This tutorial is composed of three main parts that review sensor data collection, preprocessing, and developing and implementing high-fidelity classification algorithms.

First, background and motivations for using bio-inspired intelligent hardware and software systems will be discussed. They are required now more than ever, because of the fast pace progress in sensors, actuators, and more sophisticated applications.

The second part will cover modern alternative systems to develop efficient classifiers, based on sensory data, data preprocessing, algorithms, and mapping them into hardware to achieve portability, speed, and low cost. An exposition of Sampling Spiking Neural Network (SSNN) classifiers will be given as a promising technique.

In the third part the significance of preprocessing sensors data for classification is emphasized. A preprocessing approach ought to take into account the nature of the application and the classification method. Those include: classical filters, evolutionary techniques, wavelet transform, fuzzy and hyper-fuzzy logic with their advantages and limitations explained. Furthermore, classification experiments of target tracking from radar signals, and of chemicals from mixtures with different concentrations, will be presented as good examples in achieving high fidelity classifiers.

**Keywords:** Bio-inspired systems, Spiking Neural Networks, classification algorithms, system-on-chip; sensor data preprocessing, E-nose, MISO radar data.

**TUTORIAL OUTLINE:**

1. Introduction to Bio-Inspired Systems
   1-1 Definitions and Motivations
   1-2 Approaches
   1-3 System Structures
   1-4 Need for Neuromorphic Systems

2. Applications Determine the Required System Structure and Hardware
   You cannot build an electronic human-like brain for all functions, but you definitely can surpass each brain function individually

3. Bio-Inspired Algorithms and Mapping them into Hardware
   3-1. Neural Networks:
      a. Self-organizing Feature Mapping
      b. Reinforcement NNs
c. Supervised NNs

d. Spiking NNs

3-2. Evolutionary and Genetic Techniques

4. Recent High-Precision Classification Applications
   4-1 E-Nose
   4-2 Target Tracking from Radar Signals
   4-3 Automotive Passenger Health Monitoring
   4-4 Hospital Environmental Safety

5. Bio-Inspired Approaches to AOA Determination from Radar Data
   a. Efficient Algorithms
   b. Effective Hardware

6. E-Nose (Chemical Classification)
   6-1 Alternative Bio-Inspired System Structures

   6-2 E-Nose Applications
   a. Environment Protection
   b. Health and Safety
   c. Food Processors
   d. TATP and HMTD

6-3 Sensor Data Preprocessing
   a. Classical Filters
   b. Evolutionary Methods
   c. Haar Wavelets Transform
   d. Fuzzy and Hyper-Fuzzy Logic
   e. Daubechies Wavelet Transform

6-4 Substance-Sensor FINGER PRINT Identification

6-5 E-Nose Embedded Systems and IC Chips
   a. SOFM E-Nose IC Chip
   b. Reinforcement E-Nose Digital and Analog Chips
   c. Spiking Neural Network E-Nose Chip
   d. Sampling Spiking Neural Network E-Nose Chip

6-6 Chemicals Detection from Measurements

7. Concluding Remark
Short Biography:

Dr. Hoda Soliman Abdel-Aty-Zohdy, is the John F. Dodge Chair Professor of Engineering at Oakland University. Founder and Director of the Microelectronics & Bio-Inspired Systems Design Lab, and a Professor in the Department of Electrical and Computer Engineering at Oakland University. She received the B.S. degree (with First Class Honors) from Cairo University/Faculty of Engineering, the M.S. and the Ph.D. degrees from the University of Waterloo, Canada, all in Electrical Engineering.

She received the Research Excellence Award from Oakland University in April 2013, and was selected as Technology Leader of Bio-Inspired Systems, Intergovernmental Personnel Act Appointee (IPA) at the Wright Patterson Air Force Base/AFRL 2007-2008. She served as IEEE Distinguished Lecturer 2004-06. Invited as Keynote Speaker for international conferences including: the ISSR Conference, Cairo Egypt, 2011 & 2010; the IEEE NAECON 2011, 2010, and 2009 in Dayton OH; IEEE PACRIM, Vancouver, CA 2007; The President Colloquium speaker OU 2005; the IEEE NEWCAS, Montreal, CA 2004; the IEEE ECCTD Krakow, Poland 2003; and the IEEE ICCC 2001 in Tunisia. She served as Plenary Lecturer and Workshop presenter at the international conferences on telecommunications (ICT05) South Africa, and the IEEE MWSCAS 2003, Cairo Egypt.

Dr. Abdel-Aty-Zohdy’s research is focused on: advanced bio-inspired integrated Chips; novel graphite and graphene devices; adaptive IC Chips with NNs and GAs; integrated SNN chips with applications in high-precision classification, and efficient processing as in olfaction and radar systems; IC chips for low-power, low noise; polymer electrolyte devices; protein (BR) memory; Charge-Coupled Devices (CCDs); tunable Laser for electro-optical applications. Her research resulted in 173 refereed publications, one granted patent and two invention disclosures, and more than 40 technical reports.

Her current research funding sources include: The ONR; The Air Force Research Labs (AFRL) Sensors Directorate; AFRL Information Directorate (IF); AFRL Center for Innovative Radar Engineering (CIRE); The Air Force Office of Scientific Research (AFOSR), BAA and STTR with RNET Inc.; SBIR with SYSTRAN; and Oakland University. Educational projects support is from MOSIS.

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