



POLYTECH.MONS



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ECLIPSE, a multimodal analysis of speech pathologies

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Plan of the presentation

- ❑ What is ECLIPSE?
- ❑ Context of research
- ❑ Goals
- ❑ Partners
- ❑ Speech modality
- ❑ Image modality
- ❑ What about multimodality in this project?

What is ECLIPSE?

Research Project ECLIPSE



Evaluation fonctionnelle **CL**Inique des **P**athologies
vocales et **S**uivi **E**mbarqué



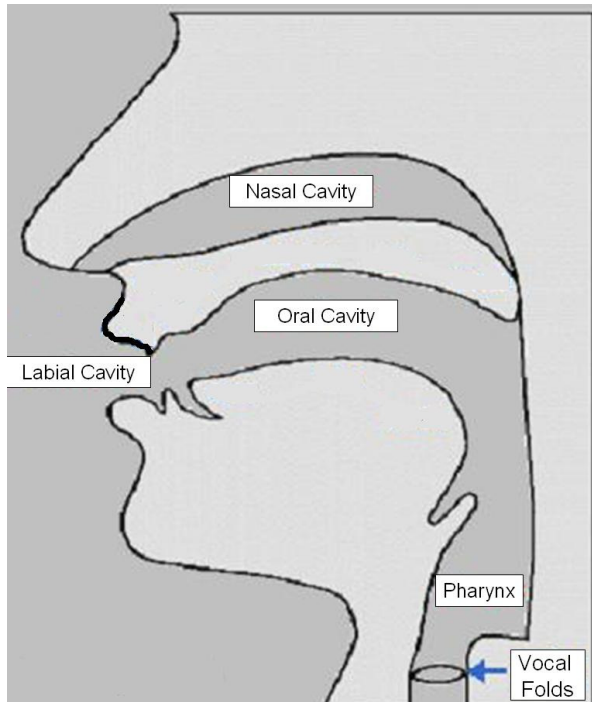
Clinical functional evaluation of vocal pathologies
and embedded follow-up

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- ❑ What about multimodality in this project?

Context of research

- Voice production and disorders



<i>Causes</i>	<i>Vocal Phenomena</i>
Vocal folds dynamics	Biphonation, diplophony
External disturbances	Amplitude and frequency modulation
Audible additive noise	Breathy voice

Context of research

□ Voice assessment (ESGVD):

- Perceptual evaluation (GRBASI scale)
- Acoustic and aerodynamic measurement
- Stroboscopic examination
- Self evaluation of the patient

□ Limitations of vocal assessment:

- Often limited to sustained vowels
- Unable to follow the evolution of pathology during work

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Goals

- ❑ Detection of dysperiodicities in connected speech
- ❑ Clinical station:
 - estimation of voice pathologies (connected speech or sustained vowel) whatever the degree of hoarseness is.
 - multimodal analysis between acoustic signal and images of the vibration of the vocal folds (high speed imaging)
- ❑ Embedded system: follow-up of the patient in his everyday life

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Partners



Faculté Polytechnique de Mons (FPMs)



Université Libre de Bruxelles (ULB)



Cliniques Universitaires Mont Godinne (UCL)



ACAPELA Group (industrial contact)

Project funded by



Walloon Region (Région Wallonne)



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- ❑ What is ECLIPSE?
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- ❑ Partners
- ❑ **Speech modality: ZZT representation**
 - **General context**
 - Definitions
 - The ZZT representation
 - Applications
- ❑ Image modality
- ❑ What about multimodality in this project?

General context

- Developed by Mr **Baris Bozkurt** and subject of his thesis entitled '*Zeros of z-transform(ZZT) representation and chirp group delay processing for analysis of source and filter characteristics of speech signals*' defended by himself in 2005

- Protected by the patent **PCT WO 2005/031702 A1** '*Method for estimating resonance frequencies*'

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Definitions

The Z-transform

$$X(z) = \sum_{n=0}^{N-1} x(n)z^{-n}$$

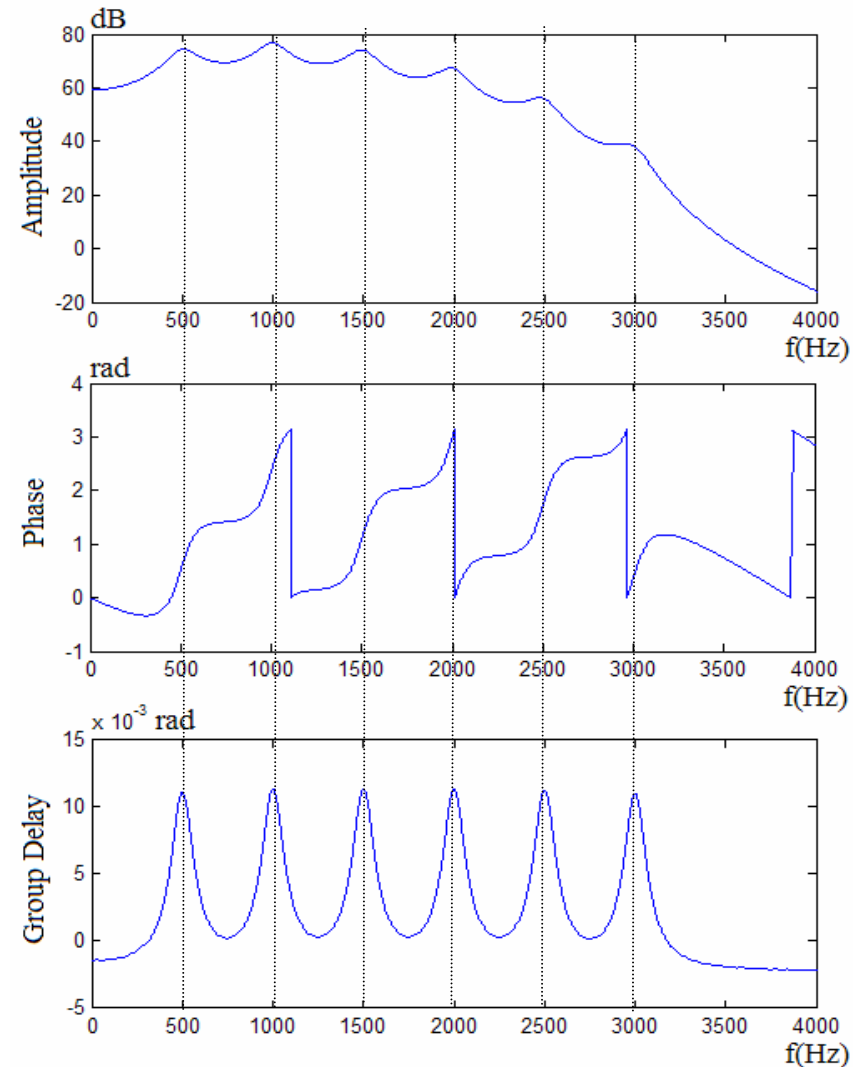
The Fourier Transform

$$X(\omega) = X(z) \Big|_{z=e^{j\omega}} = a(\omega) + jb(\omega)$$

$$\text{Amplitude} \Rightarrow |X(\omega)| = \sqrt{a(\omega)^2 + b(\omega)^2}$$

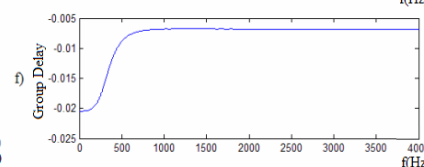
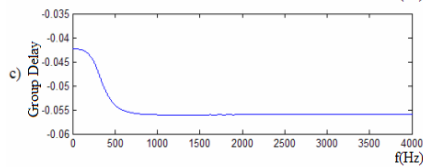
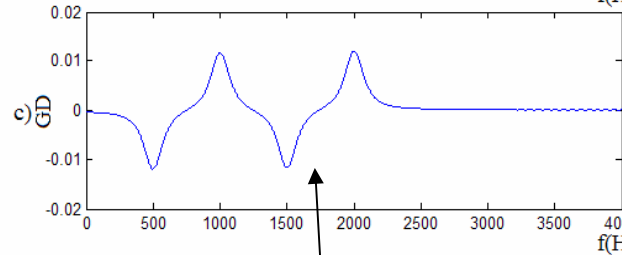
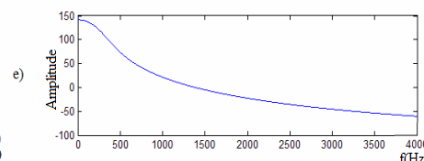
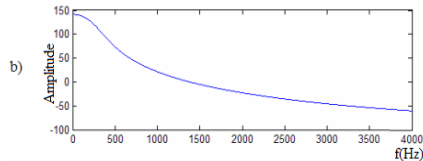
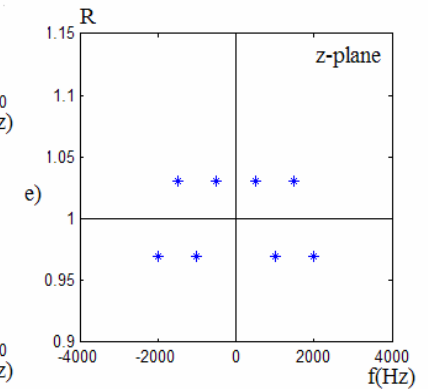
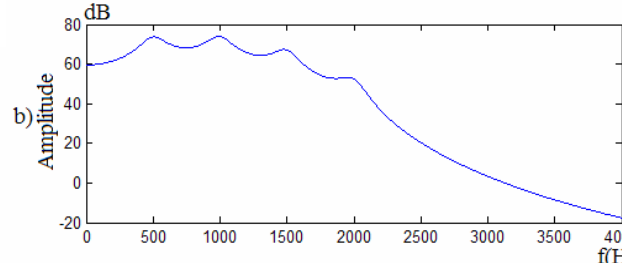
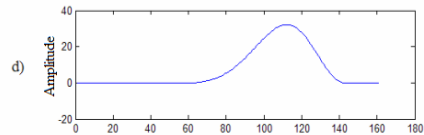
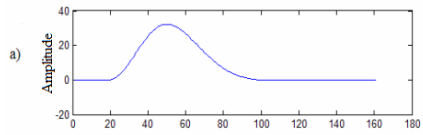
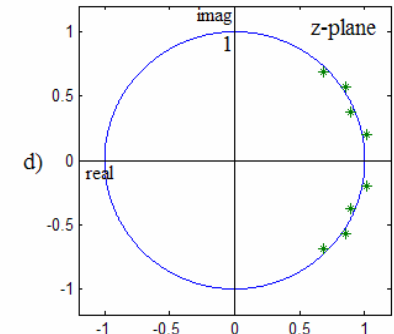
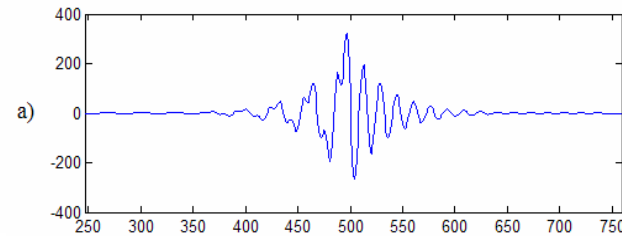
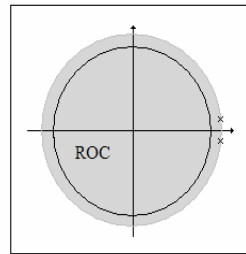
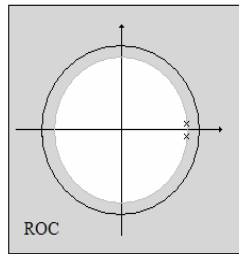
$$\text{Phase} \Rightarrow \theta(\omega) = \arctan\left(\frac{b(\omega)}{a(\omega)}\right)$$

$$\text{Group Delay} \Rightarrow \tau(\omega) = -\frac{d(\theta(\omega))}{d\omega}$$



Definitions

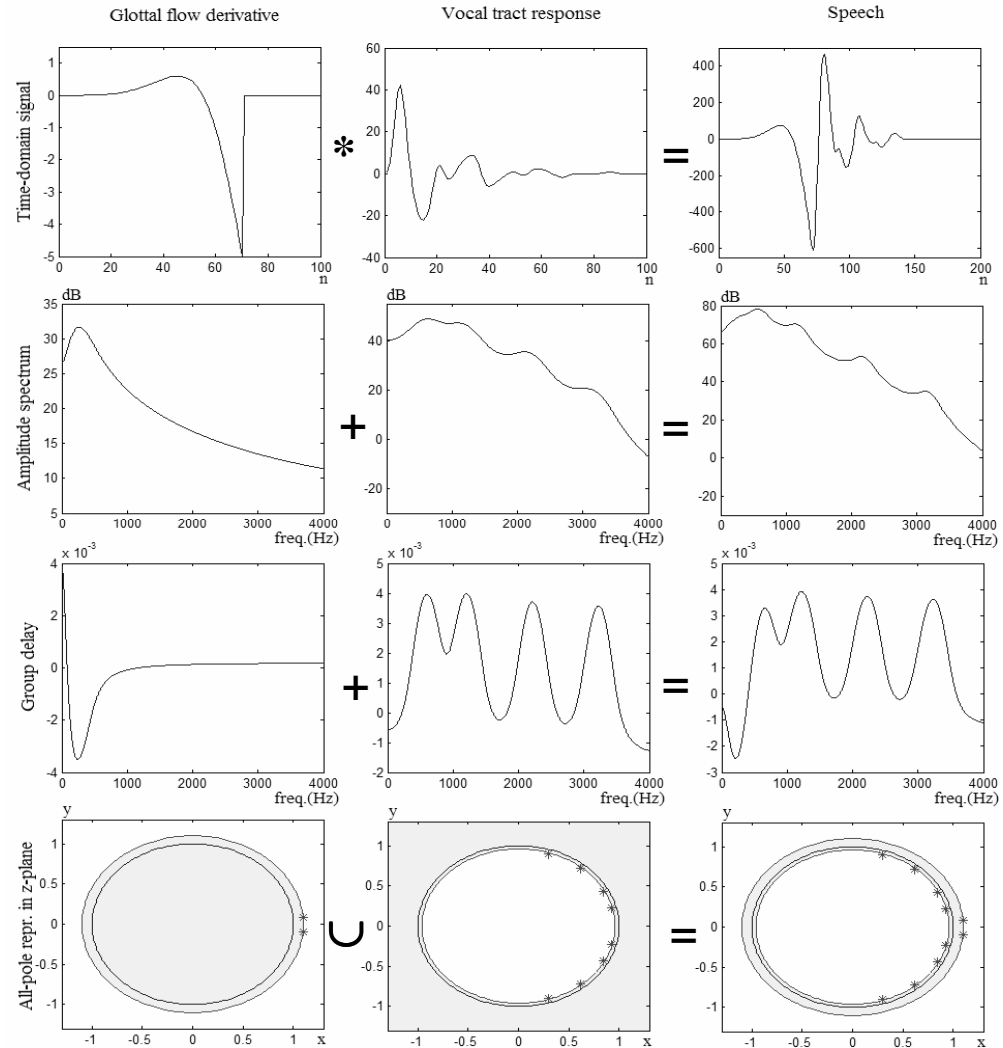
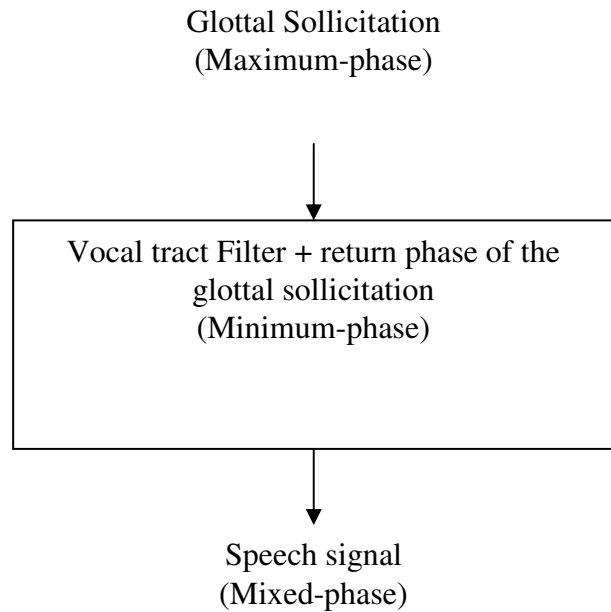
Causality/anticausality



Importance of the group delay !!!

Definitions

Mixed-phase model of speech



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- ❑ What about multimodality in this project?

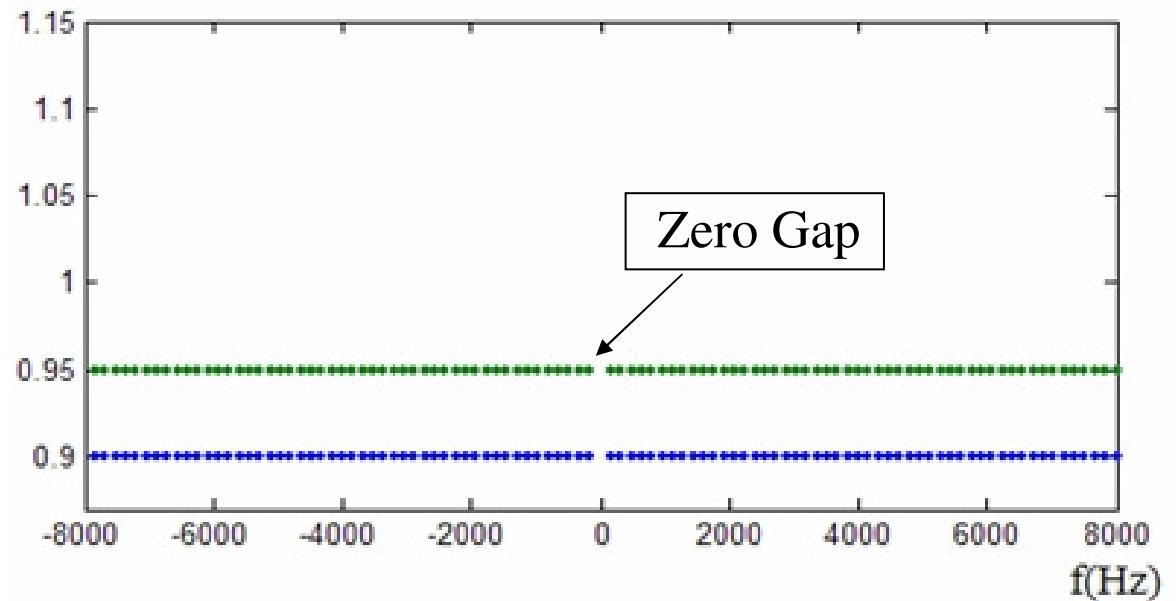
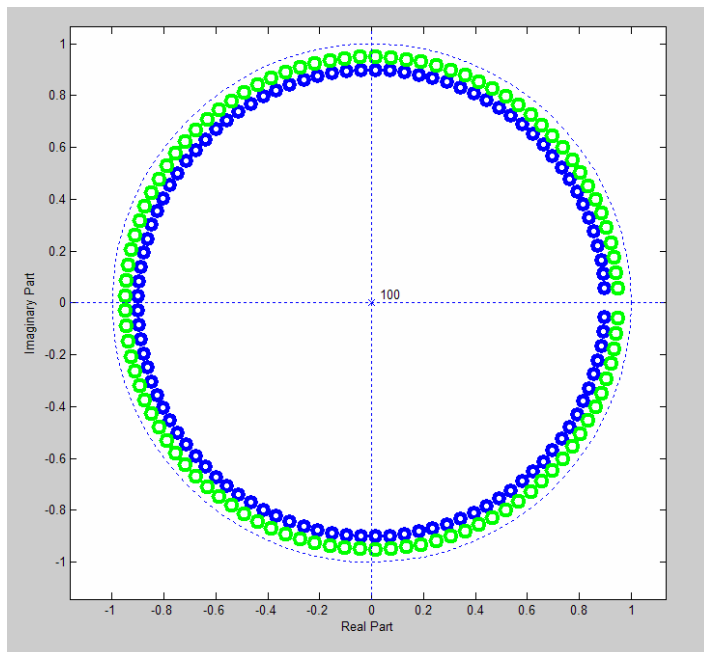
ZZT representation

ZZT definition

$$X(z) = \sum_{n=0}^{N-1} x(n) z^{-n} = x(0) z^{-N+1} \prod_{m=1}^{N-1} (z - Z_m)$$

Examples

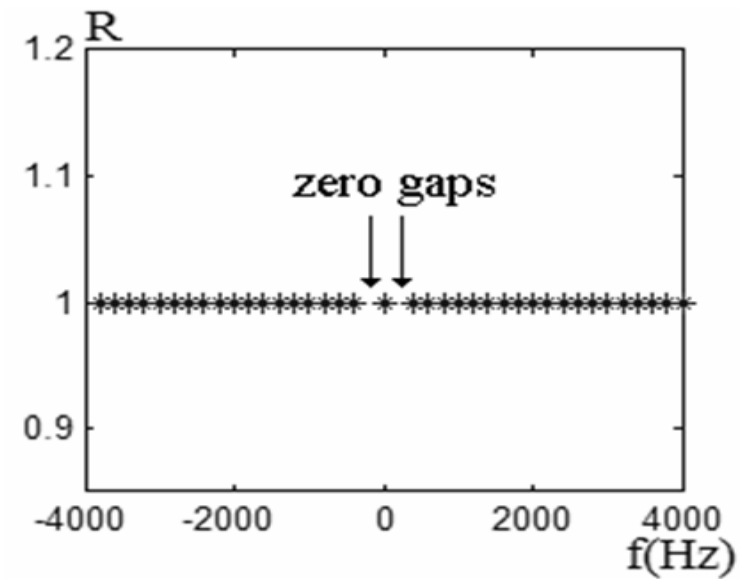
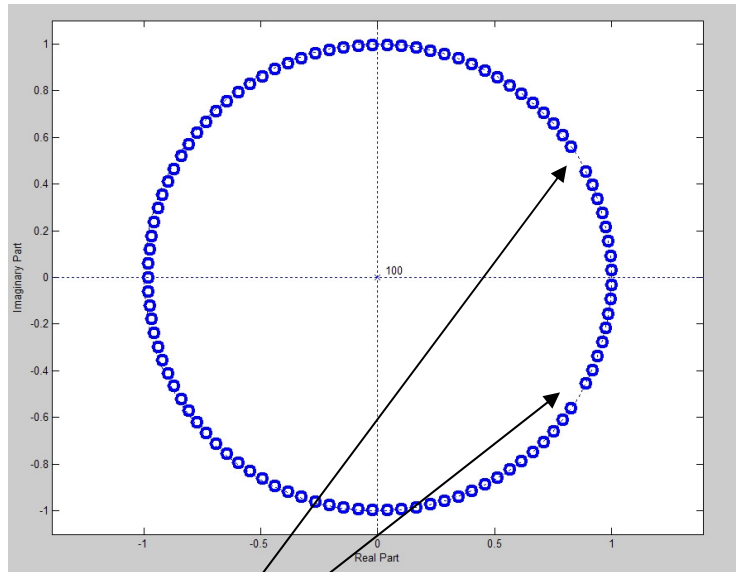
$$x(n) = a^n, n = 0, 1, \dots, N-1$$



ZZT representation

Examples

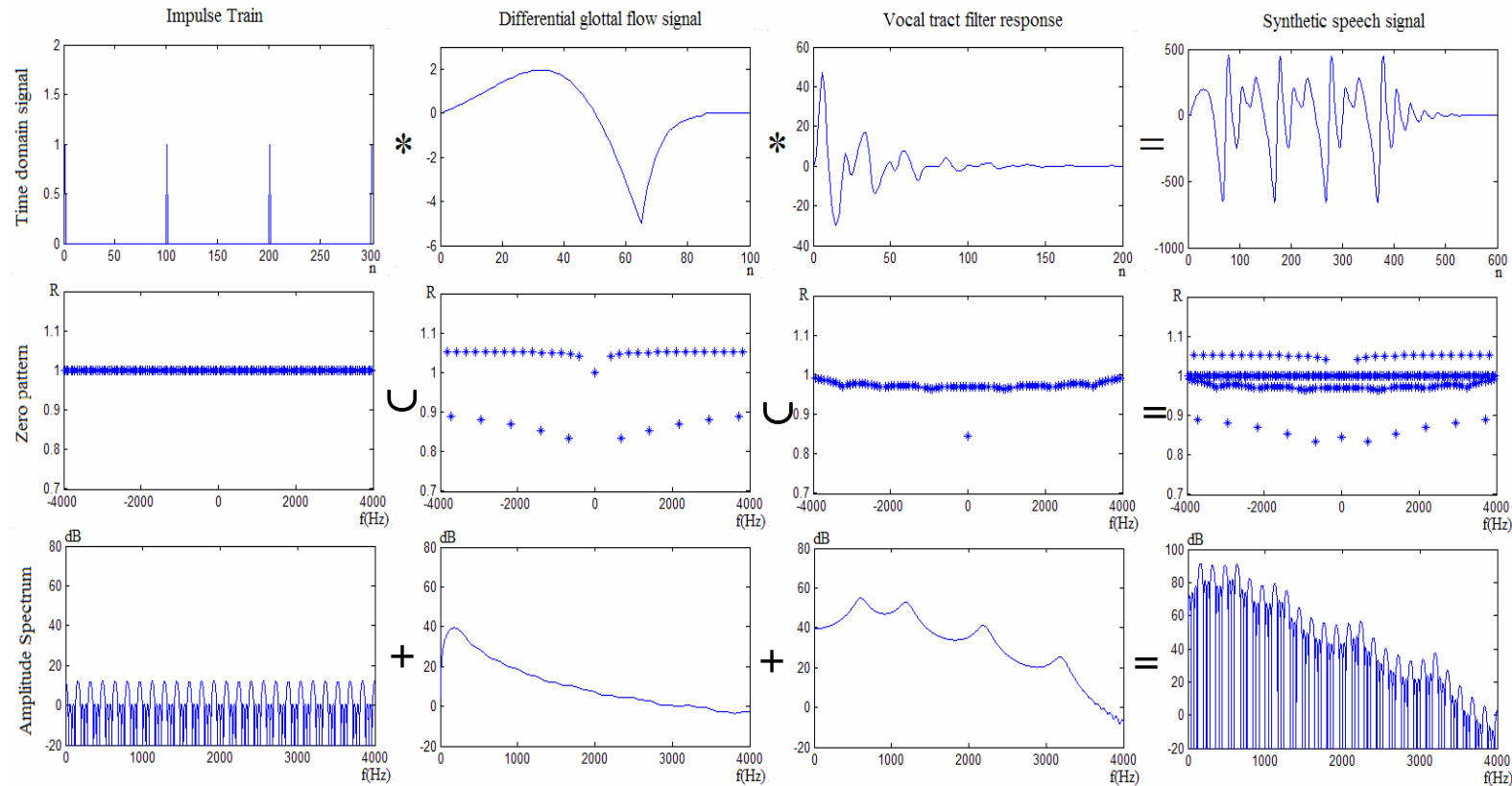
$$x(n) = \sin(\omega n), n = 0, 1 \dots N-1$$



Zero gaps

La représentation ZZT

ZZT for the mixed-phase model of speech



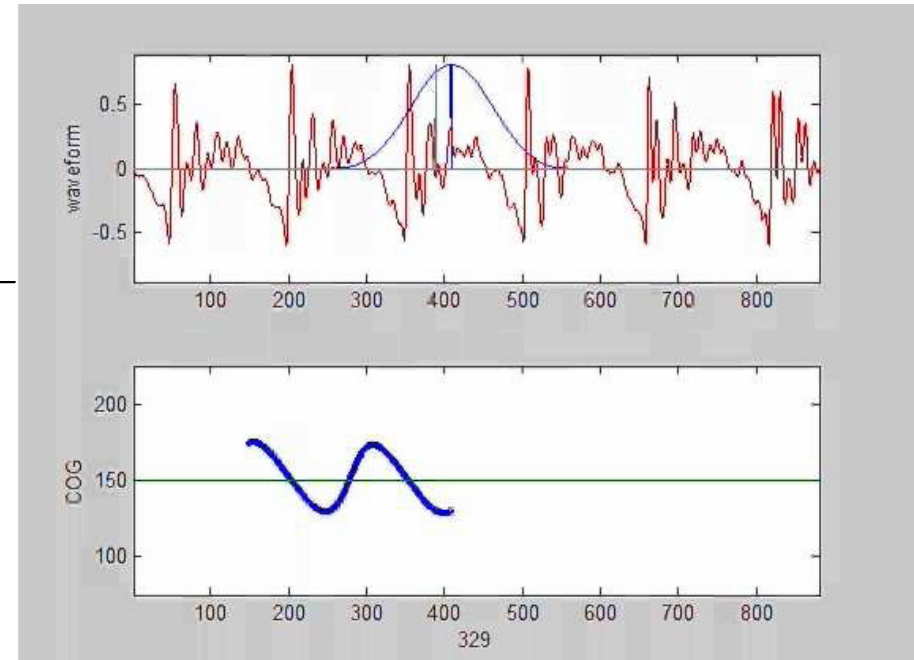
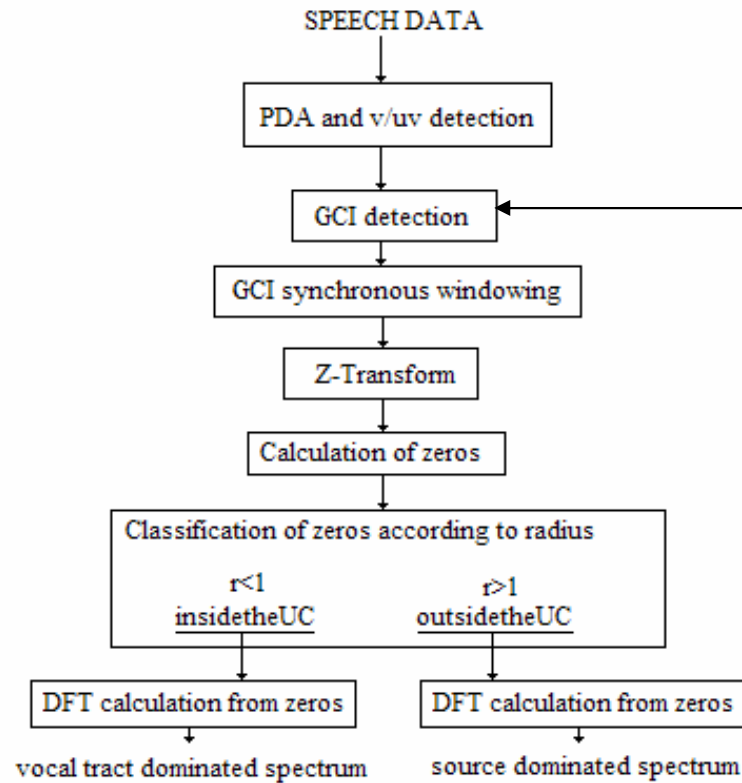
Importance of the analysis window!!

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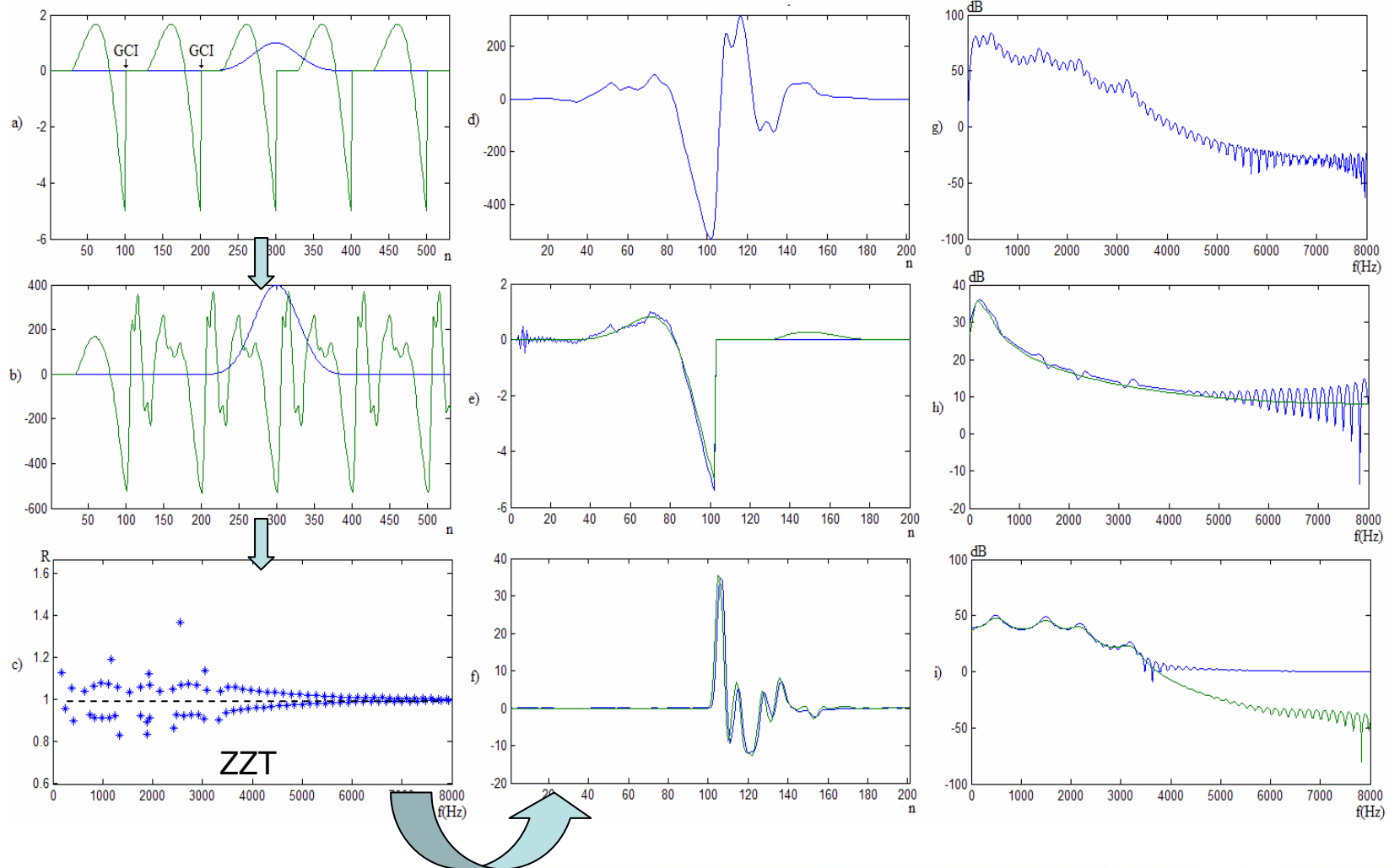
Applications

Separation glottal source – vocal tract



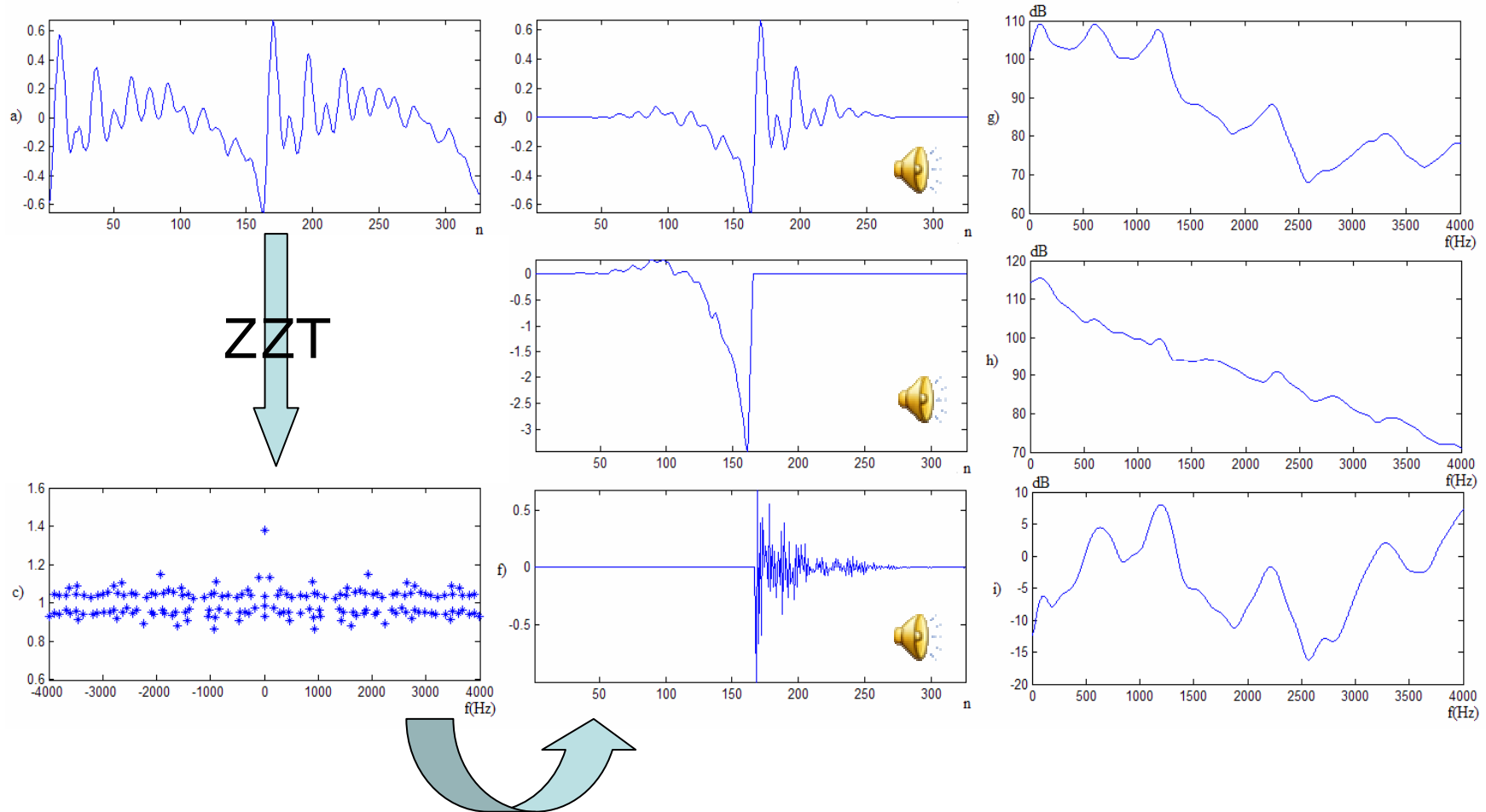
Applications

Separation glottal source – vocal tract : synthetic speech



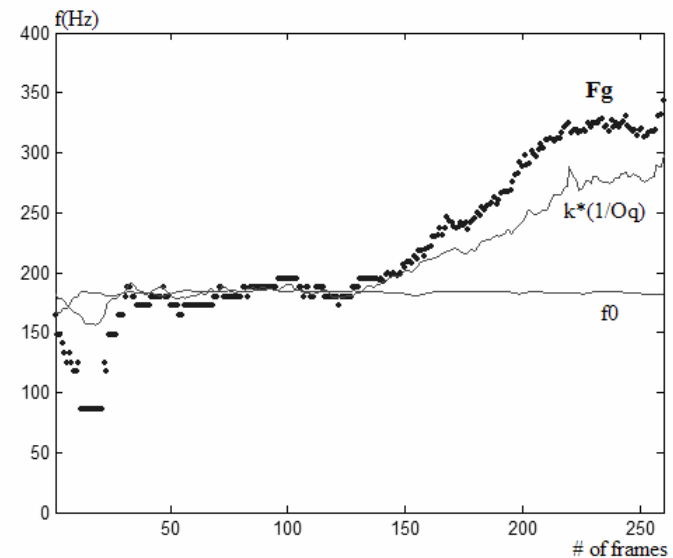
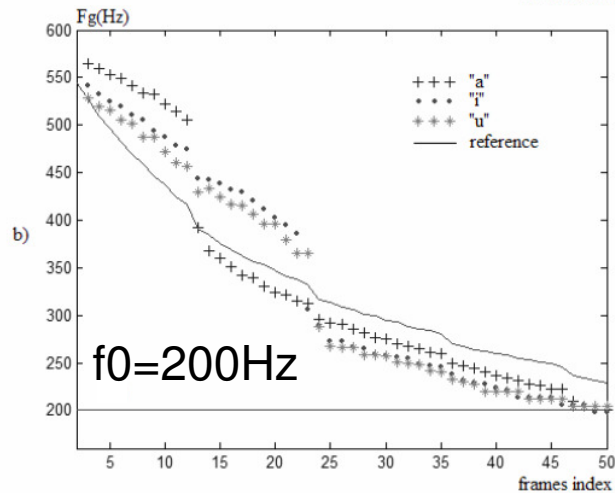
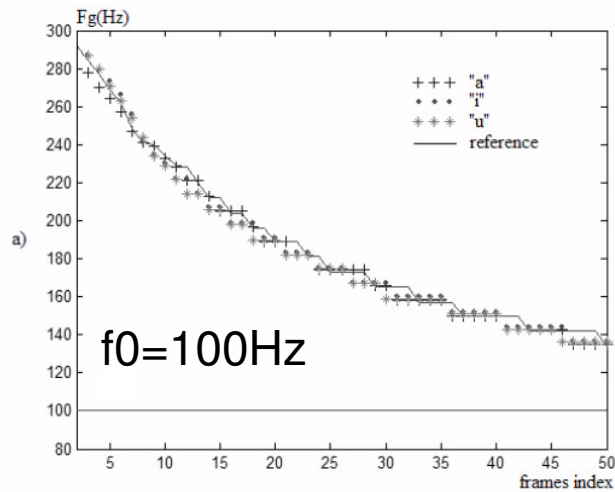
Applications

Separation glottal source – vocal tract: natural speech



Applications

Estimation of F_g (glottal formant)



$$\text{Model : } F_g = \frac{f_g(\alpha_m)}{O_q T_0}$$

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Image modality

- ❑ Image modality: analysis of the vibration of the vocal folds by undersampling
- ❑ Currently, use of the **stroboscopic imaging**
- ❑ In this project, we expect to use **high speed imaging** : up to 2000 images per second !

Image modality

- Example



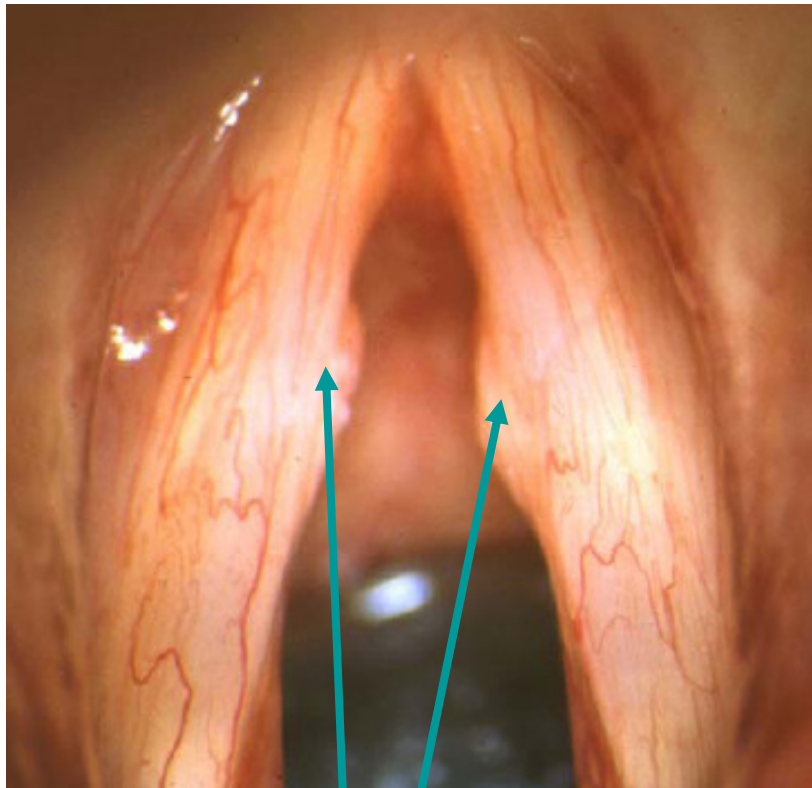
Normal vocal folds (opening)



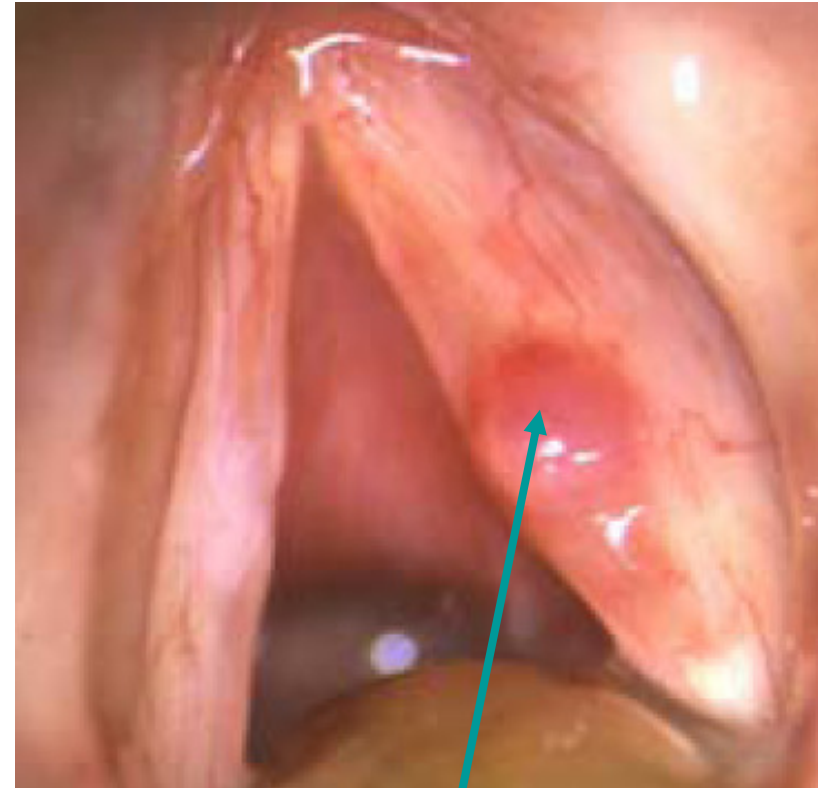
Normal vocal folds (closing)

Image modality

□ Example



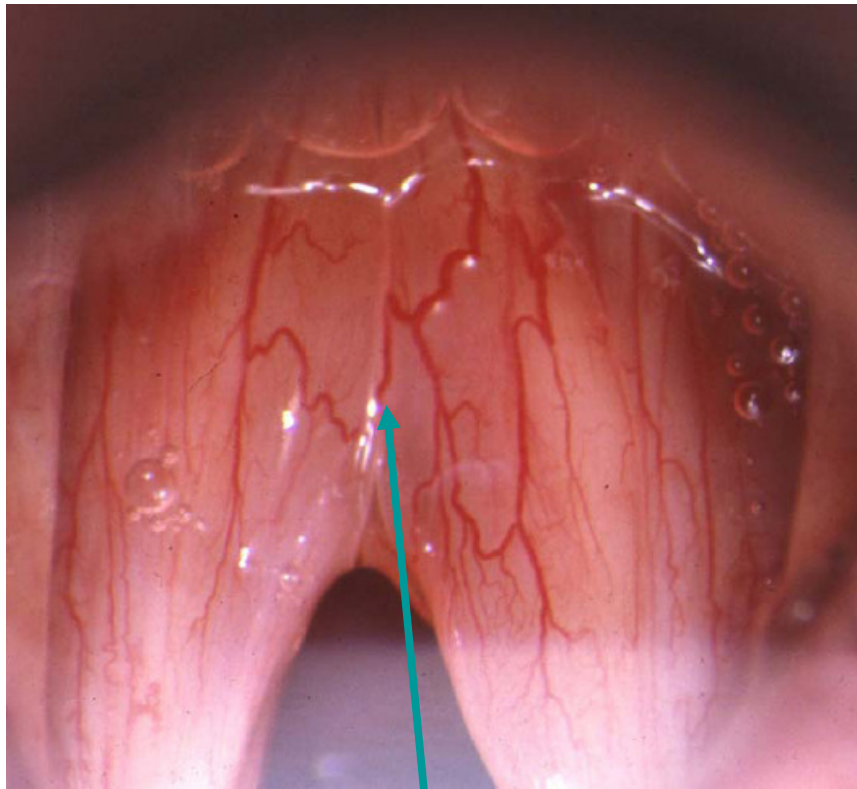
Nodules



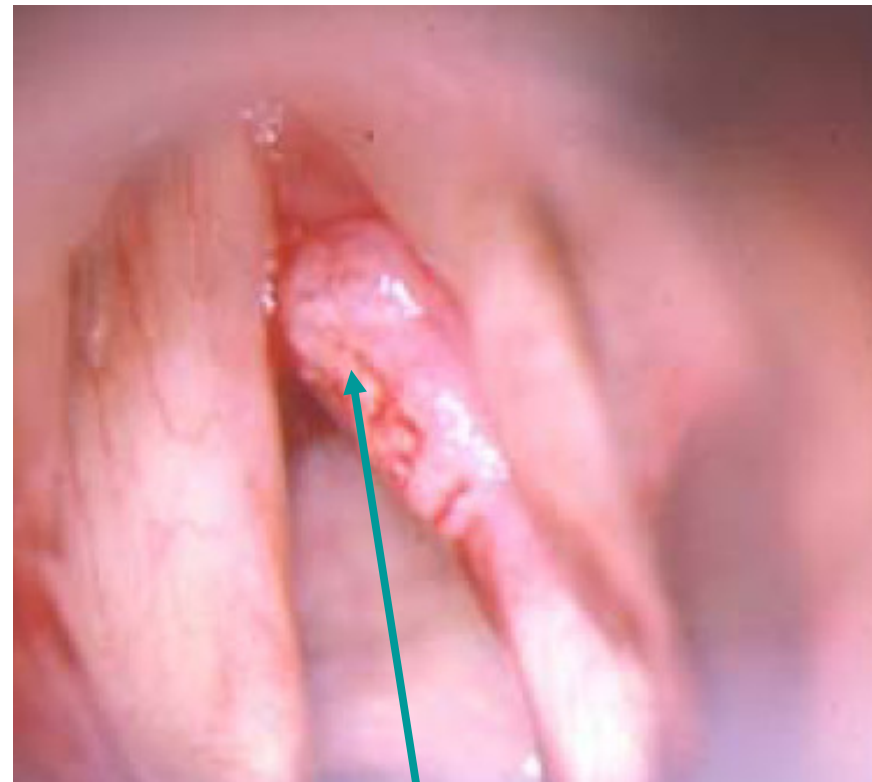
Polyp

Image modality

- Example



Reinke Oedema



Cancer

Image modality

- Example



Video

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Multimodality in this project

