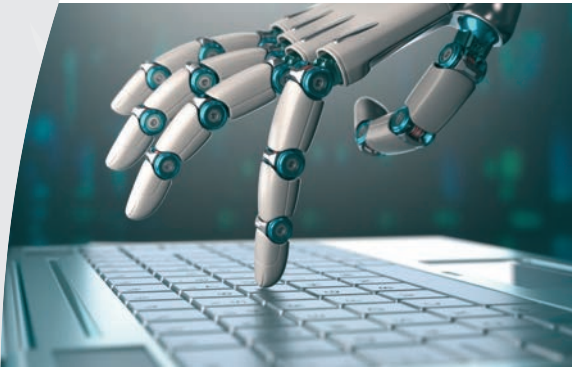




INSTITUT DE FRANCE  
Académie des sciences



Leopoldina  
Nationale Akademie  
der Wissenschaften



## Robotics AI Data Science versus Motion Intelligence

Wednesday September 5, 2018

from 8:45 am to 5:30 pm

Fondation Simone et Cino Del Duca

10, rue Alfred de Vigny, 75006 Paris

*Académie des sciences and Nationale Akademie der  
Wissenschaften Leopoldina*

Robotics and artificial intelligence (AI) are rapidly transitioning from research labs to the real world with unprecedented effects on society. The symposium aims at exploring how recent trends in AI may reinforce the historical links between Robotics and AI. Beyond the classical approaches in decision making and reasoning, the current success of AI in data science-oriented applications (with impressive progress in many domains related to ICT, e.g. image processing, natural language, medicine, etc.) have the potential to renew the way to design and program robots able to face the complexity of the physical world.

Quoting recent Villani's report on AI<sup>1</sup> : "Although robotics and AI go hand-in-hand in the collective imagination, the two fields are yet to truly converge. Many robotics applications are not within the purview of AI and vice-versa. There is, however, a whole field of exploration ready and waiting, and in which Europe has everything necessary to play a leading role. [...] Development may take place on a Franco-German axis complemented by a partnership with Italy, which has a great deal to offer". The objective of the symposium is to strengthen the cooperation between France and Germany in Robotics AI. The symposium is organized around talks by distinguished researchers and a panel aiming at defining a joint French-German strategy in research development.

<sup>1</sup> [https://www.aiforhumanity.fr/pdfs/MissionVillani\\_Report\\_ENG-VF.pdf](https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf)

# The organizers



## Jean-Paul LAUMOND

*Directeur de recherche, Laboratoire d'analyse et d'architecture des systèmes (CNRS-LAAS) and Académie des sciences*

Jean-Paul Laumond is a roboticist. His research is robot motion planning and control. In 2001 and 2002 he created and managed Kineo CAM, a spin-off company from LAAS-CNRS devoted to develop and market motion planning technology. Siemens acquired Kineo CAM in 2012. In 2006, he launched the research team Gepetto dedicated to Human Motion studies along three perspectives: artificial motion for humanoid robots, virtual motion for digital actors and mannequins, and natural motions of human beings. He has published more than 150 papers in international journals and conferences in Robotics, Computer Science, Automatic Control and Neurosciences. His current project Actanthrope (ERC-ADG 340050) is devoted to the computational foundations of anthropomorphic action. He teaches Robotics at *École normale supérieure* in Paris. He is an Institute of electrical and electronics engineers (IEEE) Fellow. He has been the 2011-2012 recipient of the *Chaire Innovation technologique Liliane Bettencourt* at *Collège de France* in Paris. He is the 2016 recipient of the IEEE Inaba Technical Award for Innovation Leading to Production. He is a member of the French Academy of Technologies and of the French *Académie des sciences*.



## Tamim ASFOUR

*Professor, Institute for Anthropomatics and Robotics, High Performance Humanoid Technologies, Karlsruhe Institute of Technology*

Tamim Asfour is full Professor of Humanoid Robotics at the Institute for Anthropomatics at KIT. His research focuses on the engineering of high performance 24/7 humanoid robotics as well as on the mechano-informatics of humanoids as the synergistic integration of mechatronics, informatics and artificial intelligence methods into humanoid robot systems, which are able to predict, act and interact in the real world. Tamim is the developer of the ARMAR humanoid robot family. He is the Founding Editor-in-Chief of the IEEE-RAS Humanoids Conference Editorial Board, president of the Executive Board of the German Robotics Society (DGR) and scientific spokesperson of the KIT Center "Information · Systems · Technologies (KCIST)". In his research, he is reaching out and connecting to neighboring areas in large-scale national and European interdisciplinary projects in the area of robotics in combination with machine learning and computer vision.



## **Sébastien CANDEL**

President, *Académie des sciences*

Sébastien Candé is an Emeritus Professor at *CentraleSupélec*, University Paris-Saclay and an Honorary Professor at *Institut universitaire de France*. He obtained an engineering degree from *École Centrale Paris* (now *CentraleSupélec*), a PhD from the California Institute of Technology and a Science Doctorate from *université Pierre-et-Marie-Curie*. His research in the domains of combustion and aeroacoustics, has applications in energy and in aerospace propulsion. Among many distinctions, Sébastien Candé has been the recipient of the silver medal of *CNRS*, the Marcel Dassault Grand Prize of *Académie des sciences*, the Distinguished Alumni Award of the California Institute of Technology, the Silver and Gold medals both from the Combustion Institute. He is currently chairing the scientific council of EDF and the launchers research and technology evaluation committee of *CNES* (the French Space Research Center).



## **Jörg HACKER**

President, *Nationale Akademie der Wissenschaften Leopoldina*

Jörg Hacker is a microbiologist. His research focused on the molecular analysis of pathogenic bacteria and host-microbe interaction. Since 1980, he worked at the Department of Microbiology at the University of Würzburg, where he was promoted to Professor in 1986. Since 1993, he led the Würzburg Institute for Molecular Infection Biology. He was Vice President of the German Research Foundation (DFG) and President of the Robert Koch Institute. Since 2010, Hacker has been President of the German National Academy of Sciences Leopoldina. He received numerous awards and became a member in various national and international academies, scientific societies and committees. From 2014 until 2016, he was a member of the Scientific Advisory Board set up by the UN Secretary-General Ban-Ki Moon.



# Program

- 08:45**      **Welcome coffee**
- 09:00**      **Welcome Addresses**  
**Sébastien CANDEL**, President, *Académie des sciences*  
**Jörg HACKER**, President, *Nationale Akademie der Wissenschaften Leopoldina*
- 09:10**      **Opening Addresses**  
**Philippe BAPTISTE**, Chief of Staff, Ministry of higher Education, Research and Innovation, France  
**Herbert ZEISEL**, Head of directorate, Federal Ministry of Education and Research, Germany
- 09:30**      **Program presentation**  
**Tamim ASFOUR**, Professor, Institute for Anthropomatics and Robotics, High Performance Humanoid Technologies, Karlsruhe Institute of Technology  
**Jean-Paul LAUMOND**, *directeur de recherche, Laboratoire d'analyse et d'architecture des systèmes (CNRS-LAAS) and Académie des sciences*
- 09:35**      **Keynote : Where Mind and Matter meet**  
**Alexander WAIBEL**, Professor, Interactive Systems Labs, Karlsruhe Institute of Technology
- 10:00**      **Robotics as the path to Artificial Intelligence**  
**Oliver BROCK**, Professor, *Technische Universität Berlin*
- 10:15**      **Towards a science of motion**  
**Nicolas MANSARD**, *directeur de recherche, Laboratoire d'analyse et d'architecture des systèmes (CNRS-LAAS)*
- 10:30**      Coffee Break
- 10:50**      **Machine Intelligence: bridging the gap between robotics and AI**  
**Sami HADDADIN**, Director, Munich School of Robotics and Machine Intelligence (MSRM), Technical University of Munich
- 11:05**      **Micro-data: the challenge of robot learning**  
**Jean-Baptiste MOURET**, *directeur de recherche, Institut national de recherche en informatique et en automatique (Inria)*
- 11:20**      **Motor learning the key to (motion) intelligence**  
**Jan PETERS**, Professor, Technische Universität Darmstadt
- 11:35**      **Robotics: the embodied physical intelligence**  
**Jean-Paul LAUMOND**, *directeur de recherche, Laboratoire d'analyse et d'architecture des systèmes (CNRS-LAAS) and Académie des sciences*
- 11:50**      **Everyday activity and science engineering (EASE)**  
**Michael BEETZ**, Professor, University Bremen

- 12:05**      **Robotics and AI: the early divorce and remarriage shades**  
**Abderrahman KHEDDAR**, *directeur de recherche, Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM) and Academie des technologies*
- 12:20**      Lunch at the *Fondation Del Duca*
- 13:35**      **Keynote: From vision and robotics to Artificial Intelligence**  
**Jean-Paul PONCE**, *directeur de recherche, Institut national de recherche en informatique et en automatique (Inria)*
- 14:00**      **A human-centric perspective on robotics and Artificial Intelligence**  
**Alin ALBU-SCHÄFFER**, *Director of the Institute of Robotics and Mechatronics, DLR, German Aerospace Center, Head of the Department of Computer Science, Technical University Munich*
- 14:15**      **Acquisition and Grounding of Robot Knowledge Through Interaction with the Physical World**  
**Raja CHATILA**, *Professor, Sorbonne Université, Director of the Institute of Intelligent Systems and Robotics*
- 14:30**      **Robotics for a human future**  
**Helge RITTER**, *Professor, Universität Bielefeld*
- 14:45**      **Medical Robotics and machine learning**  
**Michel DE MATHELIN**, *Icube, Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie, université de Strasbourg*
- 15:00**      **Robotics AI: cognitive abilities for intelligent bodies**  
**Tamim ASFOUR**, *Professor, Institute for Anthropomatics and Robotics, High Performance Humanoid Technologies, Karlsruhe Institute of Technology*
- 15:15**      **Multidisciplinary research challenges for the progress of robotics**  
**Cecilia LASCHI**, *Professor, The BioRobotics Institute, Scuola Superiore Sant'Anna*
- 15:30**      Coffee Break
- 15:50**      **Lessons learned, new horizons and impact on societal challenges in Europe**  
**Sigmar WITTIG**, *Executive Board, Nationale Akademie der Wissenschaften, Leopoldina*
- 16:00**      **Addresses from French and German Ministry and Institutions representatives**  
**Patrick GARDA**, *Director, STIC, Ministry of higher Education, Research and innovation, France*  
**Jean-Frédéric GERBEAU**, *General Director delegated to science, Inria, France*  
**Chantal KHAN-MALEK**, *Deputy Director, Europe Director for research and international cooperation, CNRS, France*  
**Herbert ZEISEL**, *Head of directorate, Federal Ministry of Education and Research, Germany*
- 16:30**      Panel discussion: working group launching
- 17:30**      End

# Abstracts and biographies

## Philippe BAPTISTE

Chief of Staff, Ministry of higher Education, Research and Innovation, France

Philippe Baptiste is the chief of Staff of the ministry for higher education, research and innovation, France.

Philippe Baptiste began his career at the French National Center for Scientific Research (CNRS) in 1999 as a computer scientist. He then joined IBM's research team in New York, where he stayed from 2000 to 2001, and lectured at Ecole Polytechnique in France, from 2002 until 2011. Mr. Baptiste became director of the computer science laboratory of Ecole Polytechnique in 2008, he was then appointed director of the CNRS Institute for Information Sciences and Technology in 2010 and became the Chief Research Officer at the CNRS in 2014. In 2016 he became Senior Vice President, Scientific Development at Total and was the first CTO of the Group.

Mr. Baptiste has published a number of books and several hundred papers and articles, of which 40 have appeared in international journals. His research interest range from theoretical computer science to operations research, business analytics and AI. He has led many R&D projects with software developers and industry-leading manufacturers.



## Herbert ZEISEL

Head of directorate, Federal Ministry of Education and Research, Germany

Dr Herbert Zeisel is Deputy Director General “Key Technologies for Growth” at the Federal Ministry of Education and Research (BMBF). He received his diploma and PhD from the Friedrich-Alexander-University in Erlangen-Nuremberg as Chemical-Engineer. In 1988, he joined the “Federal Ministry for Research and Technology” (BMFT, later BMBF) acting as Research-Manager in different ICT-Areas. From 2002 to 2010 he was the Coordinating Director of the “DLR-Projektträger” in the field of “Information and Communication Technologies” (ICT) at the German Aerospace Agency (DLR). In addition, he represented Germany as head of delegation in several European and international committees. From 2012 to 2014 Dr Zeisel headed the division for Nanotechnology, New Materials and Batteries at the BMBF and acted as member of the Board of Trustees of 10 German Research Centers.





## Alexander WAIBEL

Professor, Interactive Systems Labs, Karlsruhe Institute of Technology

Alexander Waibel is Professor of Computer Science at Carnegie Mellon University (USA) and at the Karlsruhe Institute of Technology (Germany). He is director of the International Center for Advanced Communication Technologies. Alexander Waibel is internationally known for his work on AI, Machine Learning, Multimodal Interfaces and Speech Translation Systems. He and his team developed the TDNN, the first shift-invariant “Convolutional” Neural Network, early multimodal interfaces and the first deployed speech translation and interpreting systems. Waibel is a member of the *Nationale Akademie der Wissenschaften Leopoldina* and a Fellow of the IEEE. He received BS, MS and PhD degrees from MIT and CMU, respectively.

## Where Mind and Matter meet

AI as a science has devoted much effort to exploring tasks that we as humans find difficult. With each new discovery and new paradigm that extends our frontiers, however, we discover that it is the seemingly simpler tasks that turn out to require the most in intelligence, creativity and abstraction. Based on a historic and personal perspective on AI’s progress so far, I will discuss today’s exciting advances, but also characterize the remaining (overlooked) problems for a next generation Robotic AI. We will also examine structural requirements needed to be successful in this new industrial revolution. Is Europe suitably positioned to lead the charge? Like our notions of “intelligence”, our definitions of societal structures and recipes to respond should be carefully reexamined and thoughtfully revised.



## Oliver BROCK

Professor, Technische Universität Berlin

Oliver Brock is the Alexander-von-Humboldt Professor of Robotics at the *Technische Universität Berlin*. He received his Ph.D. from Stanford University in 2000. He held post-doctoral positions at Rice University and Stanford University. Starting in 2002, he was an Assistant and then Associate Professor at the University of Massachusetts Amherst, before moving back to the *Technische Universität Berlin* in 2009. His research focuses on manipulation, perception, soft robotics, interactive machine learning, deep learning, and motion generation. He is an IEEE Fellow and president of the Robotics: Science and Systems foundation.

## Robotics as the path to Artificial Intelligence

The historical promise of robotics is to produce technological artifacts with human-like abilities. This includes physical abilities, such as locomotion and dexterity, but also intellectual abilities, including reasoning and learning, and even social skills for collaboration and training. These abilities, taken together, constitute what we refer to as intelligence. I will discuss the role of robotics in understanding and replicating these abilities. Building on recent scientific progress, e.g. soft robotics and deep learning. I will sketch a path – fundamentally enabled by robotics – towards an understanding of intelligence, which will enable a future generation of machines with human-like abilities.



## Nicolas MANSARD

*Directeur de recherche, Laboratoire d'analyse et d'architecture des systèmes  
(CNRS-LAAS)*

Nicolas Mansard is a roboticist, directeur de recherche CNRS at LAAS in Toulouse. His research activities lie at the intersection of the fields of robotics, automatic control, signal processing and numerical mathematics. They deal with sensor-based control, and more specifically the integration of sensor-based schemes into humanoid robot applications. He received the 2015 CNRS Bronze Medal. His project ANR Entracte received the Grand Prix de l'ANR in 2016.



## Towards a science of motion

The theory and methods behind machine learning are now converging to a whole scientific corpus: the science of data. Following a similar naming, roboticists are promoting a science of movement. Indeed, in order to move, a robot must solve at each new control cycle a problem composed of several thousand of variables; this problem may, or may not, be explicitly set up. Robotics research aims at understanding how to artificially reproduce the processes that the biological brain uses to solve these problems which such a natural easiness. For all that, should robotics be reduced to one of the many problems of artificial intelligence? We would rather claim that only some of the tools used by these researchers belong to AI. In this presentation, we will show why the tools that we are developing at LAAS are different from the data-based approaches; how these tools take inspiration from the science of data; and how much we are expecting from stronger collaborations in this field.

## Sami HADDADIN

*Director, Munich School of Robotics and Machine Intelligence(MSRM),  
Technical University of Munich*

Sami Haddadin is the Founding Director of the Munich School of Robotics and Machine Intelligence (MSRM) at Technical University of Munich (TUM) and holds the Chair of Robotics Science and Systems Intelligence. His research interests include intelligent robot design, robot learning, collective intelligence, human-robot interaction, nonlinear control, real-time planning, optimal control, human neuromechanics and robot safety. His work has found its way into numerous commercial robotics and AI products. The engineer and computer scientist has written more than 130 scientific articles and received numerous prestigious international scientific awards. Among others, he received the IEEE/RAS Early Career Award, the Alfred Krupp Award and the German Future Prize of the German President.



## Machine Intelligence: bridging the gap between robotics and AI

Important breakthroughs in robotics and artificial intelligence have enabled the first real-world applications of flexible, human-centered robot systems. Controlled by intelligent programming and interaction systems that "understand" man and machine, even laymen can use state-of-the-art robot technology for the first time. Their commercial introduction represents a step change in the way intelligent machines meet human needs beyond the industrial sector, e.g. also in the healthcare or private sector. In other words, they become everyday intelligent helpers in a wide variety of applications to make our lives easier. However, several grand challenges remain to be solved before unifying the fields of robotics and artificial intelligence to machine intelligence. First, the technological limits of sensory-motor and holistic system design need to be pushed significantly further in order to come closer to the unmatched performance and embodied intelligence of the human body. Second, we face the challenge of unifying the two previously separate paradigms of model-based control with data-driven machine learning algorithms such that next generation AI-algorithms seamlessly bridge the gap between physical and virtual world.



## Jean-Baptiste MOURET

*Directeur de recherche, Institut national de recherche en informatique et en automatique (Inria)*

Jean-Baptiste Mouret is a senior researcher (*Directeur de recherche*) at Inria, the French research institute dedicated to computer science and mathematics. He is currently the principal investigator of an ERC grant (ResiBots – Robots with animal-like resilience, 2015-2020). From 2009 to 2015, he was an assistant professor (*maître de conférences*) at Pierre and Marie Curie University (Paris, France). Overall, J.-B. Mouret conducts researches that intertwine machine learning and evolutionary computation to make robots that can adapt in a few minutes. His work was recently featured on the cover of *Nature* (Robots that adapt like animals, Cully et al., 2015) and it received several national and international scientific awards, including the *Prix La Recherche 2016* and the Distinguished Young Investigator in Artificial Life 2017.

### Micro-data: the challenge of robot learning

A large part of the impressive results achieved with modern machine learning (in particular, by deep learning) are made possible by the use of very large datasets. However, robots have to face the real world, in which trying something might take seconds, hours, or days. And seeing the consequence of this trial might take much more. In spite of these constraints, robots are expected to adapt like humans or animals, that is, in only a handful of trials: we refer to this challenge as « micro-data learning ». In this talk, I will describe our ongoing efforts to design micro-data learning algorithms that allow robots to discover new behaviors by trial-and-error in a few minutes (a dozen of trials), and I will highlight how such algorithms make it possible for robots to recover from unforeseen damage (e.g., learning to walk with a broken leg) without requiring a diagnosis. Overall, this talk will give an overview of what kind of prior knowledge and machine learning models can be leveraged for micro-data learning in robotics.



## Jan PETERS

*Professor, Technische Universität Darmstadt*

Jan Peters is a full professor (W3) for Intelligent Autonomous Systems at *Technische Universität Darmstadt* and a senior research scientist at the Max-Planck Institute for Intelligent Systems, where he heads the Robot Learning Group. Jan Peters has received the Dick Volz Best 2007 US PhD Thesis Runner-Up Award, the Robotics: Science & Systems - Early Career Spotlight, the INNS Young Investigator Award, the IEEE Robotics & Automation Society's Early Career Award and an ERC Starting Grant. He holds four Master's degrees in Computer Science, Electrical, Mechanical and Control Engineering from University of Southern California (USC), TU München and FernUni Hagen as well as a PhD from USC.

### Motor learning the key to (motion) intelligence

Artificial intelligence has been a vision of computer science, robotics, and cognitive science since the 1950s with learning at the core of intelligent systems. Due to the current abundance of data and computation, supervised learning techniques has taken over complete fields (web search, computer vision, natural language, customer analysis and prediction). While the impressive recent deep learning applications have led to the wide-spread belief that artificial intelligence is just around the corner, nothing could be further from the truth. Unlike such glorified curve fitting on huge data sets, an intelligent learning system has to interact with the world and learn online in real-time based on the outcomes of its own actions – similar to humans. No robot system to date can accomplish this goal. Instead, motion learning as essence of motion intelligence is key to any truly intelligent autonomous system.

## Jean-Paul LAUMOND

*Directeur de recherche, Laboratoire d'analyse et d'architecture des systèmes (CNRS-LAAS) and Académie des sciences*

Jean-Paul Laumond is a roboticist. His research is robot motion planning and control. In 2001 and 2002 he created and managed Kineo CAM, a spin-off company from LAAS-CNRS devoted to develop and market motion planning technology. Siemens acquired Kineo CAM in 2012. In 2006, he launched the research team Gepetto dedicated to Human Motion studies along three perspectives: artificial motion for humanoid robots, virtual motion for digital actors and mannequins, and natural motions of human beings. He has published more than 150 papers in international journals and conferences in Robotics, Computer Science, Automatic Control and Neurosciences. His current project Actanthrope (ERC-ADG 340050) is devoted to the computational foundations of anthropomorphic action. He is a member of the French Academy of Technologies and of the French *Académie des sciences*.



## Robotics: the embodied physical intelligence

Robots are moving machines that are subject to the laws of physics. This statement may appear obvious. However, its consequences for research organization are underestimated. Robotics research requires to explore the computational foundations of the relationship between the machine and its environment. The expected actions a robot has to perform are expressed in the physical world. Robots — like any living being — access the physical space through its body space made of its sensory space and its motor space. The degree of autonomy of the machine depends on its ability to translate the action expressed in the physical space into its sensory-motor space. Regardless of the type of approach — model-based or model-free — research assessment must be based on real physical platforms. Managing such platforms requires a level of man-power, which is most of the time out of reach of public research teams. In this presentation we will argue in favor of a public research organisation built on investments that allow to gather technicians, engineers and researchers around a single platform. Public institutions should be convinced that the level of investment in this area has to be far greater than the efforts required by the development of the research in AI. Promoting such physical platforms is a condition of success for French-German collaborations in Robotics.

## Michael BEETZ

*Professor, University Bremen*

Michael Beetz is a professor for Computer Science at the Faculty for Mathematics & Informatics of the University Bremen and head of the Institute for Artificial Intelligence (IAI). IAI investigates AI-based control methods for robotic agents, with a focus on human-scale everyday manipulation tasks. With openEASE, a web-based knowledge service providing robot and human activity data, Michael Beetz aims at improving interoperability in robotics and lowering the barriers for robot programming. Michael Beetz received his diploma degree in Computer Science with distinction from the University of Kaiserslautern. His MSc, MPhil, and PhD degrees were awarded by Yale University in 1993, 1994, and 1996 and his *Venia Legendi* from the University of Bonn in 2000. From 2006 to 2011 Michael Beetz was vice-coordinator of the German excellence cluster CoTeSys (Cognition for Technical Systems), from 2012 to 2016 coordinator of the European FP7 research project RoboHow (Web-enabled and Experiment-based Cognitive Robots that learn complex Everyday Manipulation Tasks) and since 2017 coordinator of the German Collaborative Research Centre EASE (Everyday Activity, Science and Engineering). His research interests include plan-based control of robotic agents, knowledge processing and representation for robots, integrated robot learning, and cognitive perception.



## Everyday activity and science engineering (EASE)

Recently we have witnessed the first robotic agents performing everyday manipulation activities. While these agents successfully accomplish specific instances of these tasks, they only perform them within the narrow range of conditions for which they have been carefully designed. They are still far from achieving the human ability to autonomously perform a wide range of everyday tasks reliably in a wide range of contexts. We propose Everyday Activity Science and Engineering (EASE), a fundamental research endeavour to investigate the cognitive information processing principles employed by humans to master everyday activities and to transfer the obtained insights to models for autonomous control of robotic agents. The aim of EASE is to boost the robustness, efficiency, and flexibility of various information processing subtasks necessary to master everyday activities by uncovering and exploiting the structures within these tasks.



### Abderrahman KHEDDAR

*Directeur de recherche, Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM) and Academie des technologies*

Abderrahmane Kheddar received the BS in Computer Science degree from the Institut National d'Informatique (ESI), Algiers, the MSc and PhD degree in robotics, both from the Pierre-et-Marie-Curie University, Paris. He is presently directeur de recherche at CNRS and the Codirector of the CNRS-AIST Joint Robotic Laboratory (JRL), UMI3218/RL, Tsukuba, Japan. He is also leading the Interactive Digital Humans (IDH) team at CNRS-University of Montpellier LIRMM, France. His research interests include haptics, humanoid and recently thought-based control using brain machine interfaces. He is a founding member of the IEEE/RAS chapter on haptics, the co-chair and founding member of the IEEE/RAS Technical committee on model-based optimization, he is a member of the steering committee of the IEEE Brain Initiative, Editor of the IEEE Transactions on Robotics and within the editorial board of other robotics journals; he is a founding member of the IEEE Transactions on Haptics and served in its editorial board during three years (2007-2010). He is an IEEE senior member and full member of the National Academy of Technology of France and recently knight of the national order of merits of France.

## Robotics and AI: the early divorce and remarriage shades

Recently, the number of papers dealing with learning and AI has substantially increased in major robotics conferences and journals. This evidence shows the renew of the interest of the robotics community to recent developments and trends in AI at large. Nevertheless, this interest is not new. Early developments of AI formerly attempted to solve planning, perception understanding and even control in robotics, without significant breakthroughs. Meanwhile, robotics spread from the automation fields to applications more centered toward human and services where the need of the level of cognition in terms of interactions is high. Recent trends of AI and its application in robotics exhibit the same buzz as twenty years ago. Then, it is legitimate to ask what are the robotic problems we expect to see solved and how? Or, what make recent trends in AI different in essence from years ago. The answer to this question seems to be roughly “data” and “computational power”. Whereas the latter seem to be a plausible perspective, the availability of data in robotics is neither granted nor easy to obtain. We probably need to be able to build a science of “data with robotic motions”. My talk will focus on some ideas and headlines together with experience from settling joint laboratories and collaborations with different foreign institutions and persons from different fields, because this is a critical issue for a tangible success.

## Jean-Paul PONCE

*Directeur de recherche, Institut national de recherche en informatique et en automatique (Inria)*

Jean Ponce is a Research Director at Inria and a Visiting Researcher at the NYU Center for Data Science, on leave from Ecole normale supérieure (ENS)/PSL Research University, where he is a Professor, and served as Director of the Computer Science department from 2011 to 2017. Dr. Ponce graduated in Mathematics from ENS Cachan in 1982. He received his *Doctorat de Troisième cycle* (PhD degree) and his *Doctorat d'État* (Habilitation degree) in Computer Science in 1983 and 1988 from the University of Paris Sud Orsay. Before joining ENS and Inria, Jean Ponce held positions at MIT, Stanford, and the University of Illinois at Urbana-Champaign, where he was a Full Professor until 2005. Jean Ponce's research spans Computer Vision, Machine Learning, and Robotics. He is an IEEE Fellow and a Sr. Member of the Institut Universitaire de France. He served as editor in chief for the International Journal of Computer Vision from 2003 to 2008, and chaired the IEEE Conference on Computer Vision and Pattern Recognition in 1997 and 2000, and the European Conference on Computer Vision in 2008. Jean Ponce is the recipient of two US patents, an ERC Advanced Grant, and the 2016 IEEE CVPR Longuet-Higgins Prize. He is also the author of « Computer Vision: A Modern Approach », a textbook translated in Chinese, Japanese, and Russian, and he is (slowly) writing a new textbook, « Geometric Foundations of Computer Vision ».



## From vision and robotics to Artificial Intelligence

I will discuss the evolution of the artificial intelligence (AI) field, from the mid-80s to today, largely based on my personal perspective on computer vision and robotics research, having lived through both the "winter" of AI and its recent resurgence in a modern form. The latter is due, in large part, to advances in machine learning, but also to key scientific progress in related disciplines such as computer vision, natural language processing, speech understanding and, of course, robotics, as well as an explosion of industrial interest and a new synergy between academic and industrial research. I will argue that robotics (and not just learning-based robotics) has a key role to play in the current AI revolution, and will conclude by discussing some ideas for implementing this vision as we prepare for a new (re) integrated AI.

## Alin ALBU-SCHÄFFER

*Director of the Institute of Robotics and Mechatronics, DLR, German Aerospace Center, Head of the Department of Computer Science, Technical University Munich*

Alin Albu-Schäffer received his M.S. in electrical engineering from the Technical University of Timisoara, Romania in 1993 and his Ph.D. in automatic control from the Technical University of Munich in 2002. Since 2012 he is the head of the Institute of Robotics and Mechatronics at the German Aerospace Center (DLR), which he joined in 1995. Moreover, he is a professor at the Technical University of Munich, holding the Chair for « Sensor Based Robotic Systems and Intelligent Assistance Systems ». His research interests range from robot design and control to robot intelligence and human neuroscience. He is an author of more than 200 peer reviewed journal and conference papers and received several awards, including the IEEE King-Sun Fu Best Paper Award of the Transactions on Robotics in 2012 and 2014.



## A human-centric perspective on robotics and Artificial Intelligence

Robotics and AI, consequently developed from a human-centric perspective, is going to have a disruptive impact on our society in areas such as health-care, industry, or services.

The talk will highlight some examples of successful robotics applications and discuss their evolution through the ongoing developments of AI. Putting the human in the centre of robot development also means to use robotics research in order to better understand human motion and intelligence in a synthesizing way by using the analytic tools of robotics. I will particularly highlight in this respect the interplay of biomechanics and neuro-control with robot design and advanced robotics control. Our society can directly benefit from this research through the development of better human-machine interfaces, robotized medical procedures, and prosthetic and rehabilitation devices which will even more reduce the barrier between humans and robots in the future.



## **Raja CHATILA**

Professor, *Sorbonne Université*,

Director of the Institute of Intelligent Systems and Robotics

Raja Chatila, IEEE Fellow, is Professor of Robotics, Artificial Intelligence and Ethics at *Sorbonne Université* in Paris, France, and director of the Institute of Intelligent Systems and Robotics (ISIR). He also leads the SMART Laboratory of Excellence on Human-Machine Interactions. He contributed in several areas of Artificial Intelligence and autonomous and interactive Robotics, with about 150 published papers. He is recipient of the IEEE Robotics and Automation Pioneer Award. He is chair of the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems. He was President of the IEEE Robotics and Automation Society for the term 2014-2015.

## **Acquisition and Grounding of Robot Knowledge Through Interaction with the Physical World**

Data-intensive approaches such as deep learning systems have a major issue: while they classify tremendous amounts of data, they do this without grasping the meaning of their inputs (data) or outputs (classes). It becomes easy to deceive such systems to falsely interpret some inputs. We contend that it is only through interacting with the real world that it is possible to make sense of it. Robots are machines that integrate perception and action, are situated and act in their environment. Perception should not be a one-way observation process isolated from action. Considering perception and action simultaneously enables to interpret the environment in terms of the robot's own perceptual and action capacities, thus relating the world to the robots potential activities. What an object affords to the robot, in terms of the robot's action effects, partly describes its semantics and its functions. This grounds robot knowledge in the real world.



## **Helge RITTER**

Professor, *Universität Bielefeld*

Helge Ritter studied physics and mathematics. After a Ph.D. in physics at Technical University of Munich he stayed at Helsinki University of Technology and the University of Illinois at Urbana Champaign. Since 1990 he is professor for neuroinformatics at Bielefeld University. He was awarded the SEL Alcatel Research Prize and the Leibniz Prize of the German Research Foundation. He is co-founder and Director of the Bielefeld Institute for Cognition and Robotics (CoR-Lab), member of the German Academy of Science and Engineering, the NRW Academy of Sciences, Humanities and the Arts, and since its inception in 2007 coordinator of the Bielefeld Cluster of Excellence « Cognitive Interaction Technology » (CITEC).

## **Robotics for a human future**

Advances in AI and mechatronics are about to transform the capabilities of robots: visual discrimination of objects can now be on par with humans. Improved actuators, along with « tactile intelligence » will give robots more human-like dexterity and the sensitivity to work safely and exibly « hand-hand » with humans. Complementing current task-directed robot skills with some degree of social intelligence will make robots more natural and acceptable for humans, for instance in mixed human-robot teams. With these and further developments robotics will become a decisive resource for coping with major societal challenges: maintaining competitiveness, welfare, affordable care even in aging populations, and a clean environment. While robots may substitute us in arange of fields, robotics will open up many new ones, and will ultimately enhance our understanding of what it means to be human.

## Michel DE MATHELIN

*Icube, Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie, université de Strasbourg*

Michel de Mathelin received the Electr. Eng. degree from Louvain University, Louvain-La-Neuve, Belgium, in 1987 and the M.S. and Ph.D. degrees in electrical and computer engineering from the Carnegie Mellon University, Pittsburgh, PA, in 1988 and 1993, respectively. During 1991-1992, he was a Research Scientist in the Department of Electrical Engineering, Polytechnic School of the Royal Military Academy, Brussels, Belgium. In 1993, he became Assistant Professor at Strasbourg University, France. Since 1999, he has been Professor at *Télécom Physique Strasbourg*, University of Strasbourg. He has been the head of the Automation, Vision and Robotics research group (60 people) from 2000 to 2012. Since 2013, he is the Director of the ICube Laboratory (UMR CNRS-UNISTRA 7357) with more than 650 people in the area of Engineering and Computer Science with a strong focus on biomedical and environmental engineering. In 2017, he became vice-president for technology transfer of the University of Strasbourg. Michel de Mathelin has been Associate Editor of the IEEE Control System Technology Journal from 2003 to 2011. His current research interests include medical robotics, visual servoing, adaptive and robust control. He has co-authored more than 200 international refereed journal and conference papers. With his co-authors, he received the ICRA 2004 Best Vision Paper Award, the 2005 King-Sun Fu Memorial Best IEEE Transactions on Robotics Paper Award. He holds 8 patents and is co-founder of Axilum Robotics, a startup in medical robotics. Dr. Mathelin is a fellow of the Belgian American Educational Foundation.



## Medical Robotics and machine learning

Medical robotic systems are entering the hospital more and more, especially in the field of image guided surgery and radiology. A peculiarity of these medical robotic systems is the necessary interaction with the patients and with the medical staff. For example, teleoperated surgical robots are used as assistant in minimally invasive surgery to hold the instruments inside the patient or interventional radiology robotic systems are used to move imaging devices around the patient. The control of these medical robotic systems is very often vision based and requires taking into account the interactions with the patient as well as the doctor in the case of teleoperated systems. Model based control algorithms very often find their limit, e.g., when there are interactions with the patient body, when there is a human operator in the loop, when the instruments are difficult to model, or to analyze in real time medical image feedback. Learning algorithms can be shown to be useful in these situations and outperform model-based techniques. Several practical examples will be presented.

## Tamim ASFOUR

*Professor, Institute for Anthropomatics and Robotics, High Performance Humanoid Technologies, Karlsruhe Institute of Technology*

Tamim Asfour is full Professor of Humanoid Robotics at the Institute for Anthropomatics at KIT. His research focuses on the engineering of high performance 24/7 humanoid robotics as well as on the mechano-informatics of humanoids as the synergetic integration of mechatronics, informatics and artificial intelligence methods into humanoid robot systems, which are able to predict, act and interact in the real world. Tamim is the developer of the ARMAR humanoid robot family. He is the Founding Editor-in-Chief of the IEEE-RAS Humanoids Conference Editorial Board, president of the Executive Board of the German Robotics Society (DGR) and scientific spokesperson of the KIT Center "Information · Systems · Technologies (KCIST)". In his research, he is reaching out and connecting to neighboring areas in large-scale national and European interdisciplinary projects in the area of robotics in combination with machine learning and computer vision.



## Robotics AI: cognitive abilities for intelligent bodies

Engineering robots with human like-abilities in the real world remains a grand challenge. Currently, we experience AI systems with superhuman performance in image and speech processing, medical diagnosis and games. However, the underlying techniques of these systems do not allow the transferability of solutions to different context in the same domain let alone across different domains. In robotics, motion is fundamental! The development of motion abilities requires the integration of perception and action while taking into account the physical body - the bodyware – and the interaction with the real world leading to transferable cognitive abilities. This is where current AI technologies fail. Robotics AI emphasizes the interaction between cognitive abilities and intelligent bodies to create robots with human-like abilities and even superhuman performance. I will discuss current progress (and limitations) of current AI and robotics and describe our efforts towards building humanoid robots with motion intelligence.



### Cécilia LASCHI

Professor, The BioRobotics Institute, *Scuola Superiore Sant'Anna*

Cecilia Laschi is Full Professor at the BioRobotics Institute of *Scuola Superiore Sant'Anna* in Pisa, Italy, where she serves as Rector's delegate to Research.

Her research interests are in the field of soft robotics, a research area she pioneered, including its applications in marine robotics and in the biomedical field. She has been working in humanoid robotics and neurorobotics, at the merge of neuroscience and robotics. She is senior member of the IEEE and she founded and served as General Chair for the IEEE-RAS First International Conference on Soft Robotics, Livorno, April 24-28, 2018.

## Multidisciplinary research challenges for the progress of robotics

Robotics is progressing rapidly and futuristic scenarios propose robots in daily life, creating expectations that have not yet been matched. What are the abilities that robots still miss for extensive application?

The use of soft materials is one of the current challenges for pushing the boundaries of robotics technologies and enabling more robot applications, inspired by living organisms exploiting body compliance to move effectively in complex natural environments. Recent advances in AI can help robots develop the intelligence they need to negotiate real-world scenarios.

Robots have a great potential for becoming part of our lives, for responding to societal challenges, for contributing to Europe's economic growth. New materials and AI are key directions for the future robotics progress.



### Sigmar WITTIG

Executive Board, *Nationale Akademie der Wissenschaften Leopoldina*

After earning his PhD from the RWTH Aachen and working for nine years in the USA, Wittig assumed the position of Chair of Thermal Turbomachinery in Karlsruhe in 1976. He served as Vice President of the DFG and became Rektor / President of the University of Karlsruhe in 1994 through 2002, when he accepted the position of Chairman of the Board of the German Aerospace Center and Space Agency (DLR). In addition he served as Council-Chair of the European Space Agency (ESA) from 2005 to 2007.

Wittig holds several honorary doctorates and received the German Federal Cross of Merit, 1st Class and the *Ordre National de la Légion d'Honneur*. Recently he was honored with the ASME Aircraft Engine Technology Award.

## Lessons learned, new horizons and impact on societal challenges in Europe



## Patrick GARDA

Director, STIC, Ministry of higher Education, Research and innovation, France

Patrick GARDA has been Scientific director of the ICT-Mathematics-Physics-Nanotechnologies sector at the French Ministry of Higher Education, Research and Innovation since 2016, and deputy-head of this sector since 2015.

Besides, he has been Professor of Electronics at *Sorbonne université* since 1995, attached to the *Laboratoire d'informatique de Paris 6* (LIP6), CNRS Research Scientist in Electronics at the *Institut d'électronique fondamentale* Laboratory (IEF, now C2N, in Orsay) from 1985 to 1995 and Associate Professor of Mathematics at the *École normale supérieure* de Cachan from 1981 to 1985.



## Jean-Frédéric GERBEAU

General Director delegated to science, Inria, France

Jean-Frédéric Gerbeau is Deputy CEO for Science at Inria and an adjunct Professor at *École Polytechnique*. He holds a PhD in applied mathematics (*École des Ponts*) and an habilitation thesis (UPMC, *Sorbonne université*). He spent a year at EPFL (Switzerland) as a post-doc in 1999, and at Stanford University (US) as a visiting professor in 2009.

His research focuses on mathematical modeling and numerical simulation. He was awarded the CS prize for applied mathematics by Communications and Systems (2002), the Pierre Faurre Prize (2008) and the Alcan Prize (2010) by the French Academy of Sciences.

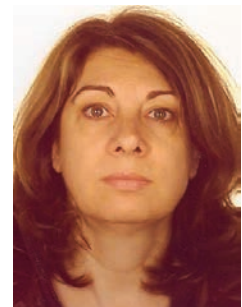


## Chantal KHAN-MALEK

Deputy Director, Europe Director for research and international cooperation, CNRS, France

Chantal Khan-Malek is Research Director at the French National Center for Scientific Research (CNRS). She has been appointed Deputy-Director in charge of cooperation with bilateral Europe at the international office (Europe of Research and International Cooperation office - DERCI), at the CNRS headquarters in Paris in July 2015. From January 2011 to June 2015, she was Deputy-Director for North Asia - Oceania at the DERCI. Previously, she had been responsible for CNRS cooperation with India, Australia and New-Zealand (2000-2002).

Chantal Khan-Malek is a specialist of micro/nanotechnologies, advanced manufacturing techniques, and their application to devices and systems. She has been actively involved in research for 25 years and worked in France, in Germany and in the USA. Her research interests revolve around lithography, replication techniques, EUV and X-ray optics, and microsystems.



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