Processes and Engineering in Mechanics and Materials Laboratory (PIMM)
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Curriculum Vitae

Dr. Nazih MECHBAL

Born mars 18th, 1971
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CURRENT POSITION AND EXPERIENCE

Associate Professor (HDR) at Arts et Métiers ParisTech (**ENSAM**), Paris.

Leader of the C3SM team (*Structural Control and Monitoring team*)

Co-Chair of the international conference **IFAC SAFPROCESS 2015, Paris France**

Visiting Professor (2010, 2013): Research projects and PHD class at UNICAMP, SP, Brazil.

ACADEMIC CAREER:

2015: **"Habilitation à Diriger des Recherches" -** Pierre et Marie Curie (Sorbonne University)
"Contribution to Active Control and Structural Health Monitoring"
2001: **Associate Professor** Arts et Métiers PariTech (ENSAM),
2000: **Post-Doctoral Research and Teaching (ATER)** at ENSAM
1999: **Doctor of Philosophy (Ph.D.) in Robotics** at l'ENSAM, Paris,
1995: **Master of Science in Robotics** at ENSAM - University Paris VI.

TEACHING ACTIVITIES AND RESPONSIBILITIES

My teaching concerns:

Under-graduate level: **Control** systems.

Graduate level: Linear and nonlinear estimation, Identification, Fault and damage detection, Mechatronics systems.

I assume various **responsibilities** and I am a member of different executive councils:

- ✓ Chair of the **Master "Advanced Systems and Robotics"** (Paris6-ENSTA-Mines ParisTech)
- ✓ Chair of **Mechatronics** third-year engineering course unit
- ✓ Responsible of "Control and Automation" study at ENSAM Paris
- ✓ Member elected to the National Council of French Universities. Ministry of education and Research (**CNU-61**).
- ✓ Member elected to the **Educational Council** (2008-2016) and of the **Administration Board** of ENSAM (2006-2012)

RESEARCH INTERESTS

The Process and Engineering in Mechanics and Materials laboratory (**PIMM**) brings together a wide range of specialists from the mechanics of materials and structures to the polymer chemistry and from forming and assembling processes, to advanced methods for numerical simulation. In particular, we deal with the consequences of the processes on the service properties via the induced defects and microstructural modifications. The activities in **structural dynamics, system and vibration control**, beyond their own justification, can make significant contributions to understand and simulate processes.

Active Control (AC) has emerged as a viable technology to minimize mechanical vibrations of structures. Recent developments have been propelled by the rapid technology growth in practical digital signal processing and by the use of promising smart materials with adaptable properties like piezoceramics. The obtained smart structure is able to react to external perturbations, but what happens if damage occurs? Could we adapt the active controller to the presence of damage? Could we adapt the controller to detain the growing of a crack?

Structural Health Monitoring (SHM) aims to detect, localize and evaluate the severity of damages. The improvement of the integrity assessment of in-service structures is the main challenge that motivates the use of SHM systems. As structures age, or undergo fatigue loads, the possibility of failure increases, which may significantly jeopardize operation and safety without timely awareness. Detecting and localizing damage in structures is a topic of growing interest.

It is well understood that damage can induce changes in the local and global properties of a structure (e.g., local effective stiffness, density, mass, thermal properties, electric/magnetic conductivity, electro-mechanical impedance and strain energy). Changing effects are present in dynamic response signals captured from the structure. Hence, it is a challenge to sense and to accommodate the damage within the active control law.

Damage Tolerant Active Control *Systems* (DTAC) comprehends the development of damage diagnosis and active control methods, applied to real structures. Due to continuous nature of structures (infinite numbers of degree of freedom) DTAC also involves specific model reduction problems. DTAC is a new field of research that has a promising future which is further fueled by the availability of smart structures and composites in several industries (e.g. aeronautic).

The activities of the **C3SM**, *Control and Monitoring of Mechanical Structure and Systems*, team are in the development and the application of theoretical automatics methods to mechanical systems and structures (composite materials, memory-shape alloys …) in order to design smart structures. The objective of our work is to develop DTAC algorithms and to validate them by finite element numerical simulations and experimentations.

My current research topics mainly concern:

Structural Health Monitoring (SHM), Active Control, Damage Tolerant Active Control (DTAC), Prognosis and Health management (PHM), Smart Structures, Estimation theory, Robust Control and Identification of mechanical systems, Finite Element (FE).

In progress Research Supervising:

- ✓ **4 PhD** Thesis directions/co-directions
- ✓ **1 Phd** Cotutelle direction with UNICAMP, Brasil
- ✓ **2 Master** Thesis directions/co-directions
- ✓ **2 SFE** (Final year engineering project).

Academic Collaboration

- *National*: University of Lille, Univer. of Nancy, INPG, Univer. Troyes, Paris 6 university, …
- *International*: UNICAMP, Brazil – *Invited Professor (two stays of 3 Months in 2010 and 2013)*

INDUSTRIAL COLLABORATION

Significant collaboration with industry through consultancy and contract research projects and also technical assistance. Here are some current projects:

- ✓ **SAFRAN AIRCELLE**: Structural Health Monitoring of A380 Nacelles (TRL 1 to 5). ***Flight tests have been conducted on an A380 nacelles.***
- ✓ **Aldebaran Robotics:** Control and identification of ROMEO legs'
- ✓ **PSA:** Design of Fault detection and diagnosis scheme for a steer-by-wire system.
- ✓ **Schlumberger**: Monitoring of a Wire Lateral Drilling (WILD) machine.
- ✓ **AIRBUS:** SHM for composite structures with piezoelectric patches.
- ✓ **SAFRAN SNECMA:** Integrated Health Monitoring development scheme for a turbojet.
- ✓ **CEA (**French government-funded nuclear research organization**):** Design of an inflatable long range inspection robot.

RECENT PUBLICATIONS

JOURNAL ARTICLES

[R1] C. Fendzi, M. Rébillat, **N. Mechbal**, M. Guskov, and G. Coffignal, " A Data Driven Temperature Compensation Approach for Structural Health Monitoring using Lamb Waves" has been accepted for publication in Structural Health Monitoring s," *Structural Health Monitoring*, 2016, (Impact factor: 1,64). *in press.*

[R2] C. Fendzi, **N. Mechbal**, M. Rebillat, and M. Guskov, "A General Bayesian Framework for Ellipse-based and Hyperbola-based Damage Localization in Anisotropic Composite Plates," *Journal of Intelligent Material Systems and Structures*, pp. 0-32, 2015. (Impact factor: 1,52). <sam-10985/9218>.

[R3] **N. Mechbal** and E. Nobrega, "Spatial H_∞ Approach to Damage Tolerant Active Control," *Structural Control and Health Monitoring*, vol. 22, no. 9, pp. 1148–1172, 2015. (Impact factor: 1,54). <hal-01102749>

[R4] **N. Mechbal**, J.S. Uribe, and M. Rebillat, "A Probabilistic Multi-class Classifier for Structural Health Monitoring," Mechanical Systems and Signal Processing, vol. 60, pp. 106-123, 2015. (Impact factor: 2,25). <doi.org/10.1016/j.ymssp.2015.01.017>

[R5] R. Hajrya and **N. Mechbal**, "Perturbation analysis for robust damage detection with application to multifunctional aircraft structures," *Smart Structures and Systems, An international Journal*, vol. 16, no. 3, 2015. (Impact Factor: 1,43). <hal-01100545>

[R6] M. Rebillat, R. Hajrya, and **N. Mechbal**, "Nonlinear structural damage detection based on cascade of hammerstein models," *Mechanical Systems and Signal Processing*, vol. 48, no. 12, pp. 247-259, 2014. (Impact factor: 2,25). <doi.org/10.1016/j.ymssp.2014.03.009>

[R7] B. Lamoureux, J.-R. Massé, and **N. Mechbal**, "Improving Aircraft Engines Prognostics and Health Management via Anticipated Model-Based Validation of Health Indicators," *Prognostics Journal*, vol. 2, no. 1, pp. 18-38, 2014. http://prognosticsjournal.com

[R8] B. Lamoureux, **N. Mechbal**, and J.R. Massé, "A Combined Sensitivity Analysis and Kriging Surrogate Modeling for Early Validation of Health Indicators," *Reliability Engineering and System Safety*, vol. 130, pp. 12-26, 2014. (Inpact factor: 1,9). <hal-01001853> <doi:10.1016/j.ymssp.2014.03.009>

[R9] R. Hajrya and **N. Mechbal**, "Principal Component Analysis and Perturbation Theory Based Robust Damage Detection of Multifunctional Aircraft Structure," *Structural Health Monitoring an International Journal*, vol. 12, no. 3, pp. 263–277, 2013. (Impact factor: 1,64). <hal-00997044> <doi:10.1177/1475921713481015>

[R10] S. Voisembert, **N. Mechbal**, A. Riwan, and A. Aoussat, "Design of a novel long-range inflatable robotic arm: Manufacturing and numerical evaluation of the joints and actuation" *Journal of Mechanisms and Robotics*, vol. 5, no. 4, p. 9, 2013. (Impact factor: 1,64). <hal-01064303> <doi:10.1115/1.4025025>

INTERNATIONAL CONFERENCES

[C1] E. Lisé, C. Hudin, N. Guenard, M. rebillat, C. Bolzmacher and **N. Mechbal**, "Combination of frequency shift and impedance-based method for robust temperature sensing using piezoceramic devices for SHM" 8th EWSHM, Bilbao, July 2016.

[C2] M. Ghrib, L. Berthe, M. Rebillat, **N. Mechbal**, M Guskov, and R. Ecault, "Laser shock a novel way to generate calibrated delamination in composites: concept and first results", 8th EWSHM, Bilbao, July 2016.

[C3] O. Hmad, **N. Mechbal**, and M. Rebillat, "Peaks Over Threshold Method for Structural Health Monitoring Detector Design," in *International Workshop on Structural Health Monitoring, IWSHM*, Standford, 2015.

[C4] **N. Mechbal** and G.O. Nobrega, "Adaptive Strategy to Damage-Tolerant Active Control," in *9th IFAC Symposium on Fault Detection, Supervision and Safety for Technical Processes, SAFEPROCESS'15*, Paris, 2015.

[C5] H. Genari, **N. Mechbal**, C. Coffignal, and G.O. Nobrega, "A Modal H_∞ Control Methodology for Damage-Tolerant Active Control," in *9th IFAC SAFEPROCESS'15*, Paris, 2015.

[C6] Y. Souami, Mechbal N., and S. Ecoutin, "A validation of robust passive-fault tolerant control approach for a linear parameter varying jet engine," in *12th International Conference on Diagnostic of Process and Systems (DPS)*, Poland, 2015.

[C7] M. Bakir, M. Rebillat, and **N. Mechbal**, "An original damage classification space based on structures nonlinear signatures," in *9th IFAC SAFEPROCESS'15*, Paris, 2015.

[C8] O. Hmad, C. Fendzi, **N. Mechbal**, and M. Rebillat, "Verification and Validation of Structural Health Monitoring Algorithms: A Maturation Procedure" in *9th IFAC SAFEPROCESS'15*, Paris, 2015.

[C9] H. Genari, O. Oliveira Neto, E. Nobrega, **N. Mechbal**, and G. Coffignal, "Robust Vibration Control of a Vertical Flexible Structure Subject to Seismic Events," in *XVII International Symposium on Dynamic Problems of Mechanics*, Natal, Brazil, 2015.

[C10] Y. Souami, **N. Mechbal**, and S. Ecoutin, "Robust Passive Fault Tolerant Control Applied to the Fuel Metering Valve of a Jet Engine," in *IEEE Aerospace Conference*, Yellowstone, USA, 2015.

[C11] T. Massot, M. Guskov, C. Fendzi, M. Rebillat, and **N. Mechbal**, "Structural Health Monitoring Process for Aircraft Nacelle," in *ACMA'2014*, Marrackech, 2014.

[C12] E. Balmes, M. Guskov, M. Rebillat, and **N. Mechbal**, "Effects of temperature on the impedance of piezoelectric actuators used for SHM," in *VIbrations SHocks and NOise*, Aix-en-Provence, 2014.

[C13] M. Rebillat, C. B. Barthes, **N. Mechbal**, and K. M. Mosalam, "Structural health monitoring of high voltage electrical switch ceramic insulators in seismic areas," in *7th European Workshop on Structural Health Monitoring*, France, #Jul# 2014, pp. 1-8. https://hal.archives-ouvertes.fr/hal-01001841

[C14] C. Fendzi, J. Morel, M. Rebillat, M. Guskov, **N. Mechbal,** G. Coffignal, "Optimal Sensors Placement to Enhance Damage Detection in Composite Plates," I*n Europ. Workshop on SHM,. EWSHM*, Nantes, France., 2014.

[C15] Y. Souami, **N. Mechbal**, and S. Ecoutin, "Robust passive fault tolerant control applied to jet engine equipment," in *Second European Conference of the Prognostics and Health Management Society*, vol. 5, Nantes, France, 2014. http://www.phmsociety.org/node/1311/

[C16] **N. Mechbal** and J.S. Uribe, "SHM with wave diffraction patterns and decision tree-based multi-class SVM," in *2013 International Conference on Smart Structures and Systems - The 2013 World Congress on Advances in Structural Engineering and Mechanics (ASEM)*, Jeju, Korea, 2013.

[C17] M. Rebillat, R. Hajrya, and **N. Mechbal**, "Detection of structural damage using the exponential sine sweep method," in *International Workshop on Structural Health Monitoring, IWSHM*, Standford, USA, 2013, pp. 1226-1234, ISBN: 978-1-60595-115-7. https://hal.archives-ouvertes.fr/hal-00874641

[C18] H. Genari, **N. Mechbal**, and E. Nobrega, "Structural Damage Diagnosis Method Based on Subspace Identification Metric," in *22nd International Congress of Mechanical Engineering,* Ribeirão Preto, 2013.

[C19] B. Lamoureux, J. R. Massé, and **N. Mechbal,** "Diagnostics of an aircraft engine pumping unit using a hybrid approach based-on surrogate modeling," in *IEEE Conference on Prognostics and Health Management (PHM)*, Gaithersburg, MD, USA, 2013, pp. 1 - 8.. DOI: 10.1109/ICPHM.2013.6621430

[C20] B. Lamoureux, **N. Mechbal**, and J.R. Massé, "Numerical key performance indicators for the validation of PHM health indicators with application to a hydraulic actuation system," *Chemical Engineering Transactions*, vol. 33, pp. 43-48, 2013.

[C21] B. Lamoureux, **N. Mechbal**, and J.R. Massé, "Selection and Validation of Health Indicators in Prognostics and Health Management System Design," in *2nd International Conference on Control and Fault-Tolerant Systems, SysTol'13*, Nice, 2013.

[C22] J. S. Uribe, **N. Mechbal**, M. Rebillat, K. Bouamama, and M. Pengov, "Probabilistic Decision Trees using SVM for Multi-class Classification," in *2nd International Conference on Control and Fault-Tolerant Systems*, France, 2013, pp. 619-624. https://hal.archives-ouvertes.fr/hal-00874652

[C23] B. Lamoureux, J. R. Massé, and **N. Mechbal**, "An Approach to the Health Monitoring of a Pumping Unit in an Aircraft Engine Fuel System," in *First European Conference of the Prognostics and Health Management Society*, Dresden, 2012, pp. 23-29.

[C24] B. Lamoureux, J.R. Massé, and **N. Mechbal**, "A Diagnosis Methodology for the Hydromechanical Actuation Loops in Aircraft Engines," in *Proceedings of the 20th Mediterranean Conference on Control and Automation (forthcoming)*, Barcelona, 2012.

[C25] B. Lamoureux, J.R. Massé, and **N. Mechbal**, "An approach to the health monitoring of the fuel system of a turbofan," in *Prognostics and Health Management (PHM), 2012 IEEE Conference on*, Denver, USA, 2012.

[C26] S. Voisembert, A. Riwan, and **N. Mechbal**, "Numerical Evaluation of a New Robotic Manipulator Based," in *8th IEEE International Conference on Automation Science and Engineering (CASE)*, Seoul, Korea, 2012.

[C27] **N. Mechbal** and E. Nobrega, "Damage Tolerant Active Control: Concept and State of Arts," in *8th IFAC SAFEPROCESS*, Mexico, 2012, pp. 63-71.. DOI: 10.3182/20120829-3-MX-2028.00257

[C28] N. R. Inocente-Junior, E. Nobrega, and **N. Mechbal**, "Improved Subspace-Based Method Applied to Structural Damage Detection," in *8th IFAC SAFEPROCESS*, Mexico, 2012, pp. 72-77. DOI: 10.3182/20120829-3-MX-2028.00046

[C29] V-B Ta, M. Vergé, **N. Mechbal**, D. Guichon, and S. Srairi, "Development of a Dynamic Intelligent Speed Adaptation (ISA)," *Procedia-Social and Behavioral Sciences*, vol. 48, pp. 2111-2120, 2012. http://dx.doi.org/10.1016/j.sbspro.2012.06.1184

[C30] R. Hajrya, **N. Mechbal**, and M. Vergé, "Damage Detection of Composite Structure Using Independent Component Analysis," in *International Workshop on Structural Health Monitoring, IWSHM*, Stanford, 2011.

[C31] R. Hajrya, **N. Mechbal**, and M. Vergé, "Proper Orthogonal Decomposition Applied to Structural Health Monitoring," in *IEEE International Conference on Communications Computing and Control Applications*, Hammamet, 2011, pp. 1-6. 10.1109/CCCA.2011.6031534

[C32] Y. Liu, N Mechbal, and M Vergé, "Damage monitoring based on wave illumination of structures," in *International Workshop on Structural Health Monitoring (IWSHM)*, Stanford, USA, 2011.

[C33] Y. Liu, **N. Mechbal**, J.-P. Nikolovski, M. Hafez, and M. Vergé, "Thin shell tactile sensing by acoustic wave diffraction patterns," in *IEEE International Conference on Robotics and Automation (ICRA)*, Shanghai, China, 2011, pp. 5929-5934. 10.1109/ICRA.2011.5979883

[C34] S. Voisembert, A. Riwan, **N. Mechbal**, and A. Barraco, "A Novel Inflatable Tendon Driven Manipulator with Constant Volume," in *Mechanisms and Robotics Conference*, Washington, USA, 2011.

[C35] S. Voisembert, A. Riwan, **N. Mechbal**, and A. Barraco, "A novel inflatable robot with constant volume," in *International Conference on Robotics and automation, ICRA*, Shanghai, China, 2011.

[C36] K. Saeed, **N. Mechbal**, G. Coffignal, and M. Vergé, "Subspace-based damage localization using Artificial Neural Network," in *Control & Automation (MED), 18th Mediterranean Conference on*, Marrakech, Morocco, June 2010, pp. 563 - 568.

[C37] R. Hajrya, M. Vergé, and **N. Mechbal**, "Active damage detection and localization applied to a composite structure using piezoceramic patches," in *Control and Fault-Tolerant Systems (SysTol)*, Oct. 2010, pp. 849 - 854.

Patent

[1] **US Patent**: J.P. Nikolovski, M. Hafez, Y. Liu, N. Mechbal, and M. Vergé, "Method and device for locating at least one touch on a touch-sensitive surface of an object," A1 US 2012/0120014, May 17, USA, 2012.

[2] **World Patent:** J.P. Nikolovski, M. Hafez, Liu, Y., **N. Mechbal**, and M. Vergé, "*Procédé et dispositif de localisation d'au moins un toucher sur une surface tactile d'un objet*". No. WO2011010037 (A1). Publié le 27/01/2011

Directed and defended Phd

PHD	*Defended*	*Ongoing*
Number	**8**	**4**

[1] C. Fendzi, " Stuctural health monitoring of composite structures: Application to the monitoring of Aeronautical Nacelles", ENSAM/SAFRAN AIRCELLE, Paris December 2015

[2] Y. Souami, "Virtual Sensors for Fault-Tolerant Systems: Application to a Jet Engine Control System", ENSAM/SAFRAN SNECMA, Paris July 2015

[3] B. Lamoureux, "Integrated Approach for the Development of Prognostics and Health Management – Application to the Aircraft Engines Fuel System", ENSAM/SAFRAN Snecma, Paris June 2014

[4] S. Voisembert, "*Design of an inflatable long range inspection robot* " ENSAM/CEA, Paris, December 2012.

[5] R. Hajrya, "*Structural Health Monitoring of aeronautical structures: a statistical approach*", ENSAM, Paris, July 2012.

[6] Ba, "*Supervision of a drilling process*", ENSAM/Schlumberger, Paris, Mars, 2010

[7] K. Saeed, "Structural Health monitoring: a Vibration Approach", ENSAM, Paris, July, 2010.

[8] Y. Liu, "Design of a vibration based tactile object", ENSAM/CEA, Paris, December 2010.

Dr. **MECHBAL Nazih**

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Signature: