

Construction of Nonlinear Data-driven Models for Condition Monitoring and Calibration with a Review of an Application to Space Telescopes.

Nicholas Tuffillaro*

Member of Technical Staff

Daniel Usikov*

Member of Technical Staff

Lee Barford*

Member of Technical Staff

Leonid Marochnik[†]

Member of Technical Staff

Robert McCutcheon[†]

Member of Technical Staff

We describe how to construct data-driven models for nonlinear components and systems based on dynamical systems theory. The models are constructed from input/output data in the time domain and their "embeddings," as described, for instance, by the Taken's Embedding Theorem [1,2,3]. These models can be used for simulations, process control, diagnostics, and sensor calibration.

We review one particular application to the Hubble Space Telescope (HST). Focal length data taken at 5 minute intervals from 1995-1999 are used to construct a model of the focal variations arising from systematic temperature variations from solar heating of the HST. A so-called "Full-Temperature Model" (FTM) is constructed and its application for calibration and diagnostics is discussed and compared with the FTM currently used by NASA [4,5]. It is argued that such data-driven models show good potential for a wide variety of applications in the Next Generation Space Telescope (NGST).

[1]. Gershenfeld, Neil A. 1999. The Nature of Mathematical Modeling, Cambridge University Press.

[2]. David M. Walker and Nicholas B. Tuffillaro Radial basis models for feedback systems with fading memory. IEEE Transactions on Circuits and Systems I, vol. 48 no. 9 pages 1147-1151, September 2001

[3]. Usikov D., 1999. Chaos Program Users Manual, Agilent Technologies (unpublished).

[4]. Hershey J., 1997. Space Telescope Institute (STScI) document SESD-97-01.

[5]. Lee Barford, Nicholas Tuffillaro, Daniel Usikov, Leonid Marochnik, and Robert McCutcheon, Calibration of Hubble Space Telescope Focal-Length Variations Using the Embedding Technique. 2001 Flight Mechanics Symposium (NASA), Edited by John P. Lynch, NASA Goddard Space Flight Center, Greenbelt, Maryland, June 19-21 2001

*System and Solutions Lab, Agilent Technologies, 3500 Deer Creek Road, MS 24M-A, Palo Alto, CA 94304; Contact Email: nbt@labs.agilent.com

[†]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218