COMPUTATIONAL TOOLS FOR SIGNAL PROCESSING
APPLICATIONS FROM INDUSTRY AND BIOINFORMATICS

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Institute Site (Main CAMPUS)
Research fields

Signal Processing (MV-SoftWare-Indust.)
Computational Chemistry
Photodynamic
Theoretical and Applied Physics
Environmental IMPACT, EDUCATION
Recycling, Composting
SUMMARY

Indicators description (Nonlinear Dynamic)

Application to mechanical systems. TEP, NPP

Bioinformatic Application (Biological Systems).

Flavonoids/Proteins Interaction

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Electricity generation in Cuba. Principal Sources

1959 - 397 MWt → 56% → > 3 000 MWt

TURBINES
Thermal PS

HIGHLY COMPLEX MACHINES

Combination of
THREE MAJOR PARTS

CONDITION MONITORING
SYSTEMS

ROTOR
FF-BEARINGS
SUPPORTING
STR.

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The trend in the Condition Monitoring is the combination of different methods. The principal task of the signal processing is to extract the maximum amount of the all significant diagnostic information from the original signals generated by the transducers.

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Indicators description (Nonlinear Dynamic)

For CMS sophisticated systems are monted ON LINE:

Procedure $\rightarrow$ Lineal dynamic $\rightarrow$ FFT

The evolution of Patterns from linear to nonlinear and the appearance of combined faults

1. Trend Diagrams
2. Waterfall Diagrams.
4. Orbit Representation.
5. Temporal Series
6. Spectral analysis.
7. Multi-Spectral Comparison.
8. Envelope Analysis.
9. “Cepstrum” application.
10. Full Spectrum

.... $\rightarrow$ the diagnostic information is not enough
**SPECTRAL ANALYSIS...**

**Typical Faults**

**Time to Frequency:** common used for a better understanding of **time series** and for **analysis and fault classification**.

**Frequency lines = defects,**
common way to fault detection

- **Unbalance**
- **Coupling Misalignment**
- **Loose Stationary Part Malfunction**
- **Fluid induced Instabilities**

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Indicators description (Nonlinear Dynamic)

Chaotic Patterns

The *CHAOTIC BEHAVIOR* of rotor to stator system
Interaction between rotating shaft with its stator and supporting structure.

Divergence from the normal Operational Condition

1. Looseness in the stationary joints;
2. Oversize, poorly lubricated bearing;
3. Rubbing rotor:

Physical Phenomena

1. System Stiffness $f(t)$ increase/decrease
2. Impacts.
3. Friction

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Indicators description (Nonlinear Dynamic)

Correlation Dimension $D_2$ (applied to mechanical systems)

1. **Estimation** = Difficult task (as a function of analyzed mechanical system)
2. –Automatic determination. (on line processing)

Pseudo-Phase Portrait PPP

1. – Under study.
2. – Limited analysis of the geometrical configuration.

... → It is necessary to develop **new methodology** and descriptors with **high sensitivity**.
Indicators description (Nonlinear Dynamic)

Method of Delay [MOD]

\[ X_i = \{ x_i, x_{i+\tau}, \ldots, x_{i+m-\tau} \}, \]

First Zero \( \text{FAC}(\tau) \)??
Unbalance

Coupling Misalignment

Hydrodynamical faults

Structural problems

Typical FAULTS vs 2D-PS

PPP as Patterns

Thickness
Indicators description (Nonlinear Dynamic)

\[ D_2 = \text{slope of the scaling region } C(r, m) \]

\[ C(r, m) = \frac{2}{N_m (N_m - 1)} \sum_{i,j=1}^{N_m} \Theta(r - \|x(i, m) - x(j, m)\|), \]

A-AD-QE Method
[A-AD-QE] method

APPLICATIONS

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Application to mechanical systems. TEP

THE PSEUDO-PHASE PORTARIT AND FD APPLIED TO

- Faults identification in Thermoelectrical PP
- Power instability in the N.Reactor
- Internal Vibration of N.Reactor
Application to mechanical systems. TEP

Data collection system...

1. Turbine
2. VibroControl 4000
3. Charge amplifier: B&K 2626
4. ADConverter
5. SoftWare VibraMec

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1024 points
500 Hz
1.. 10 Records
Application to mechanical systems. TEP

Experimental measurements in a Cuban TP

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Application to mechanical systems.

**PPP: Indicator of mechanical Changes**

**Point:** ‘4V’.

**State:**
[13 MWt, 7:32 - 7:38 pm].

**Spectrum evolution:**
Similar behavior,
PPP: Show morphological modifications.

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LZP calculado
Por el método A-AD-QE (*)

<table>
<thead>
<tr>
<th>( \ln(t_1/t_0) )</th>
<th>( \ln(t_2/t_0) )</th>
<th>LZP</th>
<th>( D_2 \pm \sigma )</th>
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<tbody>
<tr>
<td>1.37</td>
<td>1.07</td>
<td>0.30</td>
<td>1.86 ± 0.00</td>
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<tr>
<td>2.13</td>
<td>1.08</td>
<td>1.05</td>
<td>1.15 ± 0.00</td>
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<tr>
<td>1.11</td>
<td>0.59</td>
<td>0.52</td>
<td>1.14 ± 0.00</td>
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<tr>
<td>0.99</td>
<td>0.65</td>
<td>0.34</td>
<td>1.34 ± 0.00</td>
</tr>
</tbody>
</table>

PPP and CD
Application to mechanical systems. TEP

PPP vs Total dilatation of a Turbine

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**Application to mechanical systems. TEP**

**PPP vs Geometrical Configuration**

<table>
<thead>
<tr>
<th>Gr.</th>
<th>RFB</th>
<th>$A_{D_{L \text{ grad}}}$</th>
<th>$V_{M_{a \text{ vs \text{ángulo}}}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>T148 MBC</td>
<td>150.5</td>
<td><img src="image1.png" alt="Graph 1" /></td>
</tr>
<tr>
<td></td>
<td>T150 MBC</td>
<td>29.5</td>
<td><img src="image2.png" alt="Graph 2" /></td>
</tr>
<tr>
<td>II</td>
<td>T154 MBC</td>
<td>149.0</td>
<td><img src="image3.png" alt="Graph 3" /></td>
</tr>
<tr>
<td></td>
<td>T155 MBC</td>
<td>21.0</td>
<td><img src="image4.png" alt="Graph 4" /></td>
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</tbody>
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PPP vs Oil temperature

![Graphs showing PPP vs Oil temperature](image)

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Application to mechanical systems. NPP

Research Reactor (TRIGA MARK III)

BWR

PHWR (Pressurized Heavy Water Reactor)

Identification of instabilities as periodic oscillations of the neutron flux via instrumentation
Decay ratio (DR) or the main frequency, Both indicators are evaluated by means of ARMA (parametrical models)

The main hypothesis: Lineal behavior of the NUCLEAR REACTOR; Nevertheless: nonlinear behavior,

Instability case of the Nuclear Reactor
Application to mechanical systems. NPP

Research REACTOR-TRIGA MARK-III

PPP configuration and the CD value


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Application to mechanical systems. NPP

<table>
<thead>
<tr>
<th>Tipo de Reactor</th>
<th>Resultado de la aplicación de A-AD-QE</th>
<th>EFB</th>
<th>DA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BWR/6</td>
<td><img src="image1.png" alt="Graph" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Limit Cycle corrupted by NOISE


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Application to mechanical systems.

NPP

Atucha I - Argentina

Application to biological systems

The **Pseudo-Phase Portarit and Fractal Dimension**

applied to pattern recognition in biological systems.

its approach to FLAVONOIDS-PROTEINS INTERACTION
Flavonoids

class of polyphenolic compounds found in several plant species and in plant related foods (red wine, tee, olive oils, vegetables, fruits, nuts).

These compounds have evidenced very good health effects during years and their interaction with proteins seems to be one of the most important causes of their bioactivity.

We do not have general patterns for the characterization of Flavonoids-Proteins Interactions, due to the structural complexity of flavonoids.

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I. - Exploration (preparation of the data base)

II. - Classification Groups

(Conformation of the Signal according with the exponential fit.

\[ f(x) = Y_0 + Ae^{\frac{x}{t}} \]

\[ Y_0 = 24,85165, A = 0,65219, t = 3,78043 \]

REPORT THE AFFINITY ORDER OF THE INTERACTION
Application to biological systems. TEP

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The high sensitivity of the PPP was demonstrated….

- Structural modeling (PPP → pattern of MV)
- Application of the PPP as a pattern, considering REAL STRUCTURE of the protein
- Application of MDA (PDB) - RPQ

Next STEPS

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http://www.mpipks-dresden.mpg.de/~tisean/TISEAN_2.1/docs/chaospaper/node14.html