

**SCO 2013 – Complex Data Modeling and Computationally  
Intensive Statistical Methods for Estimation and Prediction, 9 –  
11 September, 2013, Milano, Italy**

**Functional Data Analysis and Classification for Profile  
Monitoring and Fault Diagnosis in Waterjet Machining  
Processes**

**M. Grasso, N. Frigerio, A. Menafoglio, P. Secchi, B.M. Colosimo**

**Abstract**

In the frame of manufacturing processes, quality characteristics may often be represented in terms of a spatially or time ordered data. Whenever the goal is to monitor the stability over time of a repeating pattern, an important issue is represented by curve registration. Usually, registration is performed in the pre-processing step, and then profile monitoring methods are applied on the resulting curves. This study investigates the possible benefits of coupling the profile registration and profile monitoring approaches, by monitoring, at the same time, the coefficients of a parametric model of the signal and the coefficients of the warping function used for registration. The method is applied to pressure signals acquired in high pressure waterjet cutting, with the aim to detect different types of faults in machine components.

**Bibliografia**

ANNONI, M., CRISTALDI, L., LAZZARONI, M., FERRARI, S. (2009): Nozzles Classification in a High-Pressure Water Jet System, *IEEE Transactions on Instrumentation and Measurement*, Vol. 58, no. 10, 3739 – 3745

AXINTE, D. A., KONG, M. C. (2009): An Integrated Monitoring Method to Supervise Waterjet Machining, In: *CIRP Annals – Manufacturing Technology*, Vol. 58, 303–306

COLOSIMO, B.M., PACELLA, M. (2007): On the Use of Principal Component Analysis to Identify Systematic Patterns in Roundness Profiles, *Quality and Reliability Engineering International*, Vol. 23, 925–941

COLOSIMO, B.M., PACELLA, M. (2010): A Comparison Study of Control Charts for Statistical Monitoring of Functional Data, *International Journal of Production Research*, Vol. 23, 707–725

JIN, J., SHI, J. (2001): Automatic Feature Extraction of Waveform Signals for In-process Diagnostic Performance Improvement, *Journal of Intelligent Manufacturing*, Vol. 12, 257–268

JUNG, U., JEONG, K.K., LU, J.C. (2006): A Vertical-Energy-Thresholding Procedure for Data Reduction with Multiple Complex Curves, *IEEE Transactions on Systems, Man, Cybernetics, Part B*, Vol. 36, N 5, 1128–1138

KRENICKY, T., MIKOSLAV R. (2012): Monitoring Of Vibrations In The Technology Of AWJ, Key Engineering Materials, Vol. 96, 229–234

PHALADIGANON, P., KIM, S.B., CHEN, V., BAEK, J-G., PARK, S-K. (2011): Bootstrap-based T2 Multivariate Control Charts, Communications in Statistics: Simulation and Computation, Vol. 40, N 5, 645–662

QIU, P., ZOU, C., WANG, Z. (2010): Nonparametric Profile Monitoring by Mixed Effects Modeling, Technometrics, Vol. 52, N 3, 265–277

RAMSAY, J.O., SILVERMAN, B.W. (2005): Functional Data Analysis (2nd edn) (Springer Series in Statistics), Springer: New York

WALKER, E., WRIGHT, S. (2002): Comparing Curves Using Additive Models, Journal of Quality Technology, Vol. 34, 118–129

WILLIAMS, J.D., WOODALL, W.H., BIRCH, J.B. (2007): Statistical Monitoring of Nonlinear Product and Process Quality Profiles, Quality and Reliability Engineering International, Vol. 23, 925–941

WOODALL, W.H., SPITZNER, D.J., MONTGOMERY, D.C., GUPTA, S. (2004): Using Control Charts to Monitor Process and Product Quality Profiles, Journal of Quality Technology, Vol. 36, N 3, 309–320

ZOU, C., TSUNG, F., WANG, Z. (2008): Monitoring Profiles Based on Nonparametric Regression Models, Technometrics, Vol. 50, 512–526