The challenges and prospects of water management in Europe and India

Université Gustave Eiffel & online

July 4th, 2023, 14:00 – 16:00 CEST

Description

This is an EU-India scientific workshop, featured as a side event to the LOTUS project's last general assembly in Europe. LOTUS is co-funded by the European Commission under the Horizon 2020 research and innovation programme under Grant Agreement N° 820881 and by the Indian Government, Ministry of Science and Technology. https://www.lotus-india.eu/
The workshop addresses challenges and prospects related to water processing and water quality in Europe and India. The international speakers are members of LOTUS consortium but will share results with a broader scope.

The workshop is organized and chaired by
Bérengère Lebental, Dr
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Université Gustave Eiffel

IEEE Sensors Council FRANCE CHAPTER

Program (see details and abstract on page 4)

July 4th, 14:00 CEST
Modifier Adaptation – using measurements to optimize with imperfect models
Sebastian Engell
Prof. Dr.-Ing.
Process Dynamics and Operations Group
Biochemical and Chemical Engineering Department
TU Dortmund, Germany
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July 4th, 14:30 CEST
Recovering electrical energy from forward osmosis process
Senthilmurugan Subbiah
Professor and Chairperson of the IITG - Technology Incubation Centre (IITG- TIC)
Department of Chemical Engineering
Indian Institute of Technology Guwahati , Assam, INDIA
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July 4th, 15h00
Affordable device for seawater analysis
Franck Le Gall
CEO
EGM, Valbonne, France
https://www.egm.io/
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July 4th, 15h30
Assessing the Effectiveness of a Low-Cost Multiparametric Sensor for Real-Time Water Quality Monitoring in a Controlled Lab-Scale Water Distribution Network
Balakumara Vignesh M
Indian Institute of Technology Guwahati, Department of Chemistry, Assam, India
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Localization:
Université Gustave Eiffel
Bâtiment Bienvenue, Room A14
14-20 boulevard Newton
77447 Marne La Vallée Cedex 2
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Remote connection:

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Modifier Adaptation – using measurements to optimize with imperfect models

Sebastian Engell, Systems Dynamics and Operations Group, TU Dortmund, Germany

In the process industries and in many other areas, a standard problem is to optimize the stationary (steady-state) operation of a system, i.e. to choose the operational degrees of freedom to maximize or minimize a cost function, e.g. the revenue or the CO2-footprint.

If this optimization is not done by trial and error, mathematical models of the system have to be employed. In what is called real-time optimization (RTO) in the process industries, these models usually are more or less complex nonlinear models that are derived from energy and mass balances, and include thermodynamic, kinetic and heat and mass transfer models. On the basis of such models, advanced optimization algorithms that use first and second order information can be used to compute the optimal operational degrees of freedom. However, there inevitably is a discrepancy between the predictions by the model and the behavior of the real system. One option to deal with this situation is to periodically re-estimate some of the model parameters and to update the model accordingly. Another option is called *modifier adaptation*: Based on the observed behavior of the system, correction terms for the optimization problem are estimated which correct the bias and the gradients of the model. If the gradients are estimated correctly, an iteration of collection of measurements, updating the modifiers, solving the optimization problem and applying the result will converge to the optimum of the real system despite the fact that the model is not predicting its behavior correctly.

In the talk, the general idea of modifier adaptation will be presented together with a technique to estimate the gradients from real-time information which is the most critical step. The successful application of the approach will be demonstrated by examples.

Prof. Dr. Sebastian Engell received a Dipl.-Ing degree in Electrical Engineering from Ruhr-Universität Bochum, Germany in 1978 and the Dr.-Ing. Degree and the venia legendi in Automatic Control from Universität Duisburg in 1981 and 1987. 1984/1985 he spent a year as a PostDoc at McGill University, Montréal, Canada. 1986-1990 he was the head of an R&D group at the Fraunhofer Institut IITB in Karlsruhe, Germany. 1990 he was appointed as a Full Professor of Process Dynamics and Operations in the Department of Chemical Engineering at TU Dortmund. 2008 he was a Distinguished Visiting Professor at Carnegie Mellon University, Pittsburgh, USA. He was Department Chairman 1996-1999 and 2012-2014 and Vice-Rector for Research and International Relations of TU Dortmund 2002-2006.

Dr. Engell is an IFAC Fellow since 2006 received best paper awards of leading journals as well as an ERC Advanced Investigator Grant in 2011. He received the Arnold Eucken Medal from the German Association for Process Engineering in 2021. He has graduated 85 PhD students at TU Dortmund. Currently he serves as the Chair of the Advisory and Programming Group of ASPIRE, the association that represents the private sector in the PPP Processes4Planet with the European Commission.

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Recovering electrical energy from forward osmosis process

Senthilmurugan Subbiah

Forward osmosis (FO) is a promising technology for energy-efficient water treatment but suffers from the drawback of reverse solute flux which often results in energy loss. Recent research has been directed toward reducing energy consumption and improving efficiency in the FO process. However, there remains a significant gap in utilization the inevitable reverse solute flux. Our study introduces an innovative approach to minimize energy consumption by transforming this reverse solute flux into sustainable electricity. Here, we fabricated membranes using two-dimensional flakes of vanadium pentoxide (VO) and reduced graphene oxide (r-GO) and cross-linked with amorphous silicon oxide (aSiO). The optimized VO-aSiO-rGO membrane showcases a remarkable ability to recover nearly 26% of the power applied for liquid pumping, exhibiting a significant advancement in the FO process. The membrane also outperforms commercial CTA-based FO membranes by achieving superior water fluxes (~45 L/m2.h) and low specific reverse salt fluxes (SRSF) (~0.13 g/L), indicating its superior separation efficiency for concentration applications. Moreover, the VO-aSiO-rGO membrane demonstrated stable performance with a water flux of 28.5 L/m2.h over 40 h of continuous operation. Additionally, it successfully generated output voltage and current values up to 293 mV and 32.2 µA, respectively, with a 106 fold salinity gradient, leading to a power density of ~ 4.72 W.m−2. The study also explored energy-recovering possibilities and crystal production in realistic scenarios using different concentrations of tea as the feed solutions. The results of this work not only address the critical gap in the efficient use of energy in the FO process but also provide a significant breakthrough towards sustainable and efficient water treatment technologies with integrated energy recovery systems.

Senthilmurugan Subbiah obtained his Bachelor of Engineering (B.E.) degree in Chemical Engineering from Bharathiar University, Coimbatore, India and Master of Technology (M.Tech.) degree in Process Engineering and Design with a minor in Chemical Engineering from Indian Institute of Technology Delhi, India, where he also completed his Ph.D. in Membrane Science and Engineering with a minor in Chemical Engineering. Currently, he serves as a Professor in the Department of Chemical Engineering at Indian Institute of Technology Guwahati, India. His research interests focuses on water and energy management, including modeling and optimization, process design and operation of membrane separation processes, waste and wastewater treatment (WWWT) for process industries, water management for oil and gas upstream, smart water grid, waste-to-energy technologies, and novel desalination technologies. Throughout his career, he has made significant contributions to his field, with 31 patent applications, 4 granted US patents, 71 journal publications, 5 book chapters, 2 industrial magazine articles, and 32 conference papers to his name.

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Affordable device for seawater analysis

Franck Le Gall

Investigations toward affordable spectrometric-based nutrient analysis and Phytoplankton imagery to detect harmful bloom in sea water.

Franck Le Gall is CEO at EGM, an innovative SME focused on integration and validation of emerging technologies. He is driving company development from IoT sensors development up to development and application of data platforms in vertical domains. Previously, he has participated in large R&D projects within the big industry (Orange, Alcatel, Thomson) and spent 9 years as Director within an innovation management company. He directed more than 10 large scale projects and studies related to the evaluation and monitoring of innovation and technical programs as well as research projects. He is now participating in several EU research projects in domains such as water management, cities, aquaculture and agriculture providing technical knowledge on the whole sensors to applications data chain. He has authored many scientific papers as well as patents. He is chairman of the ETSI ISC-CIM standardization committee, chairman of the FIWARE-ETSI digital twins working group, elected member of the FIWARE technical steering committee.

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Assessing the Effectiveness of a Low-Cost Multiparametric Sensor for Real-Time Water Quality Monitoring in a Controlled Lab-Scale Water Distribution Network

Balakumara Vignesh M

Ensuring access to good quality water is crucial for sustainable development, particularly in developing nations. However, the lack of affordable and reliable solutions for monitoring water quality remains a significant challenge. This study focuses on addressing this issue through the LOTUS project (https://www.lotus-india.eu/), which introduces a low-cost, compact, and versatile multiparametric chemical sensor for real-time monitoring of chlorine, pH, temperature, and conductivity in potable water. The proposed solution features a tube-like structure, measuring 21 cm in length and 3.5 cm in diameter. It comprises a replaceable sensor head that integrates temperature sensors, conductivity sensors, and a sensor array of multi-walled carbon nanotube (CNT) chemistors. These CNT chemistors, arranged in random networks between interdigitated electrodes, can be non-functionalized or functionalized with a dedicated polymer [1].

To evaluate its performance, seven units of the LOTUS sensor were tested in the Sense-city facility (located at Université Gustave Eiffel, France - https://sense-city.ifsttar.fr/), a 44m water loop. Operating conditions included a flow rate of 25 m3/h, pressure of 1 bar, and temperature ranging between 15°C and 20°C, with variations in conductivity (870 µS/cm to 1270 µS/cm) and chlorine levels (0 to 5 mg/L). However, due to high levels of electromagnetic interferences and limited shielding, the sensor signals were noisy, requiring denoising techniques for analysis. Results showed that the CNT-based chemistors exhibited sensitivity to pH and active chlorine (HClO) with distinguishable responses between functionalized and non-functionalized devices. However, due to the high noise level, the estimation of pH and chlorine had mean absolute errors (MAE) of 0.12 and 0.13 mg/L, respectively. The real-time water temperature estimation achieved a MAE of 0.2°C in flowing water and 0.1°C in static water, based on data obtained from chip 141. Chip AS001 demonstrated a MAE of 73.2 µS/cm for conductivity variations over 80 hours. Overall, these preliminary results demonstrate the proof of operation of the LOTUS sensor in a realistic environment, albeit with limitations imposed by the high noise level. Future work aims to design a new version of the system to mitigate noise interferences and conduct further testing in the Sense-city facility in 2023.

[1] Cousin, P. et al. (2022). Improving Water Quality and Security with Advanced Sensors and Indirect Water Sensing Methods. Springer Water. https://doi.org/10.1007/978-3-031-08262-7_11

Balakumara Vignesh received his Bachelor of Engineering degree in Electronics and Instrumentation engineering from National Engineering College, Tamil Nadu, India. He joined Indian Institute of Technology Guwahati, India as a PhD student in 2019 and his thesis focuses on Multiparametric CNT based sensors for water quality monitoring with the framework of the LOTUS project. As part his PhD, he is currently working in Laboratoire Instrumentation, Modélisation, Simulation et Expérimentation (IMSE) at Université Gustave Eiffel, France.

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