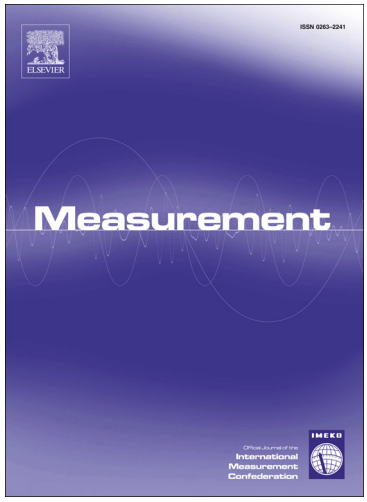

Forward and Inverse Modelling Approaches for Prediction of Light Stimulus from Electrophysiological Response in Plants

Shre Kumar Chatterjee, Sanmitra Ghosh, Saptarshi Das, Veronica Manzella, Andrea Vitaletti, Elisa Masi, Luisa Santopolo, Stefano Mancuso, Koushik Maharatna

PII: S0263-2241(14)00144-4
DOI: http://dx.doi.org/10.1016/j.measurement.2014.03.040
Reference: MEASUR 2801

To appear in: *Measurement*

Received Date: 27 November 2013
Revised Date: 13 March 2014
Accepted Date: 25 March 2014

Please cite this article as: S.K. Chatterjee, S. Ghosh, S. Das, V. Manzella, A. Vitaletti, E. Masi, L. Santopolo, S. Mancuso, K. Maharatna, Forward and Inverse Modelling Approaches for Prediction of Light Stimulus from Electrophysiological Response in Plants, *Measurement* (2014), doi: http://dx.doi.org/10.1016/j.measurement.2014.03.040

Forward and Inverse Modelling Approaches for Prediction of Light Stimulus from Electrophysiological Response in Plants

Shre Kumar Chatterjee[a], Sanmitra Ghosh[a], Saptarshi Das[a,*], Veronica Manzella[b,c], Andrea Vitaletti[b,c], Elisa Masi[d], Luisa Santopolo[d], Stefano Mancuso[d], and Koushik Maharatna[a]

a) *School of Electronics and Computer Science, University of Southampton, Southampton SO17 1BJ, United Kingdom.*
b) *WLAB S.r.L., via Adolfo Ravà 124, 00142, Rome, Italy.*
c) *DIAG, SAPIENZA Università di Roma, via Ariosto 25, 00185, Rome, Italy.*
d) *Department of Horticulture, University of Florence, viale delle Idee 30, 50019, Sesto Fiorentino, FI, Italy.*

Authors' Emails:

skc105@ecs.soton.ac.uk (S.K. Chatterjee), sg5g10@ecs.soton.ac.uk (S. Ghosh), sd2a11@ecs.soton.ac.uk (S. Das*), veronica.manzella@gmail.com (V. Manzella), andrea.vitaletti@w-lab.it (A. Vitaletti), elisa.masi@unifi.it (E. Masi), luisa.santopolo@unifi.it (L. Santopolo), stefano.mancuso@unifi.it (S. Mancuso), km3@ecs.soton.ac.uk (K. Maharatna)

Phone no: +44(0)7448572598, **Fax:** 02380 593045

Abstract:

In this paper, system identification approach has been adopted to develop a novel dynamical model for describing the relationship between light as an environmental stimulus and the electrical response as the measured output for a bay leaf (*Laurus nobilis*) plant. More specifically, the target is to predict the characteristics of the input light stimulus (in terms of on-off timing, duration and intensity) from the measured electrical response – leading to an inverse problem. We explored two major classes of system estimators to develop dynamical models – linear and nonlinear – and their several variants for establishing a forward and also an inverse relationship between the light stimulus and plant electrical response. The best class of models are given by the Nonlinear Hammerstein-Wiener (NLHW) estimator showing good data fitting results over other linear and nonlinear estimators in a statistical sense. Consequently, a few set of models using different functional variants of NLHW has been developed and their accuracy in detecting the on-off timing and intensity of the input light stimulus are compared for 19 independent plant datasets (including 2 additional species *viz. Zamioculcas zamiifolia* and *Cucumis sativus*) under similar experimental scenario.

Keywords: Dynamical modelling; environment prediction; inverse model; plant electrical signal; statistical estimators; system identification

1. Introduction

It was discovered by Burdon-Sanderson in 1873, that plants exhibit bioelectrical activity [1]. In 1926, J.C. Bose isolated the vascular bundles of a fern to show that physiological events, such as those present in animal nerves, triggered excitation which