# Lecture 1: Introduction

- **Class organization**
  - Instructor contact
  - Course objectives and outcomes
  - Lectures outline
  - Laboratory outline
  - Grading system
  - Tentative schedule
- **Lab schedule**
- **Intelligent sensor systems (ISS)**
  - Systems, sensors and intelligence
  - Definitions of ISS
  - Building blocks of ISS

# Instructor contact and meeting times

## Instructor

- Ricardo Gutierrez-Osuna
  - Office: 401 Russ
  - Tel: 775-5120
  - E-mail: rgutier@cs.wright.edu
  - Office hours: MW 4:30-5:30 PM or by appointment

## Meeting times

- Lectures
  - MW 5:35-6:50PM
  - Russ 406
- Labs
  - To be determined
  - Russ 339

# Course Objectives and Outcomes

- **The objectives of the course are to**
  - Introduce the fundamentals of intelligent sensor systems: sensors, instrumentation and pattern analysis
  - Provide the students with an integrative and multidisciplinary experience by building a complete multi-sensor intelligent system
  - Allow the students to develop instrumentation, data acquisition and pattern analysis software using modern equipment and software tools
- **The outcome of the course is the ability to design, analyze and implement**
  - Basic instrumentation and signal conditioning circuits for sensors
  - Virtual instrumentation and data acquisition software for sensors and actuators
  - Pattern analysis algorithms for multi-sensor systems

# Lecture outline

- **SENSORS**
  - Primary sensing principles and measurement variables
  - Sensor performance characteristics and terminology
- **INSTRUMENTATION**
  - Transducer measurement circuits
  - Signal conditioning circuits
  - Data conversion: DAC, ADC
  - Virtual instrumentation with LabVIEW
- **PATTERN ANALYSIS**
  - Introduction to Statistical Pattern Recognition
  - Dimensionality reduction
  - Classification
  - Validation
  - Data analysis with MATLAB
- **INTELLIGENT SENSOR SYSTEMS**
  - Structure, definitions and concepts
  - Advanced processing and control techniques
  - Smart sensors
  - Case study: the “electronic nose”
  - The future of intelligent sensor systems

# Laboratory outline

- **LAB I: Sensor interfacing**
  - Temperature sensor calibration
  - Gas sensor isothermal excitation
- **LAB II: Data acquisition**
  - Virtual instrument and GUI design
  - Analog and digital I/O
  - File I/O
- **LAB III: System integration**
  - Control of electromechanical actuators
  - Flow injection assembly
  - Integration of control, DAQ and GUI modules
- **LAB IV: Pattern analysis**
  - Signal preprocessing
  - Dimensionality reduction
  - Classification
- **LAB V: Advanced sensor excitation**
  - Pulse Width Modulation
  - Temperature cycling
  - Analysis of performance

# Grading System

- **Grading will be straight scale**
  - 90-100 A, 80-89 B, 70-79 C, 60-69 D, below 60 F
- **Course grade will be the weighted sum of three grades**
  - Laboratory (60%)
  - Midterm exam (15%)
  - Final exam (25%)
- **Exams**
  - Closed-books, closed-notes
  - One double-sided, hand-written sheet (8.5 x 11") will be allowed
  - Tests will emphasize new material

# Tentative schedule (1)

| | Date | Topic (Calendar) | Assignments |
|---|---|---|---|
| Week 1 | 1/1 | New Year's Day (No class) | |
| | 1/3 | Course Introduction | |
| Week 2 | 1/8 | Sensors I | |
| | 1/10 | Sensors II | |
| Week 3 | 1/15 | Martin Luther King, Jr. Day (No class) | |
| | 1/17 | Instrumentation I | |
| Week 4 | 1/22 | Instrumentation II | Lab 1 Sensor interfacing |
| | 1/24 | Instrumentation III | |
| Week 5 | 1/29 | LabVIEW | Lab 2 Data acquisition |
| | 1/31 | Instrumentation IV | |
| Week 6 | 2/5 | Midterm Review | |
| | 2/7 | Midterm Exam | Lab3 System integration |

# Tentative schedule (2)

| | | | |
|---|---|---|---|
| **Week 7** | 2/12 | Pattern analysis I | |
| | 2/14 | Pattern analysis II | |
| **Week 8** | 2/19 | MATLAB | Lab4<br>Pattern analysis |
| | 2/21 | Pattern analysis III | |
| **Week 9** | 2/26 | Pattern analysis IV | |
| | 2/28 | Pattern analysis V | |
| **Week 10** | 3/5 | Intelligent Sensor Systems I | Lab 5<br>Advanced sensor excitation |
| | 3/7 | Intelligent Sensor Systems II | |
| **Week 11** | 3/12 | Intelligent Sensor Systems III<br>(Last day of class) | |
| | 3/14 | Exams Week*<br>(No class) | |

**Final exam will be held Friday, March 16, 2001, from 5:30 to 7:30PM in Russ 406*

# Intelligent Sensor Systems

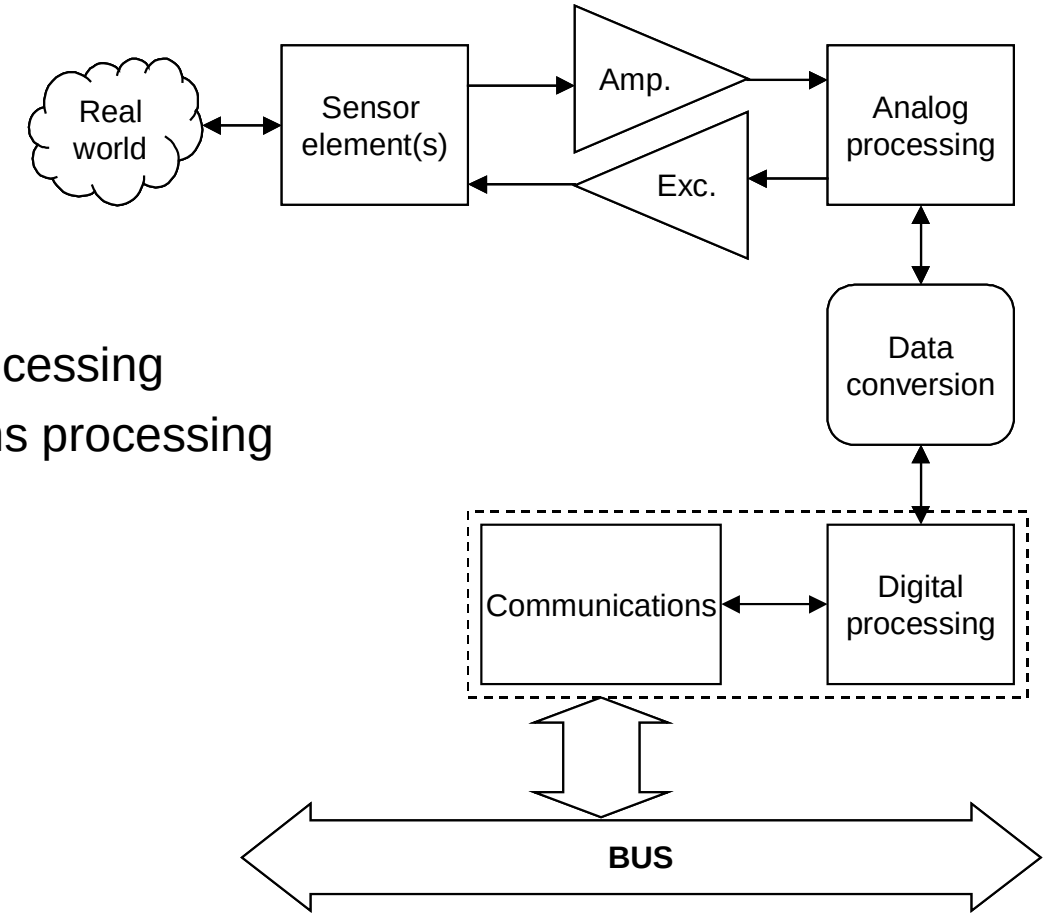
- **System**
  - A combination of two or more elements, subsystems and parts necessary to carry out one or more functions [PAW91]
  - To interact with the real world, a system requires
    - Sensors: inputs devices
    - Actuators: output devices
    - Processing: signals, information and knowledge
- **Sensor**
  - A device that receives and responds to a stimulus [Fdn97]
    - Stimulus: mechanical, thermal, magnetic, electric, optical, chemical…
    - Response: an electrical signal (in most cases)
- **Intelligence**
  - The ability to combine
    - A priori knowledge (available before experience) and
    - Adaptive learning (from experience)

# *Intelligent Sensor Systems*

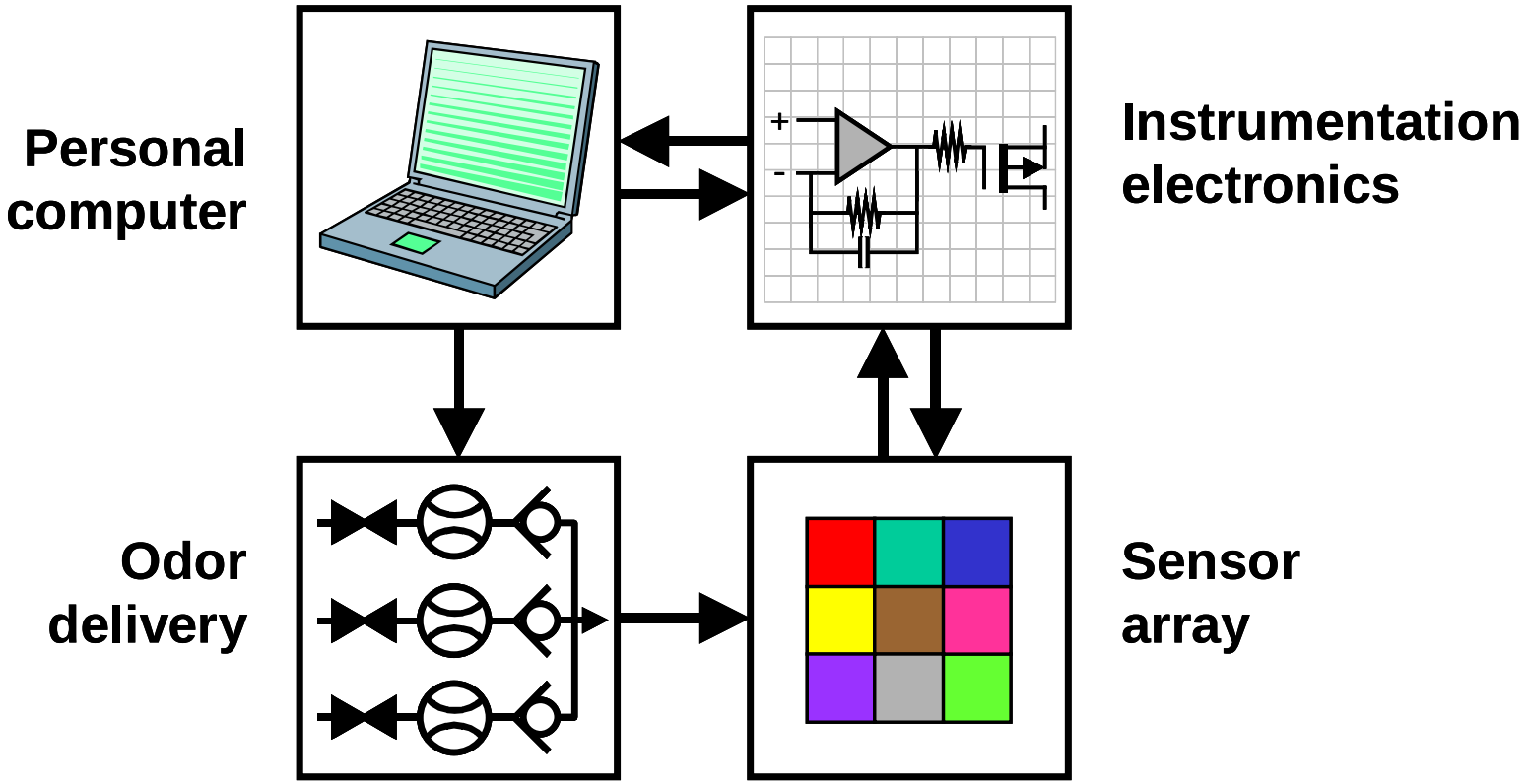
- **Several definitions are available**
  - A sensor that is capable of modifying its internal behavior to optimize the collection of data from the external world [Whi97]
    - The concepts of adaptation and compensation are central to the Intelligent Sensor philosophy
  - A device that combines a sensing element and a signal processor on a single integrated circuit [PY95a]
    - The minimum requirements of the signal processor are not clear [PY95b]
      - Basic integrated electronics (signal conditioning, ADC)
      - A micro-processor
      - Logic functions and decision making
  - A smart sensor is a sensor that provides functions beyond those necessary for generating a correct representation of a sensed or controlled quantity (IEEE 1451.2) [Fnk00]
    - This function typically simplifies the integration of the transducer into applications in a networked environment
- **"Intelligent" or "Smart" Sensors?**

# Building blocks of Intelligent Sensors

- **The principal sub-systems within an ISS are [BW96]**
  - Primary sensing element(s)
  - Excitation control
  - Amplification
  - Analogue filtering
  - Data conversion
  - Compensation
  - Digital information processing
  - Digital communications processing



# The E-nose: a model ISS



# References


[PAW91] R. Pallas-Areny and J. G. Webster, 1991, Sensors and Signal Conditioning, Wiley, New York

[Fdn97] J. Fraden, 1997, Handbook of Modern Sensors. Physics, Designs and Applications, AIP, Woodbury, NY

[Whi97] N. White, 1997, “Intelligent Sensors’” in Sensor Review 17(2), pp. 97-98

[PY95a] E. T. Powner and F. Yalcinkaya, 1995, “Intelligent sensors: structure and system,” in Sensor Review 15(3), pp. 31-34

[PY95b] E. T. Powner and F. Yalcinkaya, 1995, “From basic sensors to intelligent sensors: definitions and examples,” in Sensor Review 15(4), pp. 19-22

[Fnk00] R. Frank, 2000, Understanding Smart Sensors, Artech, Boston, MA.

[BW96] J. Brignell and N. White, 1996, Intelligent Sensor Systems, 2nd Ed., IOP, Bristol, UK.