International training course

Networked Environmental Monitoring – from sensor principles to novel services

Purpose and background

Environmental monitoring today is based on fixed measurement stations containing sophisticated analytical equipment to achieve a high data quality. However, due to the high cost for investment and maintenance only a limited number of pollutants (typ. CO, NO_x, SO_2, ozone, PM10, PM2.5, BTX, tVOC) are monitored at very few locations. Furthermore, not only is the spatial resolution limited but temporal resolution is coarse, with measurements typically providing hourly values at best. Thus, the fundamental information available on air quality (AQ) today does not meet the needs of many citizens or the requirements of **advanced environmental information (EI) services** and city infrastructure management. The current status does not reflect the increasing needs for well monitored 'smart cities', requiring e.g. real-time traffic management, identification of clean 'green' areas and routes in cities, specific information for children, elderly or citizens affected by certain pollutants or allergens, temporal air quality profiles for optimisation of ventilation strategies for improved indoor air quality, and, last but not least, for educating citizens about their local environment and the impact of their everyday life habits to their quality of life.

Novel low-cost sensor technologies are poised to support a paradigm shift by allowing ubiquitous ambient pollution monitoring with high spatio-temporal resolution available at every person´s fingertips – either through environmental information websites backed by stationary and mobile sensor networks or quite literally with **sensor technology being integrated into mobile devices and supported by Internet of Things (IoT) technologies**. The availability of such sensor data cultivates a fertile environment for the development of novel information services addressing personalised citizen needs as well as city planning and management and environmental decision making requirements. The seminar will provide an overview over the state-of-the-art in environmental monitoring today and over sensor and modelling technologies for low-cost ubiquitous monitoring as well as indicate novel EI service characteristics and future markets based on these technologies.

Seminar benefits

Participants will learn about the main aspects of air pollution, its effects and associated costs as well as the current status of air pollution meteorology with its pros and cons.

Then, an overview over modern low-cost sensor principles, operating modes and data evaluation strategies is given with clear indications on advantages and limitations compared to existing monitoring stations. Examples will be given for various benchmark applications covering different mobile and fixed sensor solutions for pollution and odour monitoring.

Finally, participants will learn how these sensor solutions can be utilized to develop novel environmental services for communities, companies and citizens. Service design principles and market penetration potentials will also be discussed.

Who should attend?

The seminar addresses a wide range of industrial participants, e.g., sensor companies interested in providing solutions for environmental monitoring, developers and operators of existing monitoring stations to learn about new sensor technologies as well as network providers and app developers interested in offering new applications and advanced services. The seminar should also provide contacts for future R&D collaborations in this field.

Scientific instructors

Environmental monitoring

Prof. Ole Hertel

Department of Environmental Science

Aarhus University

Roskilde - Denmark

oh@envs.au.dk

Smart sensor systems

Prof. Andreas Schütze

Lab for Measurement Technology

Saarland University

Saarbrücken - Germany

schuetze@lmt.uni-saarland.de

Data modelling & services

Assoc.-Prof. Kostas Karatzas

Environmental Informatics Research Group

Aristotle University

Thessaloniki - Greece

kkara@eng.auth.gr

Day 1 – Tuesday, Feb. 21, 2017

11:00 ***optional visit*** *to Air Quality monitoring station at* **H.C. Andersen's Boulevard**
operated by Department of Environmental Science, AU

13:00 **Welcome, introduction and goal of the seminar**, O. Hertel, A. Schütze, K. Karatzas

- Environmental monitoring today and tomorrow
- Smart and green cities: how and why?
- Overview and goal of the seminar

13:30 **Introduction to air pollution**, O. Hertel

- Pollutants: gases and particles
- Atmospheric chemistry
- Health effects and external costs of Air Pollution
- Atmospheric particles – physical and chemical properties, sources and sinks
- Integrated monitoring and assessment

14:30 – 15:00 coffee break

15:00 **Air pollution meteorology**, O. Hertel

- Turbulence
- Atmospheric Stability
- Mixing height
- Impact on dispersion and transport

16:30 – 17:00 coffee break

17:00 **Application example: AQ monitoring around Heathrow airport**, R. Jones, U Cambridge

- Background and motivation
- Sensor nodes and installation
- Data processing and in-network calibration
- Results and lessons learned

UNIVERSITY OF CAMBRIDGE

End approx. 18:00

19:00 dinner and get-together: **Restaurant Nimb** *(in amusement park Tivoli, http://www.nimb.dk/en)*

Day 2 – Wednesday, Feb. 22, 2017

9:00 **Gas sensor function principles**, A. Schütze

- IR absorption
- Electrochemical cells
- Semiconductor gas sensors (metal oxide and conducting polymer sensors)
- Field effect devices
- Mass sensitive devices (bulk and surface acoustic wave)
- Examples from nanotechnology and materials development

10:00 **Gas sensor characterization and calibration**, A. Schütze

- The 3S: Sensitivity, Selectivity and Stability
- Influence of ambient conditions
- Sensor drift, aging and poisoning
- Gas mixing systems and field calibration

10:30 – 11:00 coffee break

11:00 **Microsensor developments for particulate matter**, A. Massling, ENVS, AU

- Physical parameters of particulate matter with health relevance (Particle number, Ultrafine Particle number, Particle Mass, Particle surface area)
- Current knowledge on health relevance of these parameters
- Newest developments of miniature versions of particle sensors
- Expected future needs and importance of such developments

12:00 **Sensor network deployment**, A. Schütze

- Fixed monitoring stations
- Mobile monitoring stations (on trams, buses, cars)
- Personal mobile monitoring systems
- Sensors on drones

Lunch break (approx. 12.30 – 13.30)

13:30 **Multi-sensor systems (aka „electronic noses“)**, A. Schütze

- Motivation for multi-sensor systems
- Basic concepts and typical solutions
- Advantages and drawbacks of multi-sensor systems
- „Virtual multi-sensors“: obtaining multi-dimensional data from a single sensor element
- Multi-sensor signal processing and data fusion
- Application examples: quantitative ozone measurement, odour assessment

15:00 – 15:30 coffee break

15:30 **Application example: Outdoor odour nuisance monitoring,** W. Reimringer, 3S

- Background and motivation
- Sensor nodes
- Sensor installation
- Citizen network as odour reference
- Results and lessons learned

16:15 **Gas sensors in your smartphone: potential applications**, A. Schütze, K. Karatzas

- Gas sensor technologies for integration in smartphones
- Breath alcohol monitoring
- Indoor Air Quality (tVOC)
- Personal fire alarm
- Further application potential and service deployment

18:30 – 21:00 finger food dinner and hands-on examples for low-cost sensor platforms

Day 3 – Thursday, Feb. 23, 2017

9:00 **Air pollution modelling**, O. Hertel, K. Karatzas

- Plume models, urban scale and CFD
- Street pollution modelling and human exposure assessment
- Hot spots, indoor and outdoor exposure patterns
- Examples of refined AQ level estimation based on data fusion and AQ modelling
- Regional scale to long-range transport air pollution modelling – processes, methodologies, examples

10:15 – 10:45 coffee break

10:45 **Data-oriented analysis and modelling for air quality control**, K. Karatzas

- Introduction to data analysis (descriptive statistics, trend analysis)
- Multivariate correlation analysis
- Periodicity identification based on FFT
- Computational intelligence methods (Artificial Neural Networks for modelling, Self Organizing Maps for data investigations and profiling)
- Examples of sensor data analysis (the Aveiro experiment, mobile phone sensor data analysis)

11:30 **From AQ data to personalized Quality of Life information services**, K. Karatzas

- Using low-cost monitoring networks for personalized information
- Design principles of EI services for mobile devices
- Examples for Quality-of-Life services: green routes through cities
- Synergies with personal health monitoring sensors
- The business perspective

12:30 – 13:00 coffee break

13:00 **Application example: CPH sense: sensing for smart cities**, V. Venkatraman, Leapcraft

- Air quality and its impact on both health and quality of life
- AQ services for both governmental and private stakeholders
- Fully managed IOT cloud service in real time
- Focus: extract insights, provide real-time alerts, recognise patters

13:45 **Wrap-up and final remarks**

- Future trends
- Next steps

14:00 end of the seminar

Registration

I hereby register for the international training course
"Networked Environmental Monitoring – from sensor principles to novel services"

For online registration and payment please go to auws.au.dk/NetMon

Name: _____

Institution: _____

E-mail address: _____

Phone: _____

Mailing address: _____

City incl. postal code: _____

Country: _____

Date, place: _____ Signature: _____

Organisation:

Date and place:
February 21-23, 2017,
Aarhus University, Campus Emdrup, Tuborgvej 164, 2400 Copenhagen North-West, Denmark

Organisers:
Aarhus University, in co-operation with AMA Association for Sensors and Measurement

Seminar material:
All participants will receive the course material (presentation slides) plus supporting material in printed and electronic form.

Participation fee:
8.200 DKK covering participation fee, course material, coffee and soft drinks during breaks, lunch and dinner on Feb 21 and 22. Participation is limited to 20 participants.

Invoice:
After registration, participants will receive an invoice and confirmation of their participation. Please note: online registration allows direct payment per credit card.

Cancellation:
… before January 21: 1.100 DKK cancellation fee
… after January 20: 4.100 DKK (50% of participation fee)
… after February 2: no refunds
Replacement by another participant from the same institution is possible.

Please send your registration to:

Fax +45 87 15 50 10
E-mail: mu@envs.au.dk

Department of Environmental Science
Aarhus University
P.O. Box 358
Frederiksborgvej 399
DK-4000 Roskilde
Denmark