SYNTHESIS OF MULTIAXIS STATIONARY NON-GAUSSIAN SHAPED VIBRATION

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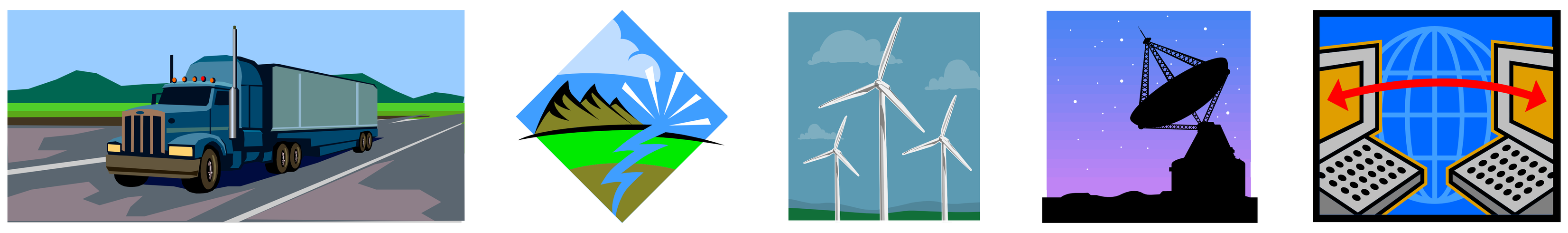
MOTIVATION

Road vibration is **random** in nature and **non-Gaussian**, although it is usually approximated through stationary Gaussian processes with prescribed PSD.

Since objects move in a 3D space, vibration is also a **multidimensional** physical process, but is usually simplified to a single dimension.

In order to properly evaluate the effect of vibration on structures, a proper **synthesis** algorithm is necessary for reproducing the vibration environment in the laboratory.

Applications



OBJECTIVE

The objective of this thesis is the development of a method for the **synthesis of non-Gaussian multiaxis road vibration**, with a prescribed PSD, *pdf* and cross-correlation. The goal is to capture the properties of the interaction between the wheel and the road in a vehicle, and provide the tools for reproducing this process at the laboratory.

METHODOLOGY

The methodology for the development of the thesis includes four main steps.

Process characterization
- Field measurements
- Signal analysis

Single axis non-Gaussian synthesis
- Effect of block processing
- Algorithmic complexity of the phase manipulation technique

Multiaxis non-Gaussian synthesis
- Extension of the phase manipulation techniques to non-Gaussian multiaxis vibration synthesis

Control of multiaxis non-Gaussian vibration
- Analysis of the possible techniques applicable to the control of the synthesized vibration

PLANNING FOR 2014-2015

Tasks for 2014-2015 include field measurements and analysis for process characterization, and further investigation of single axis non-Gaussian vibration synthesis.

		2014				2015			
Task	Description	T1	T2	T3	T4	T1	T2	T3	T4
1	Literature review								
2.a	Definition of the measurement conditions								
2.b	Field measurements								
2.c	Signal analysis						R		
3	Single axis non-Gaussian random vibration synthesis								

RESULTS AND DISCUSSION

Block processing

Block processing is commonly used for the synthesis of large random signals in order to profit from the computational advantages of the FFT.

$$z[n] = \sum_k w[n - kD]x^{(k)}[n]$$

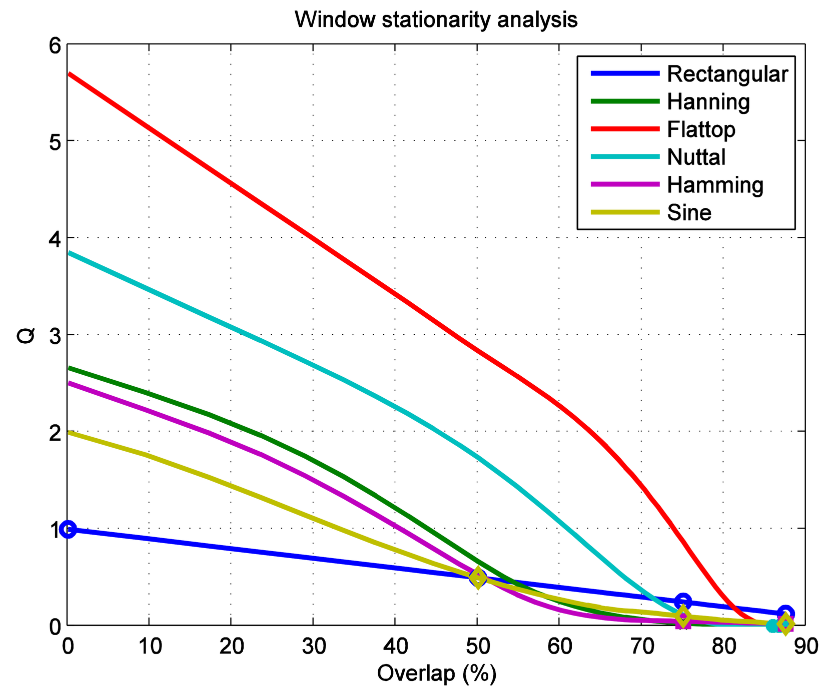
Relation between the autocorrelation of z and x: $r_z[n,\tau] = r_x[n,\tau]W[n,\tau]$

$$W[n,\tau] = \sum_k w[n - kD]w[n - kD - \tau]$$

For a stationary $x^{(k)}[n]$, the process $z[n]$ will be stationary if $W[n,\tau] = W[\tau]$. The stationarity of $W[n,\tau]$ can be quantified as:

$$A[\tau] = \max_n(W[n,\tau]) - \min_n(W[n,\tau]) \qquad Q = \max_\tau(A[\tau])$$

where the stationarity increases as Q tends to 0.

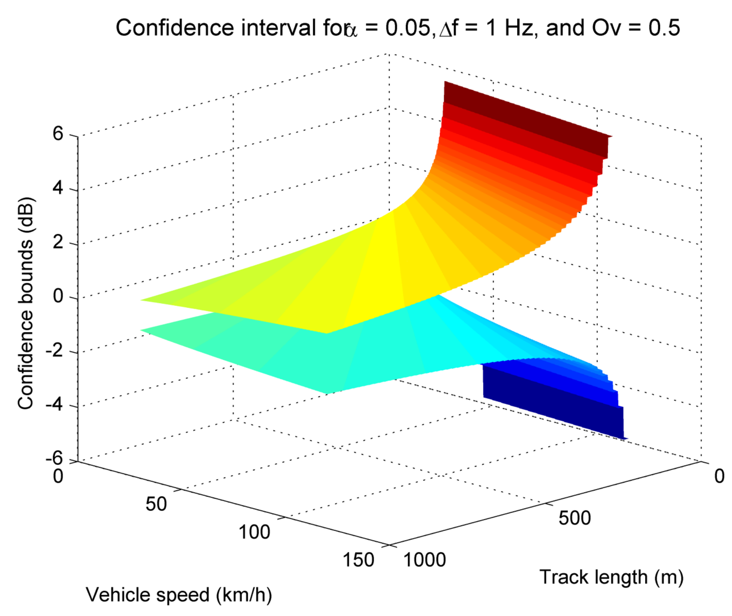


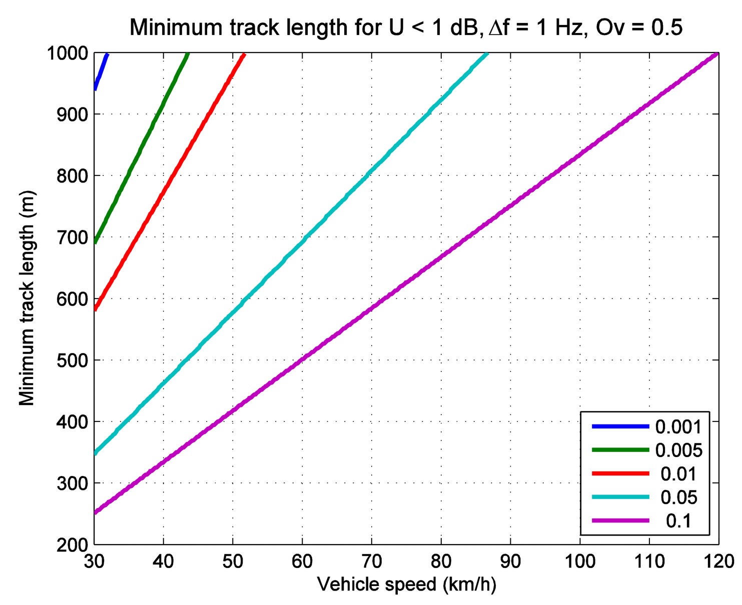
- The stationarity increases for increasing overlap factors.
- Most of the windows perform similarly above 50% overlap.
- For non-Gaussian processes, increasing the overlap will affect the distribution due to the CLT. A trade-off between stationarity and non-Gaussianity is required.

Uncertainty of the spectral estimates

Spectral estimation of non-Gaussian road vibration requires knowledge of the corresponding uncertainty.

- For Gaussian processes: $z = \frac{2K\tilde{S}_{xx}(\omega)}{S_{xx}(\omega)} \sim \chi^2_{2K}$, with $\tilde{S}_{xx}(\omega)$ the Welch periodogram.
- For large FFT sizes and/or averages, and non-Gaussian processes, the previous expression holds due to the CLT.
- Relation between the uncertainty of the estimate and the road measurement parameters:





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