Proceedings

AI4Health

Lecture Series 2020

3 March 2020 – 18 November 2020

University Luxembourg, Campus Belval

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Foreword

This event took place at the Belval Campus of the University of Luxembourg from March to November 2020.

However, due to the Corona pandemic and the associated medical challenges, the event could not be held as planned. Although the first two events could take place in March on-site, the organisers had no choice but to postpone the subsequent lectures. In the end, we managed to have the following events take place within the framework of virtual meetings (WebEx).

We would like to take this opportunity to thank the invited speakers for their understanding and flexibility, as well as for their willingness to make up for their presentation at a later date! Without this kindness, the event could not have taken place in the way it did.

We would also like to thank the Department of Computer Science, AI (ILIAS) Lab, Faculty of Science, Technology, and Medicine (FSTM), the Department of Life Sciences and Medicine, Faculty of Science, Technology, and Medicine (FSTM) and the Luxembourg Centre for Systems Biomedicine (LCSB). We hope that we have been able to provide the audience with some interesting presentations on AI and Health and stimulate further and future research in the field. We are aware that multidisciplinary research requires and demands joint efforts. The AI4Health lecture series has hopefully made a great contribution to this.

Perhaps some statistics to conclude: four speakers from Germany, two speakers from Sweden, and one speaker each from Norway, Spain and Austria were our guests. Two lectures are to be made up for in 2021. On average, 20-25 listeners attended the events, which is not bad given the pandemic situation.

We hope to welcome you again in 2021!

Belval-Université, December 2020

Daniel Abankwa
Jun Pang
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Programme

DATE	PLACE	SPEAKER	TITLE
03 March 2020, 16h00	Learning Centre, Room LH 2.02	Prof. Dr. **Andreas Maier**, University Erlangen-Nürnberg, Germany	*Known Operator Learning - An Approach to increase Trust in Deep Learning for Medical Image Processing*
10 March 2020, 16h00	MSA, Room 4.510	Prof. Dr. **Jim Torresen**, University of Oslo, Norway	*Older People Care and Mental Health Treatment by Adaptive Technology*
23 September 2020, 16h00	16h00 WEBEX	Dr. **Julio Saez-Rodriguez**, University Heidelberg, Germany	*Helping machine learning to help us in personalized medicine*
28 October 2020, 16h00	16h00 WEBEX	Dr. **Victor Vicente Palacios**, Philips Salamanca, Spain	*Artificial Intelligence applied to Cardiology*
4 November 2020, 16h00	16h00 WEBEX	Prof. Dr. **Ute Schmid**, **Bettina Finzel**, University Bamberg, Germany	*Learning from Mutual Explanations for Cooperative Decision Making in Medicine*
11 November 2020, 16h00	16h00 WEBEX	Dr. med. **Markus Lingman**, Region Halland and Prof. Dr. **Mattias Ohlsson**, Halmstad University, Sweden	*Information driven healthcare in Halland*
18 November 2020, 16h00	16h00 WEBEX	Prof. Dr. **Georg Dorffner**, Medical University Vienna, Austria	*It's all about the ground truth - how to prove that AI can outperform experts*

3 March 2020

Known Operator Learning - An Approach to increase Trust in Deep Learning for Medical Image Processing

Prof Dr **Andreas Maier**, University Erlangen-Nürnberg, Germany

Bio: Prof. Dr. Andreas Maier studied Computer Science, graduated in 2005, and received his PhD in 2009. From 2005 to 2009 he was working at the Pattern Recognition Lab at the Computer Science Department of the University of Erlangen-Nuremberg. His major research subject was medical signal processing in speech data. In this period, he developed the first online speech intelligibility assessment tool - PEAKS - that has been used to analyze over 4.000 patient and control subjects so far. From 2009 to 2010, he started working on flat-panel C-arm CT as post-doctoral fellow at the Radiological Sciences Laboratory in the Department of Radiology at the Stanford University. From 2011 to 2012 he joined Siemens Healthcare as innovation project manager and was responsible for reconstruction topics in the Angiography and X-ray business unit. In 2012, he returned the University of Erlangen-Nuremberg as head of the Medical Reconstruction Group at the Pattern Recognition lab. In 2015 he became professor and head of the Pattern Recognition Lab. Since 2016, he is member of the steering committee of the European Time Machine Consortium. In 2018, he was awarded an ERC Synergy Grant "4D nanoscope". Current research interests focuses on medical imaging, image and audio processing, digital humanities, and interpretable machine learning and the use of known operators.

Abstract: We describe an approach for incorporating prior knowledge into machine learning algorithms. We aim at applications in physics and signal processing in which we know that certain operations must be embedded into the algorithm. Any operation that allows computation of a gradient or sub-gradient towards its inputs is suited for our framework. We demonstrate a reduced a maximal error bound for deep nets by inclusion of prior knowledge. Furthermore, we also show experimentally that known operators reduce the number of free parameters. We apply this approach to various tasks ranging from CT image reconstruction

over vessel segmentation to the derivation of previously unknown imaging algorithms. As such the concept is widely applicable for many researchers in physics, imaging, and signal processing. We assume that our analysis will support further investigation of known operators in other fields of physics, medical imaging, and signal processing.

10 March 2020

Older People Care and Mental Health Treatment by Adaptive Technology

Prof Dr **Jim Torresen** , University of Oslo, Norway

Bio: Prof Dr Jim Torresen is a professor at University of Oslo where he leads the Robotics and Intelligent Systems research group. He received his M.Sc. and Dr.ing. (Ph.D) degrees in computer architecture and design from the Norwegian University of Science and Technology, University of Trondheim in 1991 and 1996, respectively. He has been employed as a senior hardware designer at NERA Telecommunications (1996-1998) and at Navia Aviation (1998-1999). Since 1999, he has been a professor at the Department of Informatics at the University of Oslo (associate professor 1999-2005). Jim Torresen has been a visiting researcher at Kyoto University, Japan for one year (1993-1994), four months at Electrotechnical laboratory, Tsukuba, Japan (1997 and 2000) and a visiting professor at Cornell University, USA for one year (2010-2011). His research interests at the moment include artificial intelligence, ethical aspects of AI and robotics, machine learning, robotics, and applying this to complex real-world applications. Several novel methods have been proposed. He has published over 200 scientific papers in international journals, books and conference proceedings. 10 tutorials and a number of invited talks have been given at international conferences and research institutes. He is in the program committee of more than ten different international conferences, associate editor of three international scientific journals as well as a regular reviewer of a number of other international journals. He has also acted as an evaluator for proposals in EU FP7 and Horizon2020 and is currently project manager/principal investigator in four externally funded research projects/centres. He is a member of the Norwegian Academy of Technological Sciences (NTVA) and the National Committee for Research Ethics in Science and Technology (NENT) where he is a member of a working group on research ethics for AI.

Abstract: Our mental state to a large extent impacts our well-being. Unfortunately, for many people, it fluctuates during lifetime and results in various degree of mental disorders. The most common one is depression but there exist a number of other ones as well like social

anxiety, Attention Deficit Hyperactivity Disorder (AHDH), and bipolar disorders. The treatment is on the other hand often long-lasting and much dependent on therapeutic follow-up. Little technology is available to measure mental state and provide any automatic support and treatment. This is what we at the University of Oslo together with clinical collaborators in Bergen in Norway are addressing in the project INtroducing personalized TReatment Of Mental health problems using Adaptive Technology (INTROMAT).

We work in the project with sensor-data collected from mental health patients and controls using mobile phones and sensor watches. We apply state-of-the-art machine learning methods to train models that can classify and foresee how the mental state is changing through time. Data comes in many formats like motion, speech, mobile phone usage, and more. Having some indication of the future development of the brain´s mental state is helpful for providing a user with self-help as well as support to the therapist. In parallel, we are implementing technology to increase health safety for older people living by themselves at home. This is by using ambient sensor technology on a mobile robot platform to remotely sense the state of a person to be able to warn the caregiver when any abnormal or emergence situation has occurred. This has relevance to mental health since the mental state can impact the well-being and risk of emergency situations. In this talk, three important aspects of these projects will be presented including the user design perspective, sensing technology and possible treatments that together target to contribute improved mental health. The talk will also address many of the ethical issues like privacy, security and safety that should be considered when developing such technology.

23 September 2020

Helping machine learning to help us in personalized medicine

Dr **Julio Saez-Rodriguez**, University Heidelberg

Bio: Julio Saez-Rodriguez is Professor of Medical Bioinformatics and Data Analysis at the Faculty of Medicine of the University of Heidelberg, and director of the institute of computational biomedicine. He is also a group leader of the EMBL-Heidelberg University Molecular Medicine Partnership Unit, and a co-director of the DREAM challenges (http://dreamchallenges.org) to crowdsource computational systems biology. He obtained his M.S. in Chemical Engineering in 2001, and a PhD in 2007 at the University of Magdeburg and the Max-Planck-Institute. He was a postdoctoral fellow at Harvard Medical School and M.I.T., and a Scientific Coordinator of the NIH-NIGMS Cell Decision Process Center from 2007 to 2010. From 2010 until 2015 he was a group leader at EMBL-EBI with a joint appointment in the EMBL Genome Biology Unit in Heidelberg, as well as a senior fellow at Wolfson College (Cambridge). From 2015 to 2018 he was professor of Computational Biomedicine at the RWTH University Medical Hospital in Aachen, Germany. He is interested in developing and applying computational methods to acquire a functional understanding of signaling networks and their deregulation in disease, and to apply this knowledge to develop novel therapeutics. Current emphasis in his group is on use of single-cell technologies, multi-omics integration, and understanding multi-cellular communication. More information at www.saezlab.org

Abstract: One area where artificial intelligence is expected to have a major impact in the health area is by developing algorithms that help us provide the right drug for each patient, that is, for personalized medicine. In this talk I will discuss our work applying machine learning on large pharmaco-genomic screenings in cell lines to build predictive models. Integration of this data with prior knowledge on signaling pathways and transcription factors provides biomarkers and offer hypotheses for novel combination therapies. Our own analysis as well as the results of a crowdsourcing effort (as part of a DREAM challenge) reveals that prediction of drug efficacy is far from accurate, implying important limitations for personalised medicine. An important aspect that deserves further attention is the dynamics of signaling networks and how they response to perturbations such as drug treatment. I will present how cell-

specific logic models, trained with measurements upon perturbations, can provides new biomarkers and treatment opportunities not noticeable by static molecular characterisation. In summary, I will advocate that combining the right data with biological knowledge will be important to build predictive models for personalized medicine.

28 October 2020

Artificial Intelligence applied to Cardiology

Dr **Victor Vicente Palacios**, Philips Salamanca, Spain

Bio: Dr Victor Vicente Palacios is currently Clinical Data Scientist at Philips Healthcare (Salamanca, Spain); he is part of an artificial intelligence research group based on the University Hospital of Salamanca (Spain) that focuses its investigations on applying machine learning and deep learning to the clinical practice, mainly applied to cardiology. He has a master's degree in mechanical engineering from the Technical University of Madrid, and a Ph.D. in multivariate statistics from the University of Salamanca. He is also a former alumnus of the "Data Science for Social Good" program (University of Chicago) and coordinator of Datalab USAL (Data Science student research group at the University of Salamanca).

Abstract: Artificial Intelligence (AI) is becoming highly advanced in different disciplines and our current challenge is to transfer all of this development to the medical field and specifically to cardiology. Examples of AI using Machine Learning (ML) or Deep Learning (DL) are becoming more and more common in cardiology. In this talk, I will present the evolution of the contributions of AI to the different application areas of cardiology such as cardiac arrhythmias, ischemic heart disease, cardiac imaging, and others. Furthermore, I will introduce the projects we have developed and the ones we are currently developing in our research group at the Hospital of Salamanca (Spain), as well as show some applications.

04 November 2020

Learning from Mutual Explanations for Cooperative Decision Making in Medicine

Prof Dr **Ute Schmid**, University Bamberg, Germany

Bio: Ute Schmid is professor for Cognitive Systems at University of Bamberg. She holds a diploma in psychology and a diploma in computer science, both from Technical University Berlin (TUB), Germany. She received both her doctoral degree (Dr. rer.nat.) and her habilitation from the Department of Computer Science of TUB. Her research focus is on interpretable and human-like machine learning, inductive programming, and multimodal explanations. Current research projects are on interpretable and explainable machine learning for medical image diagnosis (BMBF – TraMeExCo), for facial expression analysis (DFG – PainFaceReader), and for detecting irrelevant digital objects (DFG – Dare2Del in the priority program Intentional Forgetting). Ute Schmid is a fortiss resesarch fellow for Inductive Programming. She is engaged to bring AI education to school and holds many outreach talks to give a realistic picture of the benefits and risks of AI applications.

Bettina Finzel, University Bamberg, Germany

Bio: Bettina Finzel Bettina Finzel is a research assistant in the BMBF funded project Transparent Medical Expert Companion (TraMeExCo). She has a master as well as a bachelor of science both in Applied Computer Science from the University of Bamberg. She is mainly interested in comprehensible and interactive machine learning approaches for the medical domain. Bettina Finzel is active in measures to engage female high school students in computer science.

Abstract: Medical decision making is one of the most relevant real world domains where intelligent support is necessary to help human experts master the ever growing complexity. At the same time, standard approaches of data driven black box machine learning are not recommendable since medicine is a highly sensitive domain where errors may have fatal

consequences. In the talk, we will advocate interactive machine learning from mutual explanations to overcome typical problems of purely data driven approaches to machine learning. Mutual explanations, realised with the help of an interpretable machine learning approach, allow to incorporate expert knowledge in the learning process and support the correction of erroneous labels as well as dealing with noise. Mutual explanations therefore constitute a framework for explainable, comprehensible and correctable classification. Specifically, we present an extension of the inductive logic programming system Aleph which allows for interactive learning. We introduce our application LearnWithME which is based on this extension. LearnWithME gets input from a classifier such as a Convolutional Neural Net's prediction on medical images. Medical experts can ask for verbal explanations in order to evaluate the prediction. Through interaction with the verbal statements they can correct classification decisions and in addition can also correct the explanations. Thereby, expert knowledge is taken into account in form of constraints for model adaptation.

11 November 2020

Information driven healthcare in Halland

Dr. med. **Markus Lingman**, Region Halland, Sweden

Bio: Dr Markus Lingman is a specialist physician, has a background in Industrial Engineering and Management, and a PhD in medical sciences. He has done postdoctoral research in collaboration with Harvard. He is a consulting cardiologist and member of the board of directors for Halland hospital group. He is the Chief Strategy Officer and leads Region Halland's Centre for Information Driven Care (CIDD).

Prof. Dr. **Mattias Ohlsson**, Halmstad University, Sweden

Bio: Prof Dr Mattias Ohlsson has a PhD in theoretical physics and is professor of Information Technology at Halmstad University. He is also professor in Theoretical Physics at Lund University, with a specialization in machine learning for medical diagnostics. He has done a postdoctoral research stay at the Technical University of Copenhagen. Today, he heads the information driven healthcare research within Halmstad University's Centre for Applied Intelligent Systems Research (CAISR).

Abstract: Region Halland in Sweden is the main healthcare provider for the county of Halland (about 330 000 inhabitants). Region Halland realized early on the potential impact of information driven healthcare; using data and data analytics to improve the healthcare system. Region Halland have during the last ten years developed and maintained a comprehensive healthcare data infrastructure covering clinical and administrative information pertaining to every consumer in Halland of healthcare with public funding. This means approximately 500 000 patients treated in Halland now and in the past and includes all the Region's care delivery units and also the pharmacies. Work is ongoing to include the municipalities, who have responsibility for e.g. elderly care. Halmstad (Regional Capital of Halland) University, and in particular CAISR (Centre for Applied Intelligent Systems Research), have had a longstanding and seamless collaboration with Region Halland with the focus on applying AI and machine learning towards information driven healthcare solutions. This work also includes collaborations with international partners (e.g. Harvard Medical School and Brigham Women's Hospital in Boston). Over the last years, Region Halland has been able to cut costs in the healthcare service at the same time as the population has grown and there has been a substantial increase in patient arrivals to the emergency departments. Also medical quality of care has improved. The efficiency improvement has been achieved e.g. by reducing hospital bed days without affecting occupancy levels, by decreasing the admission rates to the hospital, and increasing the fraction patients that can be discharged early. Many of these achievements were enabled by using information driven healthcare, by introducing data analytics and better prognostics for the management of the healthcare system. For 2019, Region Halland is one of only two regions in Sweden that do not show a large economical deficit in the healthcare service. Several regions are flagging for large staff layoffs in their healthcare systems for 2020. Detailed and comprehensive care data, together with modern AI and analysis tools, play an important role in delivering effective care by facilitating healthcare providers to to create actionable insights and take better informed decisions. What is also required is a methodology and organization on how to systematically work with information driven improvement work around quality and productivity where the goal is to understand how the patient is affected in the healthcare system. Region Halland have developed a model for organization, working methods and a nine-step process on how to go from idea, to follow-up of an implementation of a change in the health care system. The model gives the decision maker a powerful tool to choose the initiatives that give the best results at the system level. This includes creating agile multidisciplinary teams around system issues and use the nine-step process for a data-driven improvement work that considers all the necessary aspects including production, quality and economy with the highest possible degree of detail. We will present how Region Halland works with information driven healthcare, both how to find insights and to get them implemented, and show research projects and results that have emerged through the collaboration between Region Halland and CAISR at Halmstad University. We also present ongoing work in developing methods and infrastructure for distributed machine learning, such that medical databases located at different healthcare provides can be utilized when creating AI and machine learning solutions related to information driven healthcare.

18 November 2020

It's all about the ground truth - how to prove that AI can outperform experts

Prof Dr **Georg Dorffner**, Medical University Vienna, Austria

Bio: Georg Dorffner is associated professor at the Section for Artificial Intelligence & Decision Support at the Medical University of Vienna, of which he is currently also the head. At the same university he also holds the position of the curriculum director of the university's master's programme in Medical Informatics. He received Master's degrees in Computer Science and Communication Engineering from the Vienna University of Technology in 1985 and a PhD in Computer Science from Indiana University in 1989. In 1994 he received tenure ("Habilitation") in Artificial Intelligence in Medicine for his work in novel tyspes of neural networks in clinical applications. His research has included machine learning, in particular neural networks, since the beginning of his career in the 1980s with a particular focus on time series and signal processing. From 2002 to 2014 he was the founding managing director of the company The Siesta Group, which - as a spin-off from an EU-funded project - among others successfully developed algorithms for the automated analysis of sleep signals (polysomnogrpahy) with human-level performance, which eventually was taken over by Philips for clinical commercialisation. From 2010 to 2014, Georg Dorffner was also a part-time senior managament at Philips Home Helathcare Solutions. Since the late 1990s he has frequently been advisor and/or evaluator for various EU funding programmes, in particular in FET (Future Emerging Technologies).

Abstract: Recent successful applications of AI - in particular of deep learning in imaging, signal processing and related fields - have demonstrated that machines are often able to achieve human-level performance or even outperform human experts in classification tasks for diagnostic support. Such proofs are also at the heart of regulatory decisions of whether AI systems are fit for clinical use as a medical device. In this talk I will present several applications from our own work, as well as comparable approaches from literature, highlighting the different ways of how expert performance can be measured as the benchmark for AI validation. The central question in each application is whether a "ground truth" exists and in what form, e.g. through a gold standard comparative method or through expert opinion itself.

This poses different challenges on validation that are often isufficiently addressed in literature. The talk will conclude with a more general discussion on whether and how AI sytsems can replace or, as it is often feared, replace medical personnel based on their proven performance level.

Postponed talk (due to Corona Covid-19)

Dr Mark Wernsdorfer, Research Associate, Laboratory Medicine of the University Hospital Leipzig

Machine Learning in the Clinical Decision Support System for Laboratory Medicine AMPEL

Bio: Dr Mark Wernsdorfer studied philosophy and computer science at the University of Bamberg. After his studies, he did his doctorate at the professorship Cognitive Systems on the question of consciousness in artificial systems. He then provided technical support to the Centre for Heritage Conservation Studies and Technologies. He has been a research associate at the AMPEL project of the Laboratory Medicine of the University Hospital Leipzig since October 2019. The project supports treating physicians by automatically recording laboratory values of patients, recognizing them as critical and, if necessary, reporting them to medical staff. His research interests include the philosophy of mind and artificial intelligence. In the intersection of both, he is particularly concerned with the structural prerequisites that a system must have in order to be considered intelligent, as well as the associated external prerequisites that it must have in order to be perceived as conscious by others.

Abstract: Laboratory medicine is essential for the diagnosis, therapy, and management of patients. The timely and appropriate consideration and interpretation of laboratory results is critical to, for example, review the choice of treatment or respond quickly to sudden changes in the patient's condition. Laboratory diagnostics, in general, provide relevant and high-quality information about the condition of the patient. Clinical Decision Support Systems (CDSS) assist in the digital collection of large amounts of such information, its automated delivery to the appropriate medical staff, and the development of treatment methods. This helps to avoid medical errors due to mistakes or misinterpretations. The aim of the AMPEL project at the University Hospital Leipzig is to implement and evaluate a CDSS for laboratory diagnostics. At the core of the system is the conversion of laboratory results into more condensed information, enabling better and faster treatment. From the data available to this system, machine learning methods can deduce critical patient states, biomarkers that are difficult or expensive to collect, or medical diagnoses from similar cases in the past. Medical staff can then be automatically alerted to critical constellations of biomarkers that require medical intervention, costly and time-consuming analyses can be performed in a more targeted manner, and diagnoses of rare diseases can be proposed that could otherwise have been overlooked. A transparent machine learning system has been developed that can predict diagnoses with high precision and recall. The generated models are validated by specialists and checked for medical plausibility. This ensures that the tests for models are representative and practice-oriented. A connection to the productive patient database of the University Hospital Leipzig enables the reactive adaptation of models to specific changes of the local patient population. The current status of the AMPEL project is presented. The methods used

and the problems resulting from their application to certain data sets are described by means of an exemplary case. Methods of result analysis, as well as means to improve the system and to extend its applicability in the future, are described.

Postponed talk (due to Corona Covid-19)

Prof Dr **Jeroen van den Hoven**, TU Delft, The Netherlands

Ethics of AI in Healthcare

Bio: Prof Dr Jeroen van den Hoven is university professor and full professor of Ethics and Technology at Delft University of Technology and editor in chief of Ethics and Information Technology. He is currently the scientific director of the Delft Design for Values Institute. He was the founding scientific director of 4TU.Centre for Ethics and Technology (2007-2013). In 2009, he won the World Technology Award for Ethics as well as the IFIP prize for ICT and Society for his work in Ethics and ICT. Jeroen van den Hoven was founder, and until 2016 Programme Chair, of the program of the Dutch Research Council on Responsible Innovation. He published Designing in Ethics (Van den Hoven, Miller & Pogge eds., Cambridge University Press, 2017) and Evil Online (Cocking & Van den Hoven, Blackwell, 2018) He is a permanent member of the European Group on Ethics (EGE) to the European Commission. In 2017 he was knighted in the Order of the Lion of The Netherlands.

Abstract: The attention for ethical problems of AI has rapidly increased in the last two years. At the same time the geo-political debates about digital sovereignty have become very prominent. Different parts of the world have different different images of man and models of society, and have therefore different views on how AI can and should be used and applied, which ethical issues are serious and which ones trivial. I will provide an overview of the ethical debates about AI, discuss the main ideas of Designing AI applications for moral Values, Responsible Innovation in Health Care with AI, proposals for Trustworthy AI as proposed by the High Level Group of the European Commission and indicate what some of the fundamental ethical problems of AI are that will be with us for quite some time.