



**Prof. Dr. Bernhard Kainz,
Image Data Exploration and Analysis
FAU Erlangen-Nürnberg**

Beyond Supervised Learning: From Normative Representation Learning to Agentic AI for Robust Medical Image Analysis

Abstract. Modern hospitals generate a vast ocean of medical images every day, yet interpreting them is constrained by the limited time clinicians can devote, the necessity of coordinating cross-disciplinary expertise, regional variation in training, and the inherent complexity of disease. Machine learning has been widely regarded as a solution for diagnostic automation in medical image analysis, but there are still unsolved problems in robust modelling of normal appearance and identification of features pointing into the long tail of population data. In this talk, I will explore the fitness of machine learning for applications at the front line of care and high-throughput population health screening, specifically in prenatal health screening with ultrasound and MRI, cardiac imaging, and bedside diagnosis of deep vein thrombosis.

However, I will argue that supervised machine learning might not be fit for purpose, as it cannot handle the unknown and requires a lot of annotated examples from well-defined pathological appearance. This categorisation paradigm cannot be deployed earlier in the diagnostic pathway or for health screening, where a growing number of potentially hundred-thousands of medically catalogued illnesses may be relevant for diagnosis.

Therefore, I introduce the idea of normative representation learning as a new machine learning paradigm for medical imaging. This paradigm can provide patient-specific computational tools for robust confirmation of normality, image quality control, health screening, and prevention of disease before onset. I will present novel deep learning approaches that can learn without manual labels from healthy patient data only. Our initial success with single-class learning and self-supervised learning will be discussed, along with an outlook into the future with causal machine learning methods and the potential of advanced generative models.

Finally, I will present our latest work on agentic AI for medical image analysis, as featured at MICCAI and NeurIPS. What if computers could go beyond pattern

recognition to explain their findings in natural language, check their own reasoning, and collaborate like a team of specialists? By learning from millions of scans and reports, these agentic systems can answer clinical questions, draft diagnostic notes, assess uncertainty, and identify hidden links among imaging, lifestyle data, and disease phenotypes. I will show how multi-agent architectures and large vision-language models can be orchestrated to emulate multi-disciplinary team decision-making, enabling AI systems that detect abnormalities and reason about them, cross-reference supporting evidence, and communicate findings in clinically meaningful ways.

Web: <https://bernhard-kainz.com/>

Speaker Bio. Bernhard Kainz is a professor at Friedrich-Alexander-Universität Erlangen-Nürnberg where he heads the Image Data Exploration and Analysis Lab (www.idea.tf.fau.eu) and he is Professor for Medical Image Computing in the Department of Computing at Imperial College London where he leads the human-in-the-loop computing group and co-leads the biomedical image analysis research group (biomedia.doc.ic.ac.uk). Bernhard's research is dedicated to developing novel image processing methods that augment human decision-making capabilities, with a focus on bridging the gaps between modern computing methods and clinical practice.

His current research questions include: Can we democratise rare healthcare expertise through Machine Learning, providing guidance in real-time applications and second reader expertise? Can we develop normative learning from large populations, integrating imaging, patient records, and omics, leading to data analysis that mimics human decision-making? Can agentic AI systems collaborate, reason, and explain their findings to support the 'right for explanation' in healthcare?

Bernhard's scientific drive is documented with over 150 state-of-the-art-defining scientific publications in the field. He worked and works as a scientific advisor for ThinkSono Ltd./GmbH, Ultromics Ltd., Cydar Medical Ltd., as co-founder of Fraiya Ltd., and as a clinical imaging scientist at St. Thomas' Hospital London and has collaborated with numerous industries. He is an IEEE Senior Member, senior area editor for IEEE Transactions on Medical Imaging, associate editor for Medical Image Analysis and Machine Learning for Biomedical Imaging, and has won awards, prizes, and honours, including several best paper awards. In 2023, his research was awarded an ERC Consolidator grant.

Time & Place.

Wednesday, March 25, 2026, 17:00
N27, Multimedia Room