Course: Structural Health Monitoring

Politecnico di Torino, November/December 2016
Instructor: Keith Worden, Department of Mechanical Engineering, University of Sheffield, UK

Lessons will be held at **Meeting Room "C. Ferrari" – 2nd floor DIMEAS – Dipartimento Ing. Meccanica e Aerospaziale**

Purpose of the course:

The purpose of the course is to convey the main ideas behind Structural Health Monitoring (SHM), with a particular emphasis on the data-based approach (although some aspects of model-based SHM will be covered). The course will mainly concentrate on vibration-based SHM, but will also cover aspects of wave-based SHM including traditional non-destructive evaluation methods like Acoustic Emissions. The course will be largely self-contained in terms of its mathematical content, but will assume a good familiarity with the sort of mathematics covered in an undergraduate engineering programme e.g. matrix analysis, fourier analysis and linear differential equations.

Course Schedule

Thurs. Nov. 3rd 10-12 am
Lectures 1-2: objectives, basic principles of SHM, related technologies.

Tues. Nov. 8th 10-12 am
Lectures 3-4: brief history of SHM, operational evaluation, data acquisition for SHM.

Thurs. Nov. 10th 10-12 am
Lectures 5-6: introduction to ultrasonic SHM, principles of wave propagation, guided waves.

Mon. Nov. 21st 10-12 am
Lectures 7-8: Feature extraction I: introduction to features/feature extraction, features from modal analysis for vibration-based SHM.

Tues. Nov 22nd 10-12 am
Lectures 9-10: Feature extraction II: features from nonlinear dynamics.

Thurs. Nov 24th 10-12 am
Lectures 11-12: Feature extraction III: features from time series analysis. Data normalisation I: brief look at data normalisation.

Mon. Nov 28th 10-12 am
Lectures 13-14: Statistical model building I: Monte carlo analysis, control charts, hypothesis tests, Bayes risk.

Tues. Nov 29th 10-12 am
Lectures 15-16: Statistical model building II: novelty detection, neural networks.

Mon. Dec 12th 10-12 am
Lectures 17-18: Data normalisation II: auto-associative neural networks, factor analysis etc. Fundamental axioms of SHM.

Tues. Dec. 13th 10-12 am
Lectures 19-20: outstanding problems, closure.

Thurs. Dec. 15th 10-12 am
Examination: two-hour, closed book; answer four questions from six.

Mon. Dec. 19th 10-12 am
Contingencies.

CV K. WORDEN

Research
_ 31 years of experience in research, 27 of these in structural dynamics with the emphasis on signal processing for system diagnostics and identification.
_ EPSRC Advanced Fellowship on *An Holistic Approach to Damage Identification*, January 1998 - December 2002.
_ EPSRC Established Career Fellowship on *S*3 - *Disease Surveillance for Systems and Structures*, April 2013 - March 2018.
_ 3 Books, 556 papers (188 archival journal papers) and 57 technical reports in the fields of structural dynamics and theoretical physics.
_ Direct involvement in $6.1M of funding secured since October 1994 - $4.2M as Principle Investigator.
_ 64 invited presentations, including 12 plenary/keynote lectures.

Teaching
_ Initiated several new courses: 2 MEng modules, 2 RTP modules, 1 advanced laboratory, 3 short courses, 1 extra-mural course.
_ Took over and modified 3 courses.
_ Supervised or co-supervised 27 PhD graduates.
_ Current first supervisor of 3 PhD students and second supervisor of 4 others.
_ Supervised and co-supervised 72 final-year (BEng, MEng, MSc) project students.
_ Current supervision of 1 MEng/MSc/BEng project students.
_ Developed three extensive software suites for teaching and research.

Administration
_ Head of Dynamics Research Group (2000-2008;2010-), Head of Dynamics Teaching Group.
_ Member of Departmental Strategic Planning Committee (2006-2008).
_ Member of Departmental Teaching Committee.
_ Member of Departmental Policy Committee.
_ Former Departmental Director of Postgraduate Studies (Research) (2009-2011) and member of Departmental Research Committee (2002-2011).
_ Former Departmental Director of Research (2002-2009).
_ Current supervision of 3 Postdoctoral researcher.

Professional Standing
_ Several times invited as visiting researcher at Los Alamos National Laboratories, USA.
_ Member of the EPSRC peer review college for Mechanical Engineering.
_ Member of Technical Committees of EASD (European Association of Structural Dynamics).
_ Former co-ordinator of the European COST programme in Structural Dynamics working group WG2 on *Structural Health Monitoring*.
_ Committee member of (former EPSRC) network on *Structural Integrity and Damage Assessment*
- SIDA. Former co-chair.
_ On the editorial board of 3 international journals.
_ Involved in the organisation of 47 national and international workshops and conferences.
_ 2004 Person of the Year of the International Journal of Structural Health Monitoring (jointly with Professor Wieslaw Staszewski).
_ 2013 Lifetime Achievement Award of *International Journal of Structural Health Monitoring*.
_ 2014 *Society for Experimental Mechanics*, D.J. DeMichele Award