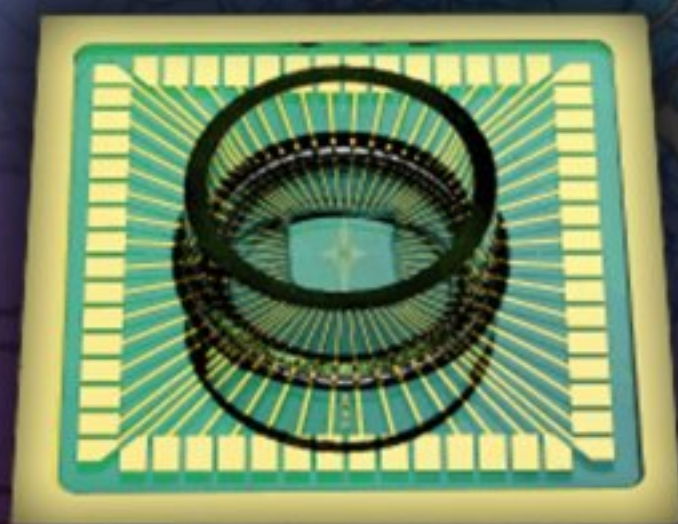


ISSN 1726-5479

SENSORS ^{vol. 121} **10** / **10** **&** **TRANSDUCERS**



Soft Sensors and Artificial Neural Networks

International Frequency Sensor Association Publishing





Editors-in-Chief: professor Sergey Y. Yurish, tel.: +34 696067716, fax: +34 93 4011989, e-mail: editor@sensorsportal.com

Editors for Western Europe

Meijer, Gerard C.M., Delft University of Technology, The Netherlands
Ferrari, Vittorio, Università di Brescia, Italy

Editor South America

Costa-Felix, Rodrigo, Inmetro, Brazil

Editor for Eastern Europe

Sachenko, Anatoly, Ternopil State Economic University, Ukraine

Editors for North America

Datskos, Panos G., Oak Ridge National Laboratory, USA
Fabien, J. Josse, Marquette University, USA
Katz, Evgeny, Clarkson University, USA

Editor for Asia

Ohyama, Shinji, Tokyo Institute of Technology, Japan

Editor for Asia-Pacific

Mukhopadhyay, Subhas, Massey University, New Zealand

Editorial Advisory Board

- Abdul Rahim, Ruzairi, Universiti Teknologi, Malaysia
Ahmad, Mohd Noor, Nothern University of Engineering, Malaysia
Annamalai, Karthigeyan, National Institute of Advanced Industrial Science and Technology, Japan
Arcega, Francisco, University of Zaragoza, Spain
Arguel, Philippe, CNRS, France
Ahn, Jae-Pyoung, Korea Institute of Science and Technology, Korea
Arndt, Michael, Robert Bosch GmbH, Germany
Ascoli, Giorgio, George Mason University, USA
Atalay, Selcuk, Inonu University, Turkey
Atghiaee, Ahmad, University of Tehran, Iran
Augutis, Vyantas, Kaunas University of Technology, Lithuania
Avachit, Patil Lalchand, North Maharashtra University, India
Ayesh, Aladdin, De Montfort University, UK
Bahreyni, Behraad, University of Manitoba, Canada
Baliga, Shankar, B., General Monitors Transnational, USA
Baoxian, Ye, Zhengzhou University, China
Barford, Lee, Agilent Laboratories, USA
Barlingay, Ravindra, RF Arrays Systems, India
Basu, Sukumar, Jadavpur University, India
Beck, Stephen, University of Sheffield, UK
Ben Bouzid, Sihem, Institut National de Recherche Scientifique, Tunisia
Benachaiba, Chellali, Universitaire de Bechar, Algeria
Binnie, T. David, Napier University, UK
Bischoff, Gerlinde, Inst. Analytical Chemistry, Germany
Bodas, Dhananjay, IMTEK, Germany
Borges Carval, Nuno, Universidade de Aveiro, Portugal
Bousbia-Salah, Mounir, University of Annaba, Algeria
Bouvet, Marcel, CNRS – UPMC, France
Brudzewski, Kazimierz, Warsaw University of Technology, Poland
Cai, Chenxin, Nanjing Normal University, China
Cai, Qingyun, Hunan University, China
Campanella, Luigi, University La Sapienza, Italy
Carvalho, Vitor, Minho University, Portugal
Cecelja, Franjo, Brunel University, London, UK
Cerdá Belmonte, Judith, Imperial College London, UK
Chakrabarty, Chandan Kumar, Universiti Tenaga Nasional, Malaysia
Chakravorty, Dipankar, Association for the Cultivation of Science, India
Changhai, Ru, Harbin Engineering University, China
Chaudhari, Gajanan, Shri Shivaji Science College, India
Chavali, Murthy, N.I. Center for Higher Education, (N.I. University), India
Chen, Jiming, Zhejiang University, China
Chen, Rongshun, National Tsing Hua University, Taiwan
Cheng, Kuo-Sheng, National Cheng Kung University, Taiwan
Chiang, Jeffrey (Cheng-Ta), Industrial Technol. Research Institute, Taiwan
Chiriach, Horia, National Institute of Research and Development, Romania
Chowdhuri, Arijit, University of Delhi, India
Chung, Wen-Yaw, Chung Yuan Christian University, Taiwan
Corres, Jesus, Universidad Publica de Navarra, Spain
Cortes, Camilo A., Universidad Nacional de Colombia, Colombia
Courtois, Christian, Universite de Valenciennes, France
Cusano, Andrea, University of Sannio, Italy
D'Amico, Arnaldo, Università di Tor Vergata, Italy
De Stefano, Luca, Institute for Microelectronics and Microsystem, Italy
Deshmukh, Kiran, Shri Shivaji Mahavidyalaya, Barshi, India
Dickert, Franz L., Vienna University, Austria
Dieguez, Angel, University of Barcelona, Spain
Dimitropoulos, Panos, University of Thessaly, Greece
Ding, Jianning, Jiangsu Polytechnic University, China
Djordjevic, Alexandar, City University of Hong Kong, Hong Kong
Donato, Nicola, University of Messina, Italy
Donato, Patricio, Universidad de Mar del Plata, Argentina
Dong, Feng, Tianjin University, China
Drljaca, Predrag, Instersema Sensoric SA, Switzerland
Dubey, Venketesh, Bournemouth University, UK
Enderle, Stefan, Univ. of Ulm and KTB Mechatronics GmbH, Germany
Erdem, Gursan K. Arzum, Ege University, Turkey
Erkmen, Aydan M., Middle East Technical University, Turkey
Estelle, Patrice, Insa Rennes, France
Estrada, Horacio, University of North Carolina, USA
Faiz, Adil, INSA Lyon, France
Fericean, Sorin, Balluff GmbH, Germany
Fernandes, Joana M., University of Porto, Portugal
Francioso, Luca, CNR-IMM Institute for Microelectronics and Microsystems, Italy
Francis, Laurent, University Catholique de Louvain, Belgium
Fu, Weiling, South-Western Hospital, Chongqing, China
Gaura, Elena, Coventry University, UK
Geng, Yanfeng, China University of Petroleum, China
Gole, James, Georgia Institute of Technology, USA
Gong, Hao, National University of Singapore, Singapore
Gonzalez de la Rosa, Juan Jose, University of Cadiz, Spain
Granel, Annette, Goteborg University, Sweden
Graff, Mason, The University of Texas at Arlington, USA
Guan, Shan, Eastman Kodak, USA
Guillet, Bruno, University of Caen, France
Guo, Zhen, New Jersey Institute of Technology, USA
Gupta, Narendra Kumar, Napier University, UK
Hadjilucas, Sillas, The University of Reading, UK
Haider, Mohammad R., Sonoma State University, USA
Hashsham, Syed, Michigan State University, USA
Hasni, Abdelhafid, Bechar University, Algeria
Hernandez, Alvaro, University of Alcalá, Spain
Hernandez, Wilmar, Universidad Politecnica de Madrid, Spain
Homencovschi, Dorel, SUNY Binghamton, USA
Horstman, Tom, U.S. Automation Group, LLC, USA
Hsiai, Tzung (John), University of Southern California, USA
Huang, Jeng-Sheng, Chung Yuan Christian University, Taiwan
Huang, Star, National Tsing Hua University, Taiwan
Huang, Wei, PSG Design Center, USA
Hui, David, University of New Orleans, USA
Jaffrezic-Renault, Nicole, Ecole Centrale de Lyon, France
Jaime Calvo-Galleg, Jaime, Universidad de Salamanca, Spain
James, Daniel, Griffith University, Australia
Janting, Jakob, DELTA Danish Electronics, Denmark
Jiang, Liudi, University of Southampton, UK
Jiang, Wei, University of Virginia, USA
Jiao, Zheng, Shanghai University, China
John, Joachim, IMEC, Belgium
Kalach, Andrew, Voronezh Institute of Ministry of Interior, Russia
Kang, Moonho, Sunmoon University, Korea South
Kaniusas, Eugenijus, Vienna University of Technology, Austria
Katake, Anup, Texas A&M University, USA
Kausel, Wilfried, University of Music, Vienna, Austria
Kavasoglu, Nese, Mugla University, Turkey
Ke, Cathy, Tyndall National Institute, Ireland
Khelifaoui, Rachid, Université de Bechar, Algeria
Khan, Asif, Aligarh Muslim University, Aligarh, India
Kim, Min Young, Kyungpook National University, Korea South
Ko, Sang Choon, Electronics. and Telecom. Research Inst., Korea South
Kockar, Hakan, Balikesir University, Turkey
Kotulska, Malgorzata, Wroclaw University of Technology, Poland
Kratz, Henrik, Uppsala University, Sweden
Kumar, Arun, University of South Florida, USA

Kumar, Subodh, National Physical Laboratory, India
Kung, Chih-Hsien, Chang-Jung Christian University, Taiwan
Lacnjevac, Caslav, University of Belgrade, Serbia
Lay-Ekuakille, Aime, University of Lecce, Italy
Lee, Jang Myung, Pusan National University, Korea South
Lee, Jun Su, Amkor Technology, Inc. South Korea
Lei, Hua, National Starch and Chemical Company, USA
Li, Genxi, Nanjing University, China
Li, Hui, Shanghai Jiaotong University, China
Li, Xian-Fang, Central South University, China
Liang, Yuanchang, University of Washington, USA
Liawruangrath, Saisunee, Chiang Mai University, Thailand
Liew, Kim Meow, City University of Hong Kong, Hong Kong
Lin, Hermann, National Kaohsiung University, Taiwan
Lin, Paul, Cleveland State University, USA
Linderholm, Pontus, EPFL - Microsystems Laboratory, Switzerland
Liu, Aihua, University of Oklahoma, USA
Liu Changgeng, Louisiana State University, USA
Liu, Cheng-Hsien, National Tsing Hua University, Taiwan
Liu, Songqin, Southeast University, China
Lodeiro, Carlos, University of Vigo, Spain
Lorenzo, Maria Encarnacio, Universidad Autonoma de Madrid, Spain
Lukaszewicz, Jerzy Pawel, Nicholas Copernicus University, Poland
Ma, Zhanfang, Northeast Normal University, China
Majstorovic, Vidosav, University of Belgrade, Serbia
Marquez, Alfredo, Centro de Investigacion en Materiales Avanzados, Mexico
Matay, Ladislav, Slovak Academy of Sciences, Slovakia
Mathur, Prafull, National Physical Laboratory, India
Maurya, D.K., Institute of Materials Research and Engineering, Singapore
Mekid, Samir, University of Manchester, UK
Melnyk, Ivan, Photon Control Inc., Canada
Mendes, Paulo, University of Minho, Portugal
Mennell, Julie, Northumbria University, UK
Mi, Bin, Boston Scientific Corporation, USA
Minas, Graca, University of Minho, Portugal
Moghavvemi, Mahmoud, University of Malaya, Malaysia
Mohammadi, Mohammad-Reza, University of Cambridge, UK
Molina Flores, Esteban, Benemérita Universidad Autónoma de Puebla, Mexico
Moradi, Majid, University of Kerman, Iran
Morello, Rosario, University "Mediterranea" of Reggio Calabria, Italy
Mounir, Ben Ali, University of Sousse, Tunisia
Mulla, Imtiaz Sirajuddin, National Chemical Laboratory, Pune, India
Neelamegam, Periasamy, Sastra Deemed University, India
Neshkova, Milka, Bulgarian Academy of Sciences, Bulgaria
Oberhammer, Joachim, Royal Institute of Technology, Sweden
Ould Lahoucine, Cherif, University of Guelma, Algeria
Pamidighanta, Sayanu, Bharat Electronics Limited (BEL), India
Pan, Jisheng, Institute of Materials Research & Engineering, Singapore
Park, Joon-Shik, Korea Electronics Technology Institute, Korea South
Penza, Michele, ENEA C.R., Italy
Pereira, Jose Miguel, Instituto Politecnico de Seteбал, Portugal
Petsev, Dimiter, University of New Mexico, USA
Pogacnik, Lea, University of Ljubljana, Slovenia
Post, Michael, National Research Council, Canada
France, Robert, University of Sussex, UK
Prasad, Ambika, Gulbarga University, India
Prateepasen, Asa, Kingmoungut's University of Technology, Thailand
Pullini, Daniele, Centro Ricerche FIAT, Italy
Pumera, Martin, National Institute for Materials Science, Japan
Radhakrishnan, S. National Chemical Laboratory, Pune, India
Rajanna, K., Indian Institute of Science, India
Ramadan, Qasem, Institute of Microelectronics, Singapore
Rao, Basuthkar, Tata Inst. of Fundamental Research, India
Raouf, Kosai, Joseph Fourier University of Grenoble, France
Reig, Candid, University of Valencia, Spain
Restivo, Maria Teresa, University of Porto, Portugal
Robert, Michel, University Henri Poincare, France
Rezazadeh, Ghader, Urmia University, Iran
Royo, Santiago, Universitat Politècnica de Catalunya, Spain
Rodriguez, Angel, Universidad Politècnica de Catalunya, Spain
Rothberg, Steve, Loughborough University, UK
Sadana, Ajit, University of Mississippi, USA
Sadeghian Marnani, Hamed, TU Delft, The Netherlands
Sandacci, Serghei, Sensor Technology Ltd., UK
Schneider, John K., Ultra-Scan Corporation, USA
Sengupta, Deepak, Advance Bio-Photonics, India
Shah, Kriyang, La Trobe University, Australia
Sapozhnikova, Ksenia, D.I.Mendeleyev Institute for Metrology, Russia
Saxena, Vibha, Bhabha Atomic Research Centre, Mumbai, India
Seif, Selemeni, Alabama A & M University, USA
Seifter, Achim, Los Alamos National Laboratory, USA
Silva Girao, Pedro, Technical University of Lisbon, Portugal
Singh, V. R., National Physical Laboratory, India
Slomovitz, Daniel, UTE, Uruguay
Smith, Martin, Open University, UK
Soleymanpour, Ahmad, Damghan Basic Science University, Iran
Somani, Prakash R., Centre for Materials for Electronics Technol., India
Srinivas, Talabattula, Indian Institute of Science, Bangalore, India
Srivastava, Arvind K., Northwestern University, USA
Stefan-van Staden, Raluca-Ioana, University of Pretoria, South Africa
Sumriddetchka, Sarun, National Electronics and Computer Technology Center, Thailand
Sun, Chengliang, Polytechnic University, Hong-Kong
Sun, Dongming, Jilin University, China
Sun, Junhua, Beijing University of Aeronautics and Astronautics, China
Sun, Zhiqiang, Central South University, China
Suri, C. Raman, Institute of Microbial Technology, India
Sysoev, Victor, Saratov State Technical University, Russia
Szewczyk, Roman, Industrial Research Inst. for Automation and Measurement, Poland
Tan, Ooi Kiang, Nanyang Technological University, Singapore,
Tang, Dianping, Southwest University, China
Tang, Jaw-Luen, National Chung Cheng University, Taiwan
Teker, Kasif, Frostburg State University, USA
Thirunavukkarasu, I., Manipal University Karnataka, India
Thumbavanam Pad, Kartik, Carnegie Mellon University, USA
Tian, Gui Yun, University of Newcastle, UK
Tsiantos, Vassilios, Technological Educational Institute of Kaval, Greece
Tsigara, Anna, National Hellenic Research Foundation, Greece
Twomey, Karen, University College Cork, Ireland
Valente, Antonio, University, Vila Real, - U.T.A.D., Portugal
Vanga, Raghav Rao, Summit Technology Services, Inc., USA
Vaseashta, Ashok, Marshall University, USA
Vazquez, Carmen, Carlos III University in Madrid, Spain
Vieira, Manuela, Instituto Superior de Engenharia de Lisboa, Portugal
Vigna, Benedetto, STMicroelectronics, Italy
Vrba, Radimir, Brno University of Technology, Czech Republic
Wandelt, Barbara, Technical University of Lodz, Poland
Wang, Jiangping, Xi'an Shiyou University, China
Wang, Kedong, Beihang University, China
Wang, Liang, Pacific Northwest National Laboratory, USA
Wang, Mi, University of Leeds, UK
Wang, Shinn-Fwu, Ching Yun University, Taiwan
Wang, Wei-Chih, University of Washington, USA
Wang, Wensheng, University of Pennsylvania, USA
Watson, Steven, Center for NanoSpace Technologies Inc., USA
Weiping, Yan, Dalian University of Technology, China
Wells, Stephen, Southern Company Services, USA
Wolkenberg, Andrzej, Institute of Electron Technology, Poland
Woods, R. Clive, Louisiana State University, USA
Wu, DerHo, National Pingtung Univ. of Science and Technology, Taiwan
Wu, Zhaoyang, Hunan University, China
Xiu Tao, Ge, Chuzhou University, China
Xu, Lisheng, The Chinese University of Hong Kong, Hong Kong
Xu, Tao, University of California, Irvine, USA
Yang, Dongfang, National Research Council, Canada
Yang, Shuang-Hua, Loughborough University, UK
Yang, Wuqiang, The University of Manchester, UK
Yang, Xiaoling, University of Georgia, Athens, GA, USA
Yaping Dan, Harvard University, USA
Ymeti, Aurel, University of Twente, Netherland
Yong Zhao, Northeastern University, China
Yu, Haihu, Wuhan University of Technology, China
Yuan, Yong, Massey University, New Zealand
Yufera Garcia, Alberto, Seville University, Spain
Zakaria, Zulkarnay, University Malaysia Perlis, Malaysia
Zagnoni, Michele, University of Southampton, UK
Zamani, Cyrus, Universitat de Barcelona, Spain
Zeni, Luigi, Second University of Naples, Italy
Zhang, Minglong, Shanghai University, China
Zhang, Qintao, University of California at Berkeley, USA
Zhang, Weiping, Shanghai Jiao Tong University, China
Zhang, Wenming, Shanghai Jiao Tong University, China
Zhang, Xueji, World Precision Instruments, Inc., USA
Zhong, Haoxiang, Henan Normal University, China
Zhu, Qing, Fujifilm Dimatix, Inc., USA
Zorzano, Luis, Universidad de La Rioja, Spain
Zourob, Mohammed, University of Cambridge, UK

Contents

Volume 121
Issue 10
October 2010

www.sensorsportal.com

ISSN 1726-5479

Research Articles

Computational Sensor Network: Book Review <i>Sergey Y. Yurish</i>	I
ANN Modeling of a Chemical Humidity Sensing Mechanism <i>Souhil Kouda, Zohir Dibi, Fayçal Meddour, Abdelghani Dendouga and Samir Barra</i>	1
Design of Artificial Neural Network-Based pH Estimator <i>Shebel A. Alsabbah, Maazouz A. Salahat and Mohammad K. Abuzalata</i>	10
Improved RBF Neural Network Based Soft Sensor: Application to the Optimal Robust Calibration of a Six Degrees of Freedom Parallel Kinematics Manipulator <i>Dan Zhang and Zhen Gao</i>	18
Real Time Interfacing of a Transducer with a Non-Linear Process using Simulated Annealing <i>S. M. GirirajKumar, K. Ramkumar, Bodla Rakesh, Sanjay Sarma O. V. and Deepak Jayaraj</i>	29
Visible and Near Infrared (VIS-NIR) Spectroscopy: Measurement and Prediction of Soluble Solid Content of Apple <i>Herlina Abdul Rahim, Kim Seng Chia and Ruzairi Abdul Rahim</i>	42
Control System Design for Cylindrical Tank Process Using Neural Model Predictive Control Technique <i>M. Sridevi, P. Madhavasarma, S. Sundaram</i>	50
Application of Genetic Algorithm for Tuning of a PID Controller for a Real Time Industrial Process <i>S. M. Giri Rajkumar, Atal. A. Kumar, N. Anantharaman</i>	56
Modeling and Control of Multivariable Process Using Intelligent Techniques <i>Subathra Balasubramanian, Radhakrishnan T. K.</i>	68
Limitations of Feedback, Feedforward and IMC Controller for a First Order Non-Linear Process with Dead Time <i>Maruthai Suresh and Ranganathan Rani Hemamalini</i>	77
Embedded Based DC Motor Speed Control System <i>Chandrasekhar T., Nagabhushan Raju K., V. V. Ramana C. H., Nagabhushana KATTE and Mani Kumar C.</i>	94
Real Time Implementation of a DC Motor Speed Control by Fuzzy Logic Controller and PI Controller Using FPGA <i>G. Sakthivel, T. S. Anandhi, S. P. Natarajan</i>	106
IDC Based Battery-free Wireless Pressure Sensor <i>Jose G. Villalobos, Zhen Xu, and Yi Jia</i>	121

Authors are encouraged to submit article in MS Word (doc) and Acrobat (pdf) formats by e-mail: editor@sensorsportal.com
Please visit journal's webpage with preparation instructions: <http://www.sensorsportal.com/HTML/DIGEST/Submission.htm>

International Frequency Sensor Association (IFSA).

ISSN 1726-5479

Advertise in *Sensors & Transducers Journal and Sensors Web Portal*



http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2010.pdf
sales@sensorsportal.com

Sensors & Transducers Journal (ISSN 1726-5479)

Open access, peer review
international journal devoted to research,
development and applications of sensors,
transducers and sensor systems.
The 2008 e-Impact Factor is 205.767

Published monthly by
International Frequency Sensor Association (IFSA)



Submit your article online:
<http://www.sensorsportal.com/HTML/DIGEST/Submission.htm>



The Seventh International Conference
on Networking and Services

ICNS 2011

May 22-27, 2011 - Venice, Italy



Important deadlines:

Submission (full paper)	January 10, 2011
Notification	February 20, 2011
Registration	March 5, 2011
Camera ready	March 20, 2011

<http://www.aria.org/conferences2011/ICNS11.html>

Tracks:

- ENCOT: Emerging Network Communications and Technologies
- COMAN: Network Control and Management
- SERVI: Multi-technology service deployment and assurance
- NGNUS: Next Generation Networks and Ubiquitous Services
- MPQSI: Multi Provider QoS/SLA Internetworking
- GRIDNS: Grid Networks and Services
- EDNA: Emergency Services and Disaster Recovery of Networks and Applications
- IPv6DFI: Deploying the Future Infrastructure
- IPDy: Internet Packet Dynamics
- GOBS: GRID over Optical Burst Switching Networks



The Third International Conference
on Bioinformatics, Biocomputational Systems and Biotechnologies

BIOTECHNO 2011

May 22-27, 2011 - Venice, Italy



Tracks:

A. Bioinformatics, chemoinformatics, neuroinformatics and applications

- Bioinformatics
- Advanced biocomputation technologies
- Chemoinformatics
- Bioimaging
- Neuroinformatics

B. Computational systems

- Bio-ontologies and semantics
- Biocomputing
- Genetics
- Molecular and Cellular Biology
- Microbiology

C. Biotechnologies and biomanufacturing

- Fundamentals in biotechnologies
- Biodevices
- Biomedical technologies
- Biological technologies
- Biomanufacturing

Important deadlines:

Submission (full paper)	January 10, 2011
Notification	February 20, 2011
Registration	March 5, 2011
Camera ready	March 20, 2011

<http://www.aria.org/conferences2011/BIOTECHNO11.html>



The Sixth International Conference on Systems

ICONS 2011

January 23-28, 2011 - St. Maarten,
The Netherlands Antilles



Important deadlines:

Submission (full paper)	September 25, 2010
Notification	October 20, 2010
Registration	November 5, 2010
Camera ready	November 5, 2010

<http://www.aria.org/conferences2011/ICONS11.html>

Tracks:

- Systems' theory and practice
- System engineering
- System instrumentation
- Embedded systems and systems-on-the-chip
- Target-oriented systems [emulation, simulation, prediction, etc.]
- Specialized systems [sensor-based, mobile, multimedia, biometrics, etc.]
- Validation systems
- Security and protection systems
- Advanced systems [expert, tutoring, self-adapting, interactive, etc.]
- Application-oriented systems [content, eHealth, radar, financial, vehicular, etc.]
- Safety in industrial systems
- Complex Systems

Design of Artificial Neural Network-Based pH Estimator

Shebel A. Alsabbah, Maazouz A. Salahat and Mohammad K. Abuzalata

Mechatronics Engineering Division, Faculty of Engineering Technology,

Al-Balqa Applied University, P.O Box 15008, Amman (11134), Jordan

Tel.: +962777745553, +962 6 4790333

E-mail: shebel_asad@hotmail.com and dsalahat@yahoo.com

Received: 11 July 2010 /Accepted: 18 October 2010 /Published: 26 October 2010

Abstract: Taking into consideration the cost, size and drawbacks might be found with real hardware instrument for measuring pH values such that the complications of the wiring, installing, calibrating and troubleshooting the system, would make a person look for a cheaper, accurate, and alternative choice to perform the measuring operation, Where's hereby, a feedforward artificial neural network-based pH estimator has to be proposed. The proposed estimator has been designed with multi-layer perceptrons. One input which is a measured base stream and two outputs represent pH values at strong base and strong/weak acids for a titration process. The created data base has been obtained with consideration of temperature variation. The final numerical results ensure the effectiveness and robustness of the design neural network-based pH estimator. *Copyright © 2010 IFSA.*

Keywords: pH electrode, Titration process, Neural network and Training algorithm.

1. Introduction

pH plants had always drawn the attention of the chemical engineers due to its importance in different fields: from the medicine and the effect of pH on the enzymes and blood, to industry which is concerned with manufacturing of textile dyes, and bleach products, to the environmental issues concerned with treating waste water to be environmentally safe and the acidic rains researches, and finally in the army to have a safe monitoring of the pH in the nuclear reactors and the resulted materials [1].

The pH unit measures the degree of acidity or basicity of a solution. And To be more exact it is the measurement of the Hydrogen ion concentration, [H⁺]. The value of the pH of any solution is between

0-14, where the values below 7 pH exhibit acidic properties, while values above 7 pH exhibit basic properties, and 7 is neither acidic nor basic, therefore it is called "neutral".

The pH of a solution is an important propriety that a chemical engineer depends on to judge the solution, which is the basic procedure towards the analysis and treating the solution, especially while the pH could express a sensitive and dangerous effect of this solution on the surrounding environment.

This work aims to save the trouble of providing a big financial support and a large skillful labor crew that are needed to operate the system, by simply replacing all the complementary devices of measuring and compensating with a software that is programmed with enough insight and understanding of the system, and is able to produce a signal that represent the required estimation after performing the needed compensation and correction of the factors, this done with the design of a neural network-inversely thermo-chemical model to produce an output that simply expresses the estimated value of pH with respect to different input parameters (mass concentration and base flow rate) taking into account temperature variation.

2. Conventional Methods for Evaluation of pH

Before explaining, briefly, the conventional pH evaluation methods and how do they work on sensing and measuring the pH, it is essential to explain the measuring mechanism of pH in solutions.

A pH measurement loop is made up of three components, the pH sensor, which includes a measuring electrode, a reference electrode, and a temperature sensor; a preamplifier; and an analyzer or transmitter. A pH measurement loop is essentially a battery where the positive terminal is the measuring electrode and the negative terminal is the reference electrode. The measuring electrode, which is sensitive to the hydrogen ion, develops a potential (voltage) directly related to the hydrogen ion concentration of the solution. The reference electrode provides a stable potential against which the measuring electrode can be compared.

2.1. pH Meter

When immersed in the solution, the reference electrode potential does not change with the changing hydrogen ion concentration. A solution in the reference electrode also makes contact with the sample solution and the measuring electrode through a junction, completing the circuit. Output of the measuring electrode changes with temperature (even though the process remains at a constant pH) [1], so a temperature sensor is necessary to correct for this change in output. This is done in the analyzer or transmitter software. Fig. 1 shows a simplified typical pH sensor.

The pH sensor components are usually combined into one device called a combination pH electrode. The measuring electrode is usually glass and quite fragile, as seen in Fig. 2. Note that the thin, lithium doped glass membrane across which the pH voltage is generated.

Recent developments have replaced the glass with more durable solid-state sensors. The preamplifier is a signal-conditioning device. It takes the high-impedance pH electrode signal and changes it into low impedance signal which the analyzer or transmitter can accept. The preamplifier also strengthens and stabilizes the signal, making it less susceptible to electrical noise.

The sensor's electrical signal is then displayed. This is commonly done in a 120/240 V ac-powered analyzer or in a 24 V dc loop-powered transmitter.

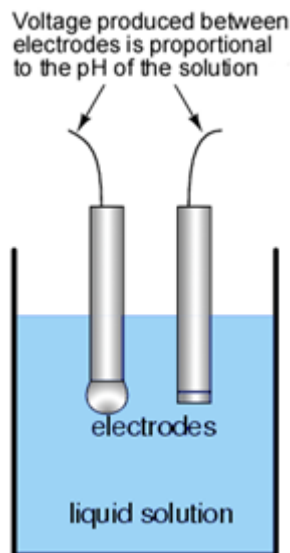


Fig. 1. Shows a simplified pH meter.

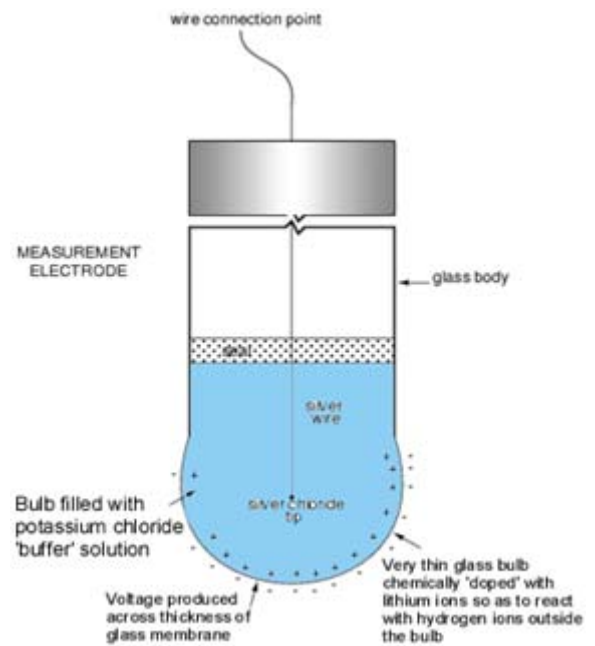


Fig. 2. Measuring Electrode- glassed body.

Additionally, the analyzer or transmitter has a man machine interface for calibrating the sensor and configuring outputs and alarms, if pH control is being done.

Keep in mind, application requirements should be carefully considered when choosing a pH electrode. Accurate pH measurement and the resulting precise control that it can allow, can go a long way toward process optimization and result in increased product quality and consistency. Accurate, stable pH measurement also controls and often lowers chemical usage, minimizing system maintenance and expense.

2.2. pH Measurement

While pH can be measured by color changes in certain chemical powders, continuous process monitoring and control of pH requires a more sophisticated approach. The most common approach is the use of a specially-prepared electrode designed to allow hydrogen ions in the solution to migrate through a selective barrier, producing a measurable potential (voltage) difference proportional to the solution's pH.

What is important to understand is that these two electrodes generate a voltage directly proportional to the pH of the solution. At a pH of 7 (neutral), the electrodes will produce 0 volts between them. At a low pH (acid) a voltage will be developed of one polarity, and at a high pH (caustic) a voltage will be developed of the opposite polarity.

An unfortunate design constraint of pH electrodes is that one of them (called the measurement electrode) must be constructed of special glass to create the ion-selective barrier needed to screen out hydrogen ions from all the other ions floating around in the solution. This glass is chemically doped with lithium ions, which is what makes it react electrochemically to hydrogen ions. Since glass is an extremely good insulator. This presents a major problem if our intent is to measure voltage between the two electrodes. The circuit path from one electrode contact, through the glass barrier, through the solution, to the other electrode, and back through the other electrode's contact, is one of extremely high resistance.

The other electrode (called the reference electrode) is made from a chemical solution of neutral (7) pH buffer solution (usually potassium chloride) allowed to exchange ions with the process solution through a porous separator, forming a relatively low resistance connection to the test liquid. At first, it could be thought of just dipping a metal wire into the solution to get an electrical connection to the liquid. But this method won't be useful because metals tend to be highly reactive in ionic solutions and can produce a significant voltage across the interface of metal to-liquid contact. The use of a wet chemical interface with the measured solution is necessary to avoid creating such a voltage, which of course would be falsely interpreted by any measuring device as being indicative of pH [1, 2].

2.3. Troubles Found with pH Metering and Conventional Solutions

Many troubles of pH measurement could be faced in practice. For example, electrical interference, relay hunting, in-Line calibration, current transmission 4-20 mA, pH measurement in liquids with hydrofluoric acid, ORP measurements, prevention of chemical wastage and manual temperature compensation [1].

3. Non-Conventional Proposed NN-Based Evaluation Method

With respect to the problem geometry that has been discussed in previous sections, it could be concluded the importance to find an alternative solution for evaluation of pH values instead of pH probe. The proposed evaluation method, as an alternative for conventional methods, should have an adaptive feature. That is means, to estimate pH with respect to the measurement of the base stream and with taking into account any temperature variations without needs of temperature probe (another hardware compensation). However, there are many instances where a temperature probe is not being used. This typically would be when there is no large variation in temperature of the process [2].

So, the physical problem which we deal with is non linear, that is why a non linear feedforward multi-layer neural network MLP-NN has been chosen and validated, numerically, with MatLab (M-files) as will seen in the next sections.

3.1. Structure of the Proposed MLP-NNE

The structure of an artificial multi-layer neural network pH estimator (MLP-NNE), seen in Fig. 3.

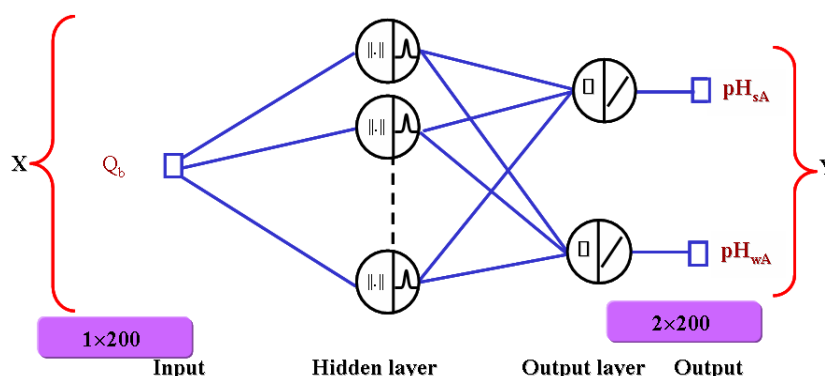


Fig. 3. Structure of the proposed MLP-NNE.

Fig. 3 shows the internal structure of the proposed NN. In Fig. 3, the NN has 1 input (Q_b) represents the measured base stream and 2 outputs pH_{SA} and pH_{WA} . Where pH_{SA} and pH_{WA} are the pH at strong and weak acid, respectively.

The structure used in this work for this type of application constitutes of one hidden layer with a hyperbolic tangent activation function and output layer with linear function as shown above.

3.2. The Training Algorithm

The training algorithm used in this work is the conventional backpropagation algorithm.

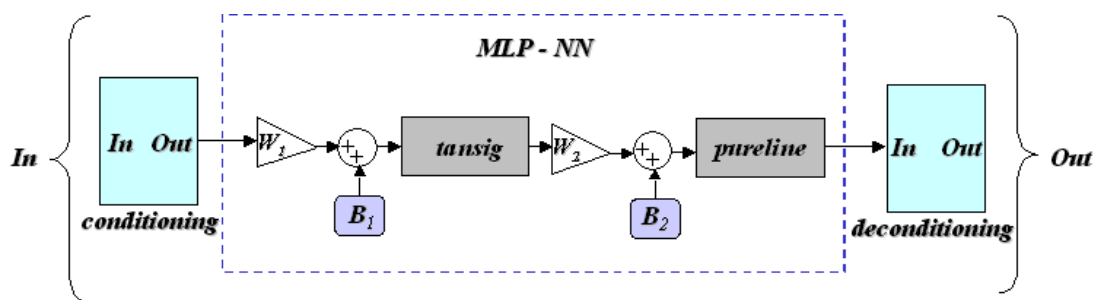


Fig. 4. Internal structure NNE.

The main three algorithms (training, validation and testing) of the NN pH estimator are presented as follows (Fig. 5).

For such problems, where the MLP-NN is proposed to estimate the pH, there is no general method to fix the architecture of the network (number of neurons in the hidden layer). In this case, we are going to study certain number of neuronal architectures.

For each architecture, we do different initializations of synaptic parameters to assure that the training of the NN converges towards the total minimum of the error criterion. For each structure, we calculate the mean square error MSE in the training and validation data bases (as shown in Fig. 6).

Then, the adequate structure that we are concerned is the structure which has the least square error in the validation base (in our case is equal 0.01).

Fig. 6 presents the evaluation of the minimal MSE in the validation data base (in green color) that had been used to define the number of neurons in the hidden layer (in our case is equal 2) for the chosen structure.

For such application, we aimed to vary the number of neurons in the hidden layer from 1 to 20 neurons, as presented above in the x-axis for the relation between the MSE via the number of neurons in the hidden layer. And for each structure, three different initialisations of synaptic parameters had been carried out. The training had been done using Levenberg-Marquardt algorithm [3, 4].

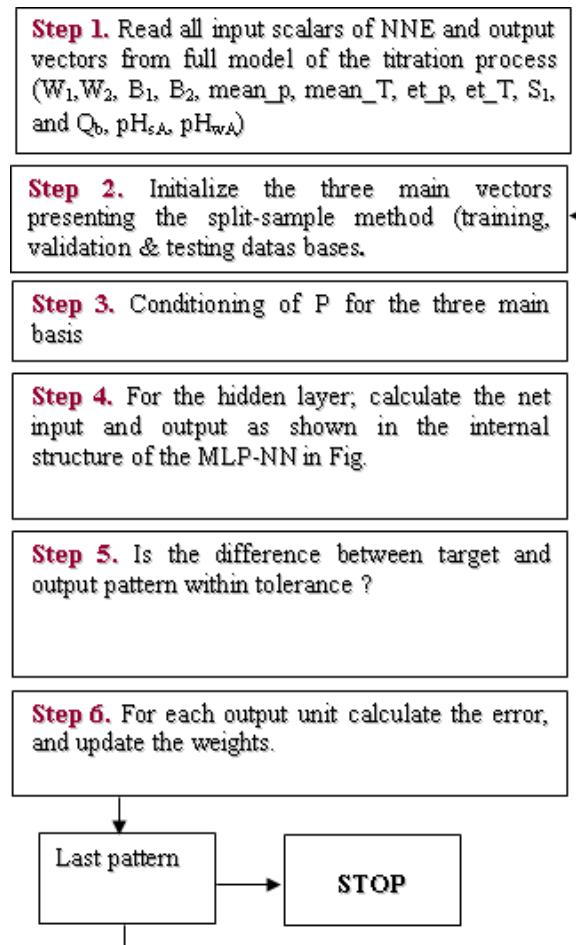


Fig. 5. Flow chart presents the NN three main algorithms (training, validation and testing).

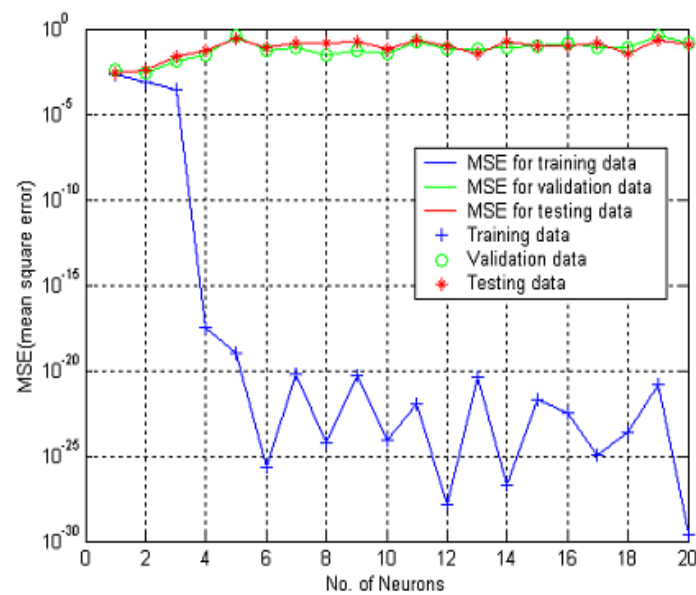


Fig. 6. MSE for both the training and validation data bases.

3.3. Interpretation of Results

Finally, the capacity of the net will be tested, with respect to extracted experimental data base, to find the estimated pH that corresponded to the least error between the estimated and ideal ones for different 200 values of input vectors.

The utilized examples had been subdivided into three stages (training (100), validation (68) and testing (32)) as performed by split-sample method [3].

The testing data base is of different values than the precedent ones (training and validation data base).

The error between the real and estimated speed values is defined for each parameter by the relative error $ER(pH)$ calculated by the following formula (1),

$$ER(pH) = \sqrt{\frac{1}{N} \sum_{i=1}^n \left[\frac{pH' - pH}{pH} \right]^2}, \quad (1)$$

where N is the number of considered points (in our case is equal 32).

For the proposed design, it had been found that the relative error is 0.02 %, which is accepted. So the designed MLP-NNE has a sufficient value of accuracy.

4. Results

After design steps and net training, the performance of the proposed estimator that calculates the pH values with respect to the base flow measurements in l/min has been tested and then validated numerically, as following (Fig. 7):

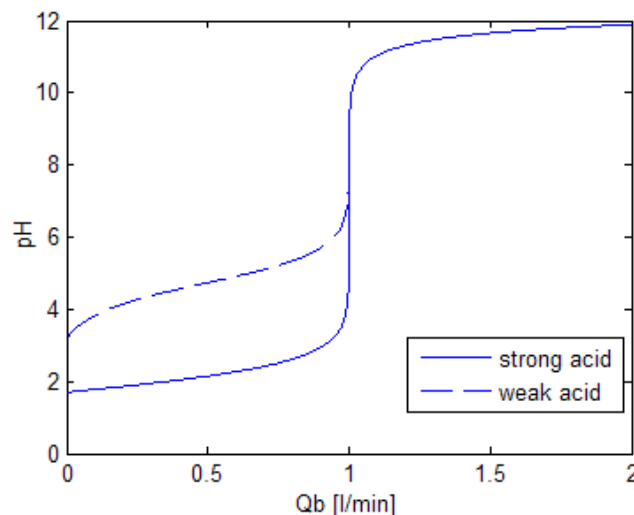


Fig. 7. The estimated curves for strong based strong/weak acid.

It was found, when comparing with ideal curves (Fig. 8), that the numerical proposed estimator is well performed. And the results are being satisfied.

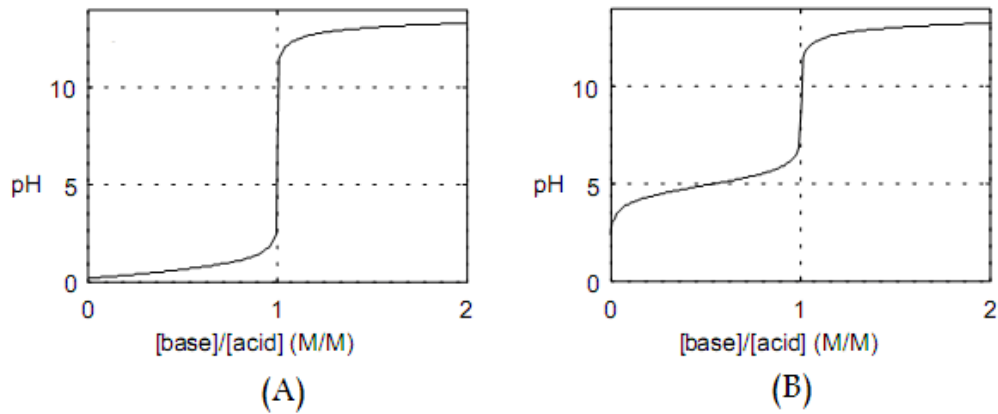


Fig. 8. The ideal curves for strong based strong/weak acid (A and B respectively).

5. Conclusions and Perspectives

- The proposed structure for MLP-NNE has been designed to solve the varieties of troubles might be found with the real hardware (pH electrode) and convention methods for evaluation of pH.
- The effectiveness of the proposed observer has been ensured as well concluded when comparing Fig. 7 (estimated titration curve) with Fig. 8 (ideal titration curve).
- The proposed NN-based pH estimator if implemented experimentally will optimize the size of overall plant with cost reduction to meet the industrial enquiries. And this is one of perspectives of the present work.

References

- [1]. Gregory K. McMillan and Cameron, *Advanced pH Measurement and Control*, 3rd edition, *ISA*.
- [2]. Luyben, W. L., *Process Modelling, Simulation and Control for Chemical Engineers*, *McGraw-Hill*, New York, 1989.
- [3]. H. Selcuk Noagy, *Prediction of Internal Temperature in Three-Phase Induction Motors with ANN*, *European Transactions on Electrical Power*, *John Wiley & Sons*, 2009.
- [4]. Nikhil, Bestamin Özkaya, Ari Visa, Chiu-Yue Lin, Jaakko A. Puhakka, and Olli Yli-Harja, *An Artificial Neural Network Based Model for Predicting H₂ Production Rates in a Sucrose-Based Bioreactor System*. *Proceedings of World Academy of Science, Engineering and Technology*, Vol. 27, February 2008.
- [5]. Evern Guner, *Adaptive Neuro Fuzzy Inference System Applications in Chemical Processes*, A Thesis submitted to the *Graduate School of Natural and Applied Sciences of the Middle East Technical University*, In partial fulfillment of the requirement for the degree of Master of Science in the department of Chemical Engineering, November 2003.



The Fourth International Conference on Advances
in Circuits, Electronics and Micro-electronics

CENICS 2011

August 21-27, 2011 - French Riviera, France



Important deadlines:

Submission deadline	March 23, 2011
Notification	April 30, 2011
Registration	May 15, 2011
Camera ready	May 22, 2011

Tracks:

- Semiconductors and applications
- Design, models and languages
- Signal processing circuits
- Arithmetic computational circuits
- Microelectronics
- Electronics technologies
- Special circuits
- Consumer electronics
- Application-oriented electronics

<http://www.iaria.org/conferences2011/CENICS11.html>



The Second International Conference
on Sensor Device Technologies and Applications

SENSORDEVICES 2011

August 21-27, 2011 - French Riviera, France



Important deadlines:

Submission deadline	March 23, 2011
Notification	April 30, 2011
Registration	May 15, 2011
Camera ready	May 22, 2011

Tracks:

- Sensor devices
- Photonics
- Infrared
- Ultrasonic and Piezosensors
- Sensor device technologies
- Sensors signal conditioning and interfacing circuits
- Medical devices and sensors applications
- Sensors domain-oriented devices, technologies, and applications
- Sensor-based localization and tracking technologies

<http://www.iaria.org/conferences2011/SENSORDEVICES11.html>



The Fifth International Conference on Sensor
Technologies and Applications

SENSORCOMM 2011

August 21-27, 2011 - French Riviera, France



Important deadlines:

Submission deadline	March 23, 2011
Notification	April 30, 2011
Registration	May 15, 2011
Camera ready	May 22, 2011

Tracks:

- APASN: Architectures, protocols and algorithms of sensor networks
- MECSN: Energy, management and control of sensor networks
- RASQOFT: Resource allocation, services, QoS and fault tolerance in sensor networks
- PESMOSN: Performance, simulation and modelling of sensor networks
- SEMOSN: Security and monitoring of sensor networks
- SECSN: Sensor circuits and sensor devices
- RIWISN: Radio issues in wireless sensor networks
- SAPSN: Software, applications and programming of sensor networks
- DAIPSN: Data allocation and information in sensor networks
- DISN: Deployments and implementations of sensor networks
- UNWAT: Under water sensors and systems
- ENOPT: Energy optimization in wireless sensor networks

<http://www.iaria.org/conferences2011/SENSORCOMM11.html>

Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In addition, some special sponsored and conference issues published annually. *Sensors & Transducers Journal* is indexed and abstracted very quickly by Chemical Abstracts, IndexCopernicus Journals Master List, Open J-Gate, Google Scholar, etc.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

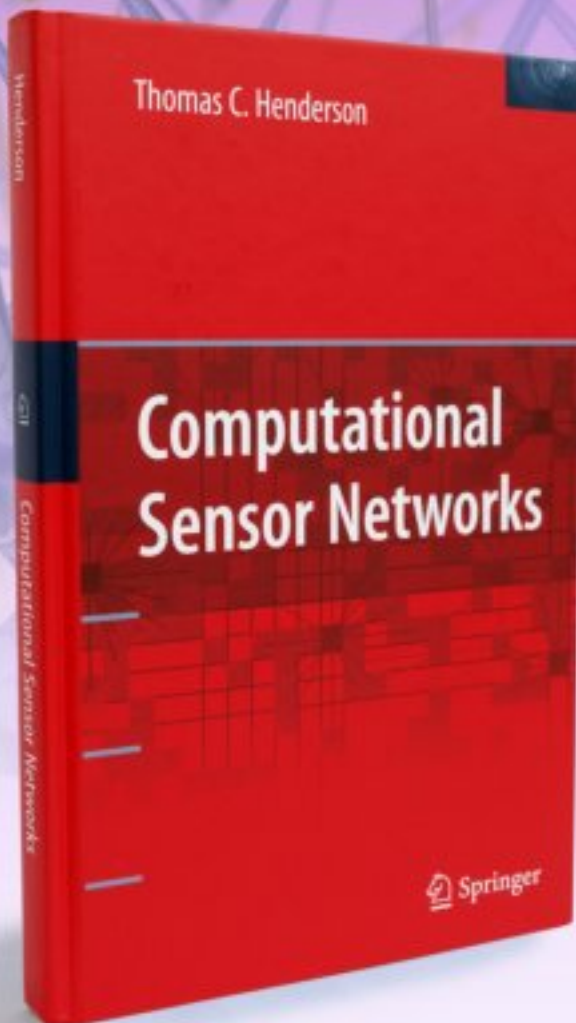
- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

Submission of papers

Articles should be written in English. Authors are invited to submit by e-mail editor@sensorsportal.com 8-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: <http://www.sensorsportal.com/HTML/DIGEST/Submission.htm> Authors must follow the instructions strictly when submitting their manuscripts.

Advertising Information

Advertising orders and enquires may be sent to sales@sensorsportal.com Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2009.pdf



This text proposes a model-based approach to the design and implementation of Computational Sensor Networks. This high-level paradigm for the development and application of sensor device networks provides a strong scientific computing foundation, as well as the basis for robust software engineering practices. Building upon a model-based approach the text discusses computational modeling of sensor networks and covers real-time computational mapping that allows for modification of system parameters according to real-time performance measures.

Drawing upon years of theoretical development and practical experience, and using numerous examples and illustrative applications, Thomas Henderson covers the sensor network as a computational science tool.

Computational Sensor Network is a must have book and will greatly benefit sensor network application engineers, computer engineers, computer scientists and those involved in the development, design and building of sensor networks in an industrial, research and an academic environment.

Order online:

http://www.sensorsportal.com/HTML/BOOKSTORE/Computational_SN.htm