LANGUAGE DEPENDENCY OF OBJECTIVE SPEECH QUALITY CRITERIA IN MOBILE NETWORKS

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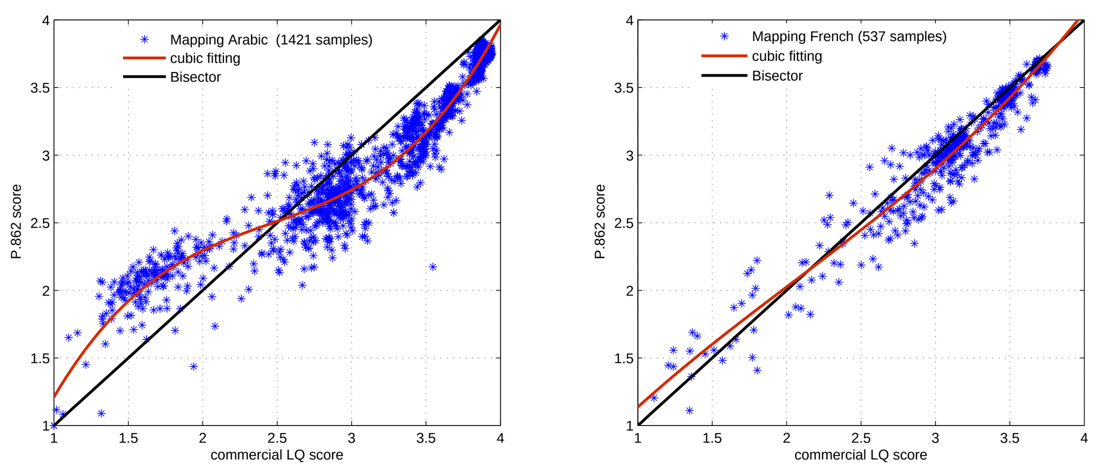
Introduction

- Main motivation
  - Non adequacy of quality assessment algorithms to Arabic speech
  - Which language feature is responsible for this dependency?
- T/F non stationarity measure of languages:
  - The stationarity index (SI)
  - Language dependency of the local T/F characteristics
- Effect of arbitrary frame by frame analysis on the T/F speech content: Case of PESQ

- Commercial objective quality assessment criteria has shown language dependency when used in actual mobile communications network. To analyze this dependency, we focus on time/frequency analysis of speech and we show that different languages have different "non stationary" behavior.

Main motivation

Commercial LQ scores vs. PESQ P.862: mapping for different languages



Arabic samples mapping — French samples mapping

=> Language dependent behavior

Test procedure: measurements in the mobile network of Tunisiana, one ref. speech sample per language (male/female speakers, 6s)

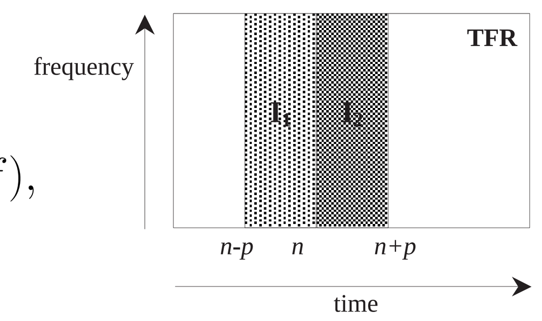
Which language feature is responsible for language dependency?

A feature which discriminates between languages:

- Linguistic approach [Grabe et al., 2002]: rhythmic language classification (stressed, syllable and mora-timed), based on *isochronously repeated rhythmic units*
- Statistical-linguistic approach [Ramus et al., 1999]: Statistics of vocalic-consonantal intervals duration(%V, Δ C)
- Signal processing approach: Voiced-unvoiced transitions detected and measured in the time-frequency domain.

T/F stationarity measure of languages: stationarity indices SI

- Sliding sub-images I_1 and I_2:



$$I_1(n;\tau,f) = TFR(n-p+\tau,f),$$
$$I_2(n;\tau,f) = TFR(n+\tau,f).$$

Sliding step $\tau \in [0,p]$ and p is a sensitivity parameter.

- Normalized sub-images NI_1 and NI_2

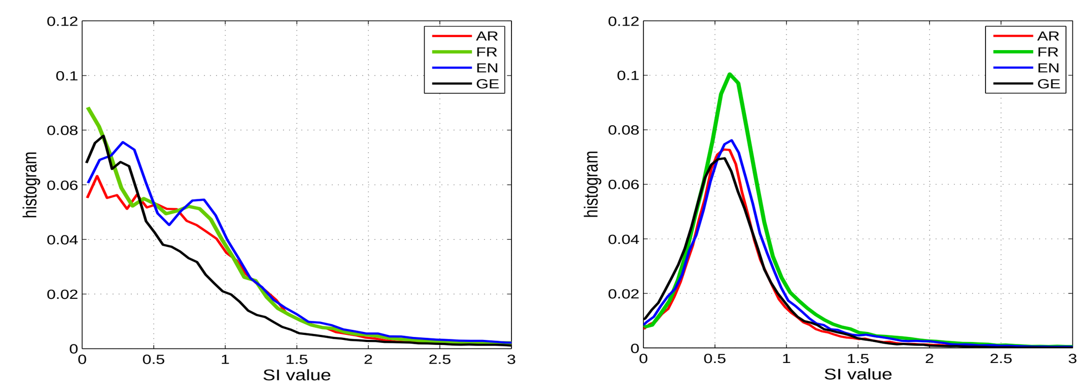
$$NI_k(n;\tau,f) = \frac{|I_k(n;\tau,f)|}{\int_{\tau=0}^{p}\int_{-\infty}^{+\infty}|I_k(n;\tau,f)|df d\tau} \quad k=1,2$$

- Küllback Distance between sub-images:

$$SI_{ku}(n) = \int_{\tau=0}^{p}\int_{-\infty}^{+\infty}(NI_1(n;\tau,f)-NI_2(n;\tau,f))\log\left(\frac{NI_1(n;\tau,f)}{NI_2(n;\tau,f)}\right)df d\tau$$

Variability of the local T/F speech content: Histograms of stationarity indices

- Languages have different SI histograms: bimodality for English, flatness for Arabic, rather unimodal for French



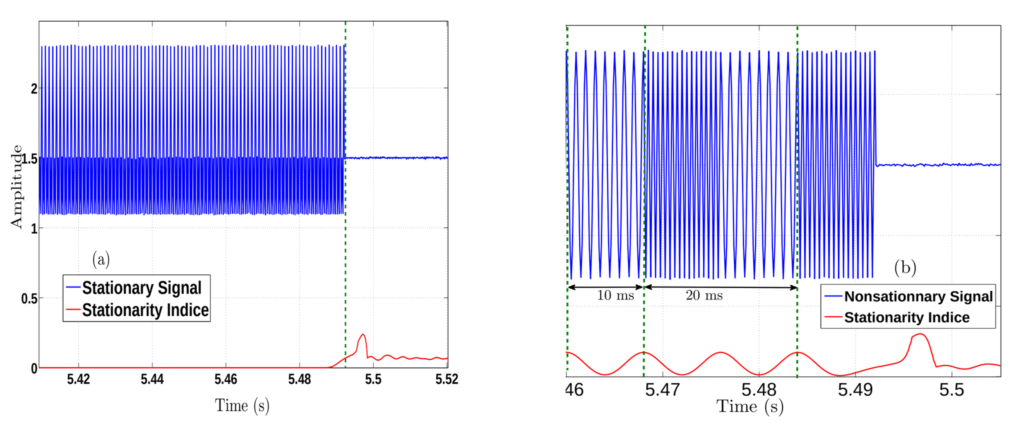
UIT-T P.50 original speech samples — stationarized(LPC modeled)samples

⇒ Languages have different non stationary behavior

- Histograms of stationarized languages show all the same unimodal behavior: Differences in the non stationarity characteristics between languages are reduced

Compromise between frame size and stationarity of signals

SI of test signals

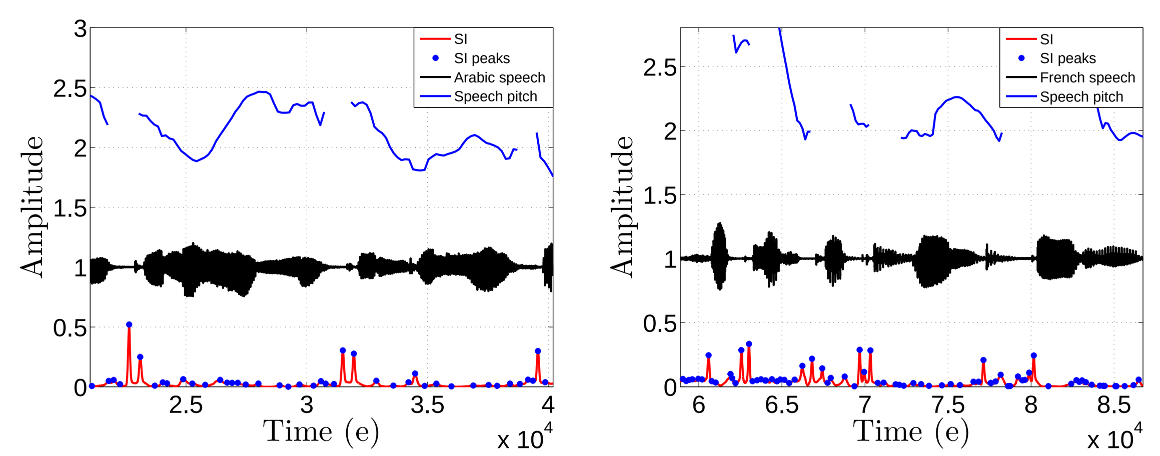


(a) Sum of 2 sinusoids (stationary) — **(b)** 2 concatenated sinusoids (non stationary)

- Signal (a) is stationary: use of a large analysis frame
- Signal (b) is non stationary (SI peaks): frame size depends on stationary segment duration

Optimal frame size = Distance between SI peaks

Speech test material for frame size optimization



Pitch and Stationarity Indices of an Arabic and a French sentence

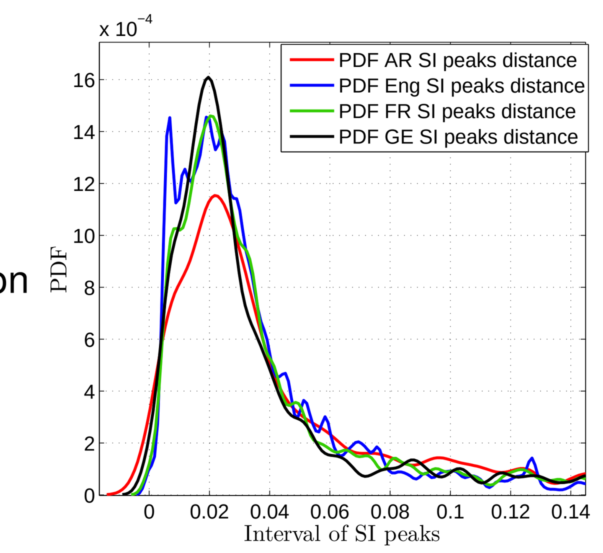
We compute the distance between SI peaks:

- 16 sentences (8s) in Arabic, French, German and English
- Speech Database: ITU-T P.50 (F_s=16 kHz, 16 bits)

SI threshold $= 0.02$ => Voiced/Unvoiced transition

Optimal analysis frame size for different languages

- 20 ms frame size suitable for AR, GE, FR
- ENG case: 2 frame duration - 10ms and 20ms - seems to be suitable



⇒ Optimal analysis frame size is 20ms as usually stated

⇒ For some languages, a variable frame size should be used

Conclusions

- Many speech processing systems are based on signal stationarity over 20 ms analysis frames
- This work confirms the analysis frame size of 20 ms (usually stated) for FR, GE and AR
- Some languages, like English, have a different period of stationarity: 10ms and 20ms
- A variable analysis frame size would enhance speech processing and reduce the effect of language dependency (as the example of AAC-coder for Music coding)

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