ERCIM "Alain Bensoussan"
Fellowship Scientific Report

Fellow: Van Tuan Do
Visited Location : VTT Technical Research Centre of Finland, Espoo, Finland
Duration of Visit: 12 months
Scientific coordinator: Ville Kotovirta

I - Scientific activity

As an ERCIM postdoctoral research fellow working at VTT Technical Research Centre of Finland, I carried out further research on machine fault detection and diagnosis. My research work mostly contributed to a practical project called 'Tolkku'. In this project, we developed a toolbox for machine operation and maintenance in Matlab environment. This toolbox provides data processing functionality suited especially for condition monitoring and diagnosis of machines. My roles in this project were mostly developing signal processing functions, documentations and demonstrations for bearing and gearbox fault detection, creating functions for calculating popular statistical features such as kurtosis, clearance factor, energy index, energy operation, etc. Moreover, I also developed a number of toolbox functions for signal processing in frequency domain. Those functions are generally used in applications for machine fault detection with vibration data from machine such as: digital filter design functions, functions for calculating spectrum (FFT, welch, short time Fourier Transform, Wigner distribution), and functions for envelop analysis. The functions' implementation is not a straightforward of known techniques. It was well handled with missing and screened values.

Other than building toolbox functions for Tolkku, I also carried out research on the application of Empirical Mode Decomposition (EMD) algorithm for bearing fault detection. An adaptive EMD for bearing fault detection was developed. The testing results with simulation and experiment data showed that the adaptive EMD performed better than the original EMD algorithm. This investigation was sent to a journal for a potential publication. During this ERCIM program, I also further studied the application of SIFT features (Scale Invariant Feature Transform) for texture recognition. I developed a classification framework for texture recognition and retrieval using SIFT and adaptive mean shift clustering algorithm. The results of this work will be in the proceedings of JCSSE'12 conference, and later on in the IEEE explore.

II- Publication(s) during your fellowship

Please insert the title(s), author(s) and abstract(s) of the published paper(s). You may also mention the paper(s) which were prepared during your fellowship period and are under reviewing.

Paper #1:

Tuan Do, Antti Aikala and Olli Saarela. Framework for Texture Classification and Retrieval Using Scale Invariant Feature Transform. Proceedings of JCSSE'12. Bangkok, Thailand.

Abstract:
Texture images can be characterized with key features extracted from images. In this paper, the scale invariant feature transform (hereinafter SIFT) algorithm is utilized to generate local features for texture image classification. The local features are selected as inputs for texture classification framework. For each texture category, a texton dictionary is built based on the local features. To establish the texton dictionary, an adaptive mean shift clustering algorithm is run with all local features to generate key features (called textons) for texton dictionary. The texton dictionaries among texture categories are supposed be distinctive from each other to provide a highest performance in term of classification accuracy. A framework is proposed for classifying images into corresponding categories by matching their local features with textons from the texton dictionaries. This can be done by a histogram model of 'match' vectors versus texture categories. Finally, our texture image database and the Ponce texture database are used to test the proposed approach. The results indicate a potential of our proposed method based on high classification accuracies achieved. They are 100% with our testing database for both classification and retrieval and 92 % and 100% with Ponce database for classification and retrieval, respectively.

Paper #2:
Tuan Do, Olli Saarela and Ming Zuo. Adaptive Empirical Mode Decomposition for Bearing Fault Detection. Under review of Mechanical System and Signal Processing.

Abstract:
Many techniques for bearing fault detection have been proposed. Two of the most effective approaches are using envelope analysis and empirical mode decomposition method (EMD) – also known as Hilbert Huang transform (HHT) for vibration signal. Both approaches are able to detect the bearing fault when the vibration data are not strongly disturbed by noise. In the approach using EMD method, the EMD algorithm is used to decompose the vibration data into components with well-defined instantaneous frequency called IMFs (intrinsic mode function). Then a spectral analysis is used for selected IMFs to indicate the appearance of nominal bearing defect frequencies (nominal frequencies), which are caused by bearing faults. However, when the data are strongly disturbed by noise and other sources, the approach can be failed. The EMD algorithm generates IMFs itself; hence, the IMFs will also contain both fault signal part and other components. It becomes more serious when the other components are dominant and have significant amplitudes near the same frequencies as the fault signal part. Moreover, in the IMF extracting process, the EMD methods keeps removing the low frequency components until the residual is an IMF; therefore, until the IMF is found some of fault signal part can be removed and will appeared in the next IMFs. Hence, it is obvious to say that the energy of fault signal part can spread in some IMFs that will lead the detecting faulty features in any of those IMFs to be weak. In this paper, we address the weakness of the EMD method for bearing fault detection by introducing an adaptive EMD (AEMD). The AEMD algorithm is aimed to generate IMFs so that one of them contains most of the energy of the fault signal part; hence, it assists our model to detect the bearing fault better. Moreover, the bearing fault detection model using the AEMD method with simulation data is compared with those of using envelope analysis and the latest version of the EMD called ensemble EMD algorithm. An application study of bearing fault detection with AEMD method is also carried out.

Paper #3:

Stephen Fox and Tuan Do. Getting real about Big Data: implementation challenges for automated data collection and automated data analysis. Under review of International Journal of Physical Distribution & Logistics Management.

Abstract:
Purpose - The purpose of this paper is go beyond hype about Big Data, by providing description of action, mechanism, context, and outcome for an industrial implementation automated data collection and analysis. In particular, automated prediction of operating state condition for ocean going vessels such as cargo ships and cruise liners.

Design/methodology/approach – A critical realist study informed by findings from action research carried out to improve the prediction of operating state condition.

Findings – Hype about Big Data underplays the many challenges of automating data collection and analysis in industrial settings. Such biased framing of technologies can lead to sub-optimal decisions, such as investing in a technology without understanding of the time, effort and cost involved in realising hope for benefits. Moreover, initial biased framing of a technology implementation project can provide a lasting rationale, which leads to continuing commitment to a failing course of action.

Practical implications – When considering investing in automated prediction of operation state condition, consideration should be given to at least twenty-six factors ranging from the planning of data sampling rates, through the robust fixing of sensors, to the implementation of data mining algorithms and signal models.

Originality/value – The originality of this paper is that critical realism is used to reveal causal mechanism and causal context for enabling automated prediction of operating state condition. The value of this paper is that is provides a detailed example of how critical realism can be used to go beyond the hype surrounding many potential technology investments for industrial organizations.

Paper type – Research paper

Paper #4:
Tuan Do, Mikko Lehtonen and Olli Saarela. Acoustic Emission Signal Analysis for Planetary Gearbox Fault Detection with Hilbert Huang Transform. In preparation.

III -Attended Seminars, Workshops, and Conferences

Please identify the name(s), date(s) and place(s) of the events in which you participated during your fellowship period.

JCSSE'12 international conference, 30 May – June 1, 2012, Bangkok Thailand.
Workshop on FOVI-TOLKKU-InterSync collaboration, 23 Jan, 2012, Hyvinkää, Finland

IV – Research Exchange Programme (12 month scheme)

Please identify the name(s), date(s) and place(s) of your Research Exchanges during your fellowship period and detail them.

I did not have any exchange program.