Scientific Report

First name / Family name	Beatriz / Galindo Prieto
Nationality	Spanish
Name of the *Host Organisation*	Norwegian University of Science and Technology (NTNU)
First Name / family name of the *Scientific Coordinator*	Frank / Westad
Period of the fellowship	01/09/2017 – 31/08/2018

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

Dr Beatriz Galindo-Prieto performed her fellowship (ERCIM 'Alain Bensoussan' Fellowship Programme) as Post-Doctoral Fellow at the Department of Engineering Cybernetics (ITK) of NTNU (Trondheim, Norway, 2017-2018). Her scientific coordinator was Prof. Frank Westad. Dr B. Galindo-Prieto interacted and worked with research teams from Gløshaugen and Dragvoll campuses at NTNU, as well as international groups of her network in Norway and Sweden, involved in multivariate data analysis of big data. The work of Galindo-Prieto yielded four papers (one already published, and three submitted and under review, in peer-reviewed journals). These papers show the high positive impact of applying multivariate data analysis methods to large streams of data under different perspectives and in different fields (cybernetics, hyperspectral imaging, pattern recognition, biology systems, machine learning, classification methods, prediction, and variable/feature selection, among other). As common point, these fields require advanced multivariate analysis of high-dimensional and/or complex data, which is an important challenge nowadays.

Dr B. Galindo-Prieto also attended several events such as seminars, workshops, courses and conferences during the fellowship. She carried out her REP visit in Germany. Further details are included in Section III of this report. In addition, Galindo-Prieto showed her

commitment with the host institution (ITK, NTNU) co-supervising MSc students (together with Prof Westad as main supervisor) when needed, these led to the successful completion of the corresponding MSc theses. She lectured topics related to dimensionality reduction of big data and feature selection methods in two NTNU courses at MSc and PhD levels: *Structures and Contexions in Complex Systems* (TTK19) and *Multivariat data- og meta-modellering* (TK8116). She also attended activities and social events organized by ITK (NTNU), such as the Christmas dinner, the Final Course lunch/party, barbeques and many scientific talks, among other. She also interacted with other groups of ITK in order to discuss common scientific points related to the Cyborg project, capture of NIR images by using drones, cognitive data analysis, robotics, signal processing, EEG data analysis, applicability of MVA methods for machine learning in petrochemical industry, and pre-processing of different types of cybernetics data, inter alia.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

<u>PAPER I.</u> Dr B. Galindo-Prieto, together with Prof. F. Westad, developed an advanced method to classify pixels directly from NIR hyperspectral images with focus on method validation and calculation of uncertainties. The details (title, authors, journal, DOI, citation, and abstract) are provided below. The paper, published in a peer reviewed journal with open access named "Journal of Spectral Imaging", is enclosed to this report.

Title: *Classification in hyperspectral images by independent component analysis, segmented cross-validation and uncertainty estimates.*

Main author: B. Galindo-Prieto

Co-author: F. Westad

Peer-reviewed journal: Journal of Spectral Imaging (Special Issue on Chemometrics in Hyperspectral Imaging)

Publication date: 25th of February 2018

DOI reference: 10.1255/jsi.2018.a4

Citation ref.: B. Galindo-Prieto and F. Westad, "Classification in hyperspectral Images by independent component analysis, segmented cross-validation and uncertainty estimates", J. Spectral Imaging 7, a4 (2018).

Abstract: Independent component analysis combined with various strategies for cross validation, uncertainty estimates by jack-knifing and critical Hotelling's T^2 limits estimation, proposed in this paper, is used for classification purposes in hyperspectral images. To the best of our knowledge, the combined approach of methods used in this paper has not been previously applied to hyperspectral imaging analysis for interpretation and classification in the literature. The data analysis performed here aims to distinguish between four … … …

<u>PAPER II.</u> Dr B. Galindo-Prieto, in collaboration with the *Language Acquisition and Language Processing Lab* of NTNU (Prof Vulchanova's group, Dragvoll Campus), submitted a manuscript related to analysis of cognitive data (eye- and hand- tracked data) for better understanding of language processing in children with autism spectrum disorder. The manuscript has been already revised, and it is pending on editor's decision in the peer-reviewed journal Cognitive Science.

Title: *Gaze and motor traces of language processing: Evidence from autism spectrum disorders in comparison to typical controls.*
Main author: M. Vulchanova
Co-authors: S. Chahboun, B. Galindo-Prieto, V. Vulchanov
Peer -reviewed journal: Cognitive Science
Status: Revised, pending on journal decision.
DOI reference: N/A
Citation ref.: M. Vulchanova, S. Chahboun, B. Galindo-Prieto, V. Vulchanov, *Gaze and motor traces of language processing: Evidence from autism spectrum disorders in comparison to typical controls*, Cognition Science, 2018. Manuscript under review.

Abstract: Earlier research has attested differences between performance measures and data obtained with methods which tap on-line language processing. Studies, comparing performance outcomes and their underlying processes, are however scarce and provide limited data from quite diverse populations. In this study we investigate concretely what strategies underlie figurative language processing in two groups of participants distinguished by the presence of a developmental deficit, highly verbal … … …

PAPER III. Dr B. Galindo-Prieto, as continuation of her previous work at Umeå University (Sweden), has submitted a manuscript related to method development in multivariate analysis of multiblock big data with focus on the variable influence on projection (VIP) concept. This work is done in collaboration with Umeå University and the Swedish University of Agricultural Sciences, among other. The manuscript is currently under review and the details are provided below.

Title: *Multiblock variable influence on orthogonal projections (multiblock-VIOP) for enhanced interpretation of total, global, local and unique variations in OnPLS models.*
Main author: B. Galindo-Prieto
Co-authors: P. Geladi, J. Trygg
Peer-reviewed journal: Journal of Chemometrics
Status: submitted, under review.
DOI reference: N/A
Citation ref.: B. Galindo-Prieto, P. Geladi, J. Trygg, Multiblock variable influence on orthogonal projections (multiblock-VIOP) for enhanced interpretation of total, global, local and unique variations in OnPLS models, 2018, (under review).

Abstract: A method for variable selection in multiblock analysis, called multiblock variable influence on orthogonal projections (i.e. Multiblock-VIOP, or MB-VIOP), was recently developed and is now explained in detail in this paper. Multiblock-VIOP is a model based variable selection method which uses the data matrices, the scores, and the normalized loadings of an OnPLS model in order to sort the input variables of a large number of data matrices according to their importance for both simplification and … … …

PAPER IV. Dr B. Galindo-Prieto started a collaboration with Karolinska Institute (Stockholm, Sweden) related to multiblock data integration and dimensionality reduction in her previous position at Umeå University. During the ERCIM fellowship, Galindo-Prieto continued and finished this work and the corresponding manuscript has been recently submitted to a peer reviewed journal. Details are found below.

Title: *OnPLS-based multi-block data integration: a multivariate approach to interrogating biological interactions in asthma*

Main author: S.N. Reinke

Co-authors: B. Galindo-Prieto, T. Skotare, D.I. Broadhurst, A. Singhania, D. Horowitz, R. Djukanović, T.S.C. Hinks, P. Geladi, J. Trygg, C.E. Wheelock

Peer-reviewed journal: Analytical Chemistry

Status: submitted, under review.

DOI reference: N/A

Citation ref.: S.N. Reinke, B. Galindo-Prieto, T. Skotare, D.I. Broadhurst, A. Singhania, D. Horowitz, R. Djukanović, T.S.C. Hinks, P. Geladi, J. Trygg, C.E. Wheelock, OnPLS-based multi-block data integration: a multivariate approach to interrogating biological interactions in asthma, 2018, under review.

Abstract: Integration of multi-omics data remains a key challenge in fulfilling the potential of comprehensive systems biology. Multiple-block orthogonal projections to latent structures (OnPLS) is a projection method that simultaneously models multiple data matrices, reducing feature space without relying on *a priori* biological knowledge. In order to improve the interpretability of OnPLS models, the associated multi-block variable influence on orthogonal projections (MB-VIOP) method is used to identify variables with the highest contribution to the model. This study … … …

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Dr B. Galindo-Prieto was **invited as speaker to** *the 6th Annual Conference of AnalytiX 2018* **hold in Miami (USA, March 2018)**, where she presented relevant results obtained during her fellowship in both poster and oral presentations (invitation letter, assistance certificate and abstracts are enclosed). Moreover, Galindo-Prieto was **awarded a travel grant by ITK** (*ITKs Midler til Vitenskapelige Reiser*) **to attend the Hyperspectral Image Analysis workshop/seminar (2 ECTS) at the University of Copenhagen** (organized by Copenhagen School of Chemometrics, CSC, June 2018, Denmark), where she presented results related to her papers in four posters and she obtained the corresponding course certificate (also enclosed). She also attended a workshop related to cognitive sciences and multivariate data analysis in Trondheim (organized by her collaborators at Dragvoll campus, NTNU).

IV – RESEARCH EXCHANGE PROGRAMME (REP)

Dr B. Galindo-Prieto carried out her REP visit as guest ERCIM post-doctoral fellow with **Prof Dr Jochen Garcke's group at the Fraunhofer Institute for Algorithms and Scientific Computing (SCAI) in Sankt Augustin (Germany)** from 14th to 18th of May (the certificate is enclosed). She exchanged methods and ideas with Prof. Dr. J. Garcke and his group, especially in relation to analysis for prediction using data from sensors of air generators (turbines), non-linear systems, and data from the automotive industry. Galindo-Prieto applied various multivariate methods to their data, resulting in a discussion of the results that is still ongoing.