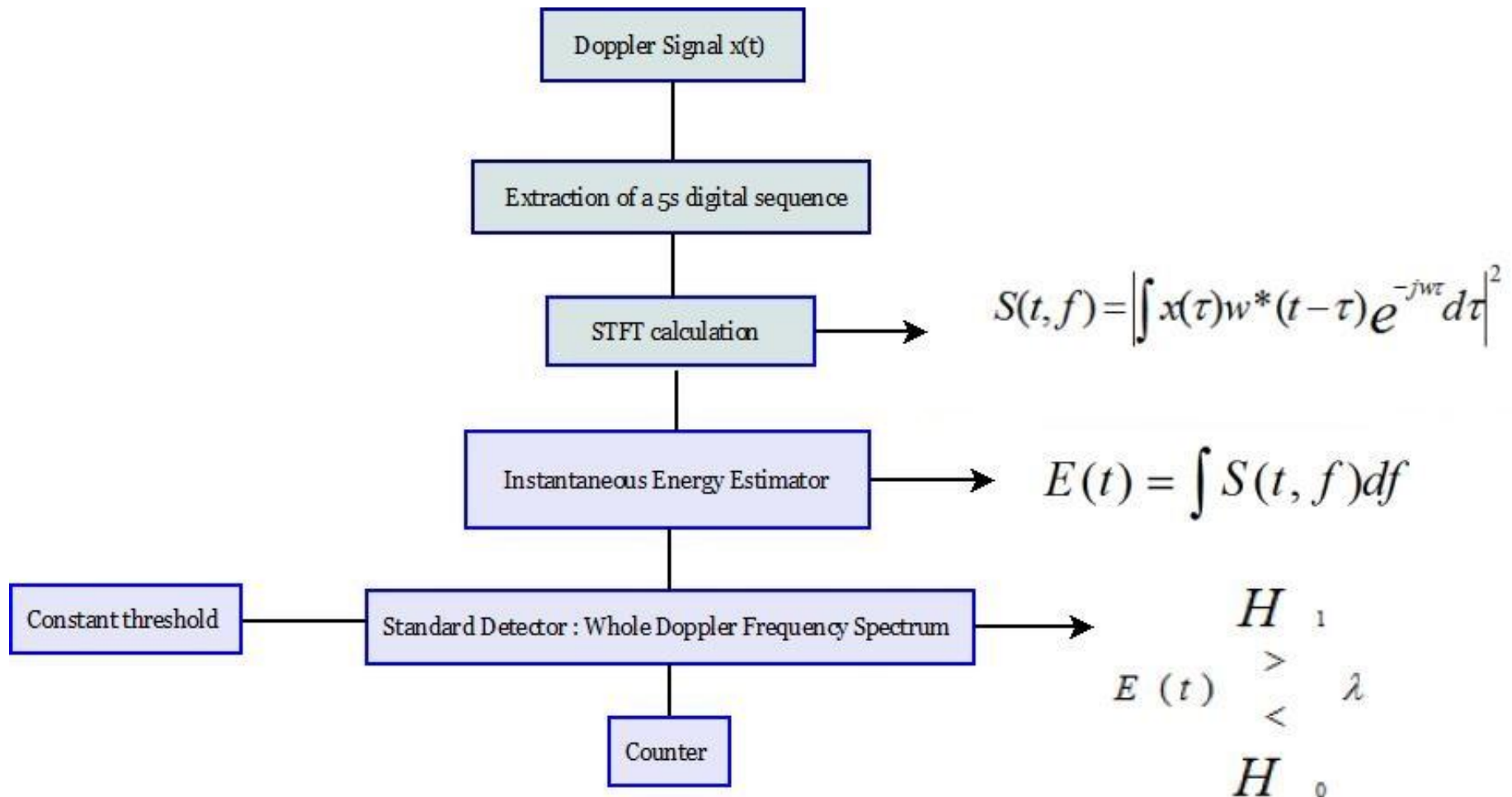
## The Gold Standard of Detection

- Audible Detection
  - Normal Speed
  - Half of the normal speed
- Visual Detection: Spectrogram



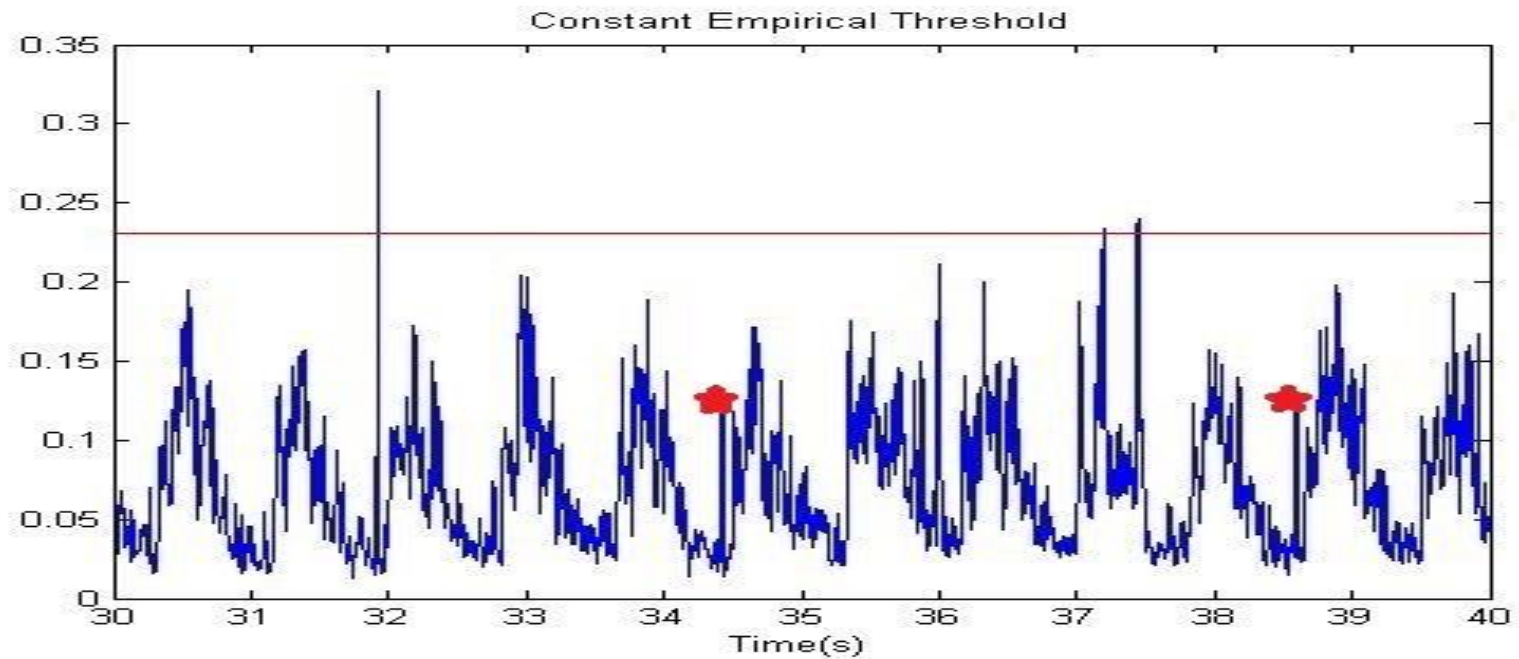
## A Typical Embolus Detection System

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## Whole Band Detection + Constant threshold

- Inability of detecting small/ weak micro-emboli



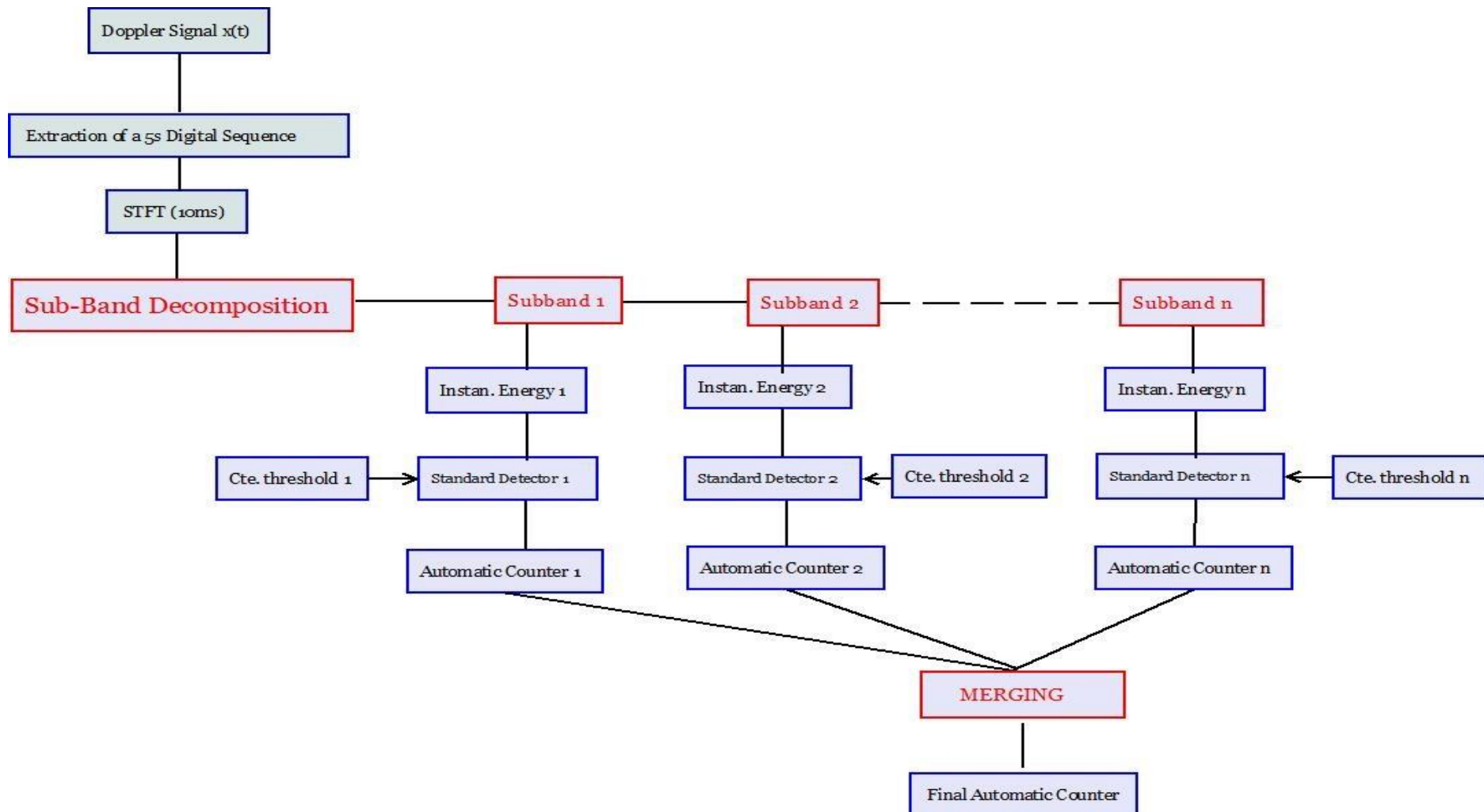


## Possible Solutions

- Propose new thresholding techniques
- Change the detection method
- Apply detection on a different 'Space'

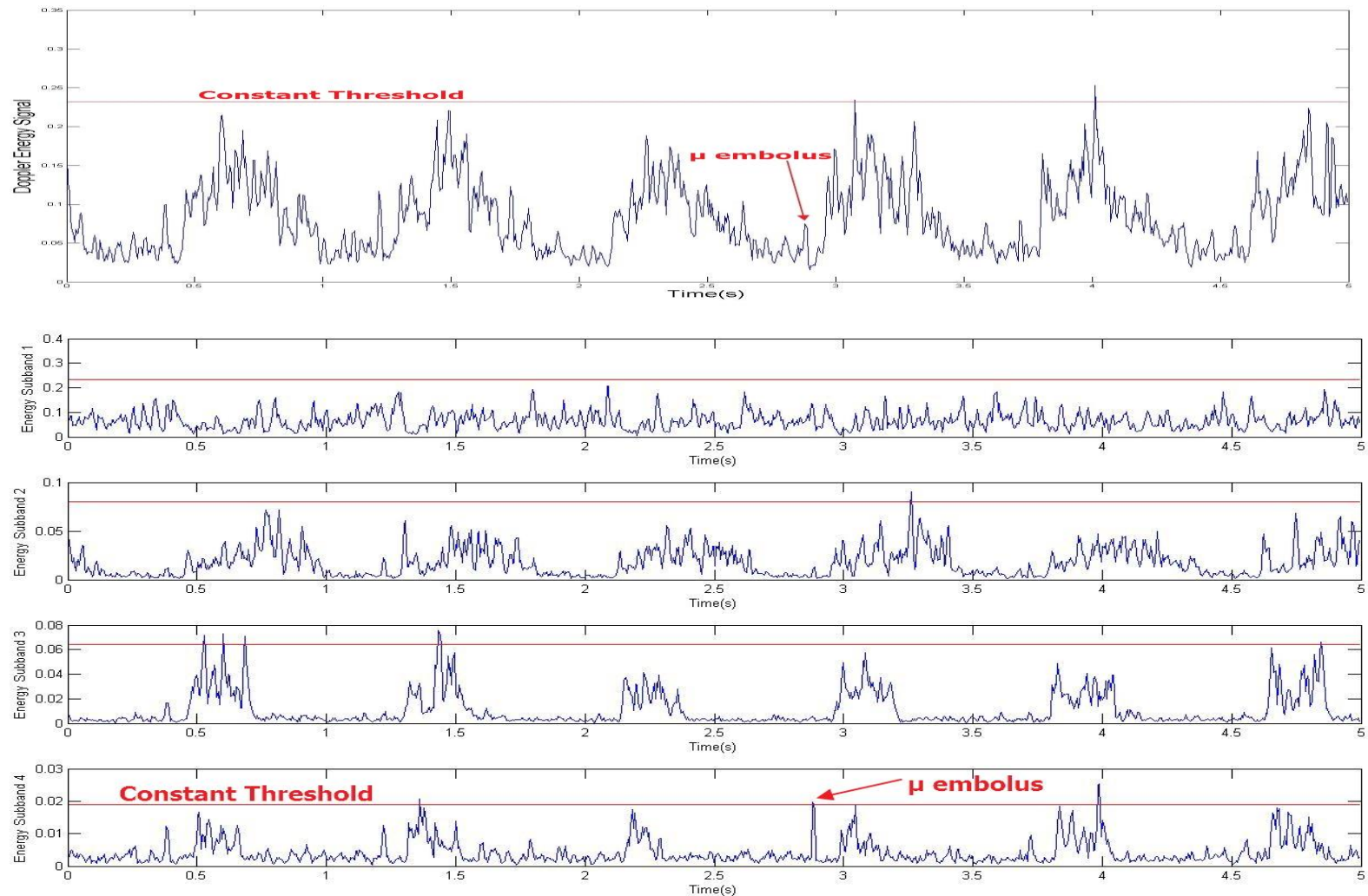
## Sub-band Decomposition Detection Procedure

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## Sub-band Decomposition - Application of a bank of $n$ ideal frequency filters

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## Results – Statistical Parameters

- Detection Rate (DR) or Sensitivity calculated as the number of true positive detections / the number of gold standard detections.
- False Alarm Rate (FAR) calculated as the number of false positive detections / the total number of detections
- Embolus Relative Intensity Increase: indicates how strong an embolic signal is, relative to the background Doppler signal. It is calculated as the ratio of the energy backscattered from the embolus to that of the moving blood surrounding it.

## Results 1 – Training Phase to Determine Optimal Number of Sub-bands

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Number of Sub-band De- composition	Detection Rate (%)	FAR (%)
2 Sub-bands	55.1	53.0
4 Sub-bands	78.8	41.6
8 Sub-bands	80.8	65.1

## Results 2– Testing Phase to Compare the Performance of each Detector

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Detector Type	Detection Rate (%)	FAR (%)	EBR ( <i>dB</i> )
Standard Detector	66.0	43.7	24.4
4-Sub-band Detector	78.9	36.5	39.6

## Conclusion and Observation

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- We proposed a detector decomposed in  $N$  detectors associated to  $N$  Doppler frequency sub-bands as a tool for improved micro-embolus detection, compared to standard detection based on the whole Doppler band
- Constant Empirical thresholds were used
- Increasing the Detection Rate and reducing the number of false positive detections
  - Sub-band Detection : an initiation towards a complete method for micro-embolus detection
- Improvement of the Embolus Relative Intensity Increase
  - Any processing method that improves the Embolus Relative would be able to ameliorate the performance of a micro-embolus detection system
- Eventual Improvements: Sub-band detection coupled with original advanced thresholding techniques

## Eventual Improvements

Detector Type	Detection Rate (%)	FAR(%)
4 sub-band detector with a time-varying threshold	97%	4%



# Thank You

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