IMMIV

Annual Report 2021

Statement of authorship

Contact information

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MOHN MEDICAL IMAGING AND VISUALIZATION CENTER- ACTIVITIES REPORT

First release, September 3, 2021

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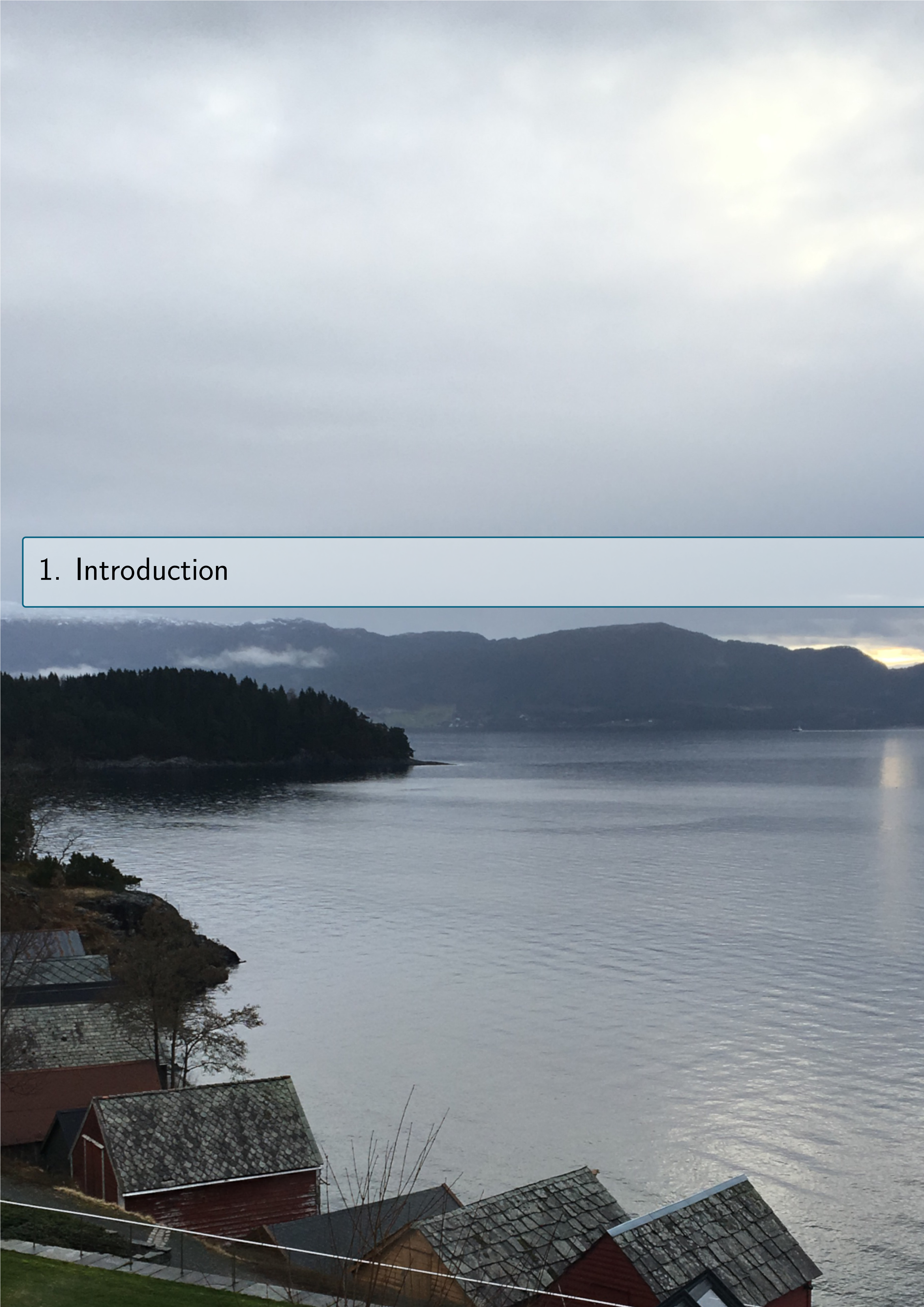
1. Introduction



-Ingfrid Haldorsen
MMIV Centre Leader

Mohn Medical Imaging and Visualization center (MMIV) was established in 2017 due to generous financial support from the Trond Mohn Foundation (TMF) coupled by human and financial support by Haukeland University Hospital (HUS) and the University of Bergen (UiB). These institutions shared the ambitious vision: To establish a center for imaging- and visualization research in Bergen. MMIV has since then facilitated high-impact research capitalizing on the advanced preclinical- and clinical imaging infrastructure available at Haukeland/UiB. The center fosters close cooperation across institutions, faculties and departments boosting interdisciplinary research collaboration that yields novel insight relevant for patient care.

MMIV has already grown to become a strong interdisciplinary research center hosting >40 dedicated scientists. Since 2019 MMIV has been co-localized in the new HUS premises on the top floor of the Haraldsplass building in Ulriksdalen, providing and excellent view of Bergensdalen. More importantly, the center comprises a vibrant hub for the exchange of ideas and expertise among researchers that all work on projects that prosper within MMIV.

MMIV is a part of the Department of Radiology at Haukeland University Hospital, and we are very happy to be located within the hospital – close to the patients and the factors that impact patient care: *precise diagnosis and staging, accurate prognostication*, and the *development of tailored and targeted treatment strategies*. The support from CEO Eivind Hansen, HUS and the Head of Dep. of Radiology Aslak Aslaksen, HUS has been instrumental for the successful organization of MMIV within HUS. Furthermore, we highly appreciate the support from UiB and Western Norway University of Applied Sciences (HVL) and their researchers working at MMIV, who represent cornerstones of the center. Importantly, the collaborative and mutually supportive attitudes displayed from all involved institutions is central for the success of the center!

One highlight in 2020 was the MMIV conference in hybrid format entitled: **"Enabling imaging technology to transform patient care"**. The conference had 50 participants at Bikuben and >200 virtual attendees, with an excellent technical setup ensuring the success of the hybrid format. The title of the conference captures one of the missions of MMIV: **By capitalizing on the multidisciplinary expertise within the center, we strive to merge efforts with clinical doctors in their endeavors to transform patient care**. The conference featured world-leading experts in machine learning and advanced imaging technologies as well as clinical experts highlighting the clinical relevance and potential impact of these novel methods for patient care.

Another highlight in 2020 was the inauguration of **PRESIMAL – a National Network for Precision Imaging and Machine Learning** funded by *Nasjonal samarbeidsgruppe for helseforskning i spesialisthelsetjenesten (NSG)*. **MMIV** is the coordinator of PRESIMAL and Associate Professor Eli Eikefjord has been recruited as network coordinator; she is also a part of the leadership team at MMIV.

As the Head of MMIV, it is my true privilege to introduce you to this report, showcasing some of the highlights and successful achievements at MMIV in recent years. Furthermore, I am confident that we are on the right track pursuing more scientific success at MMIV also in the years to come. Most importantly, we will continue to motivate researchers locally and nationally to scrutinize and search for small pieces in the greater puzzle that may transform patient care - a mission really worth striving for!

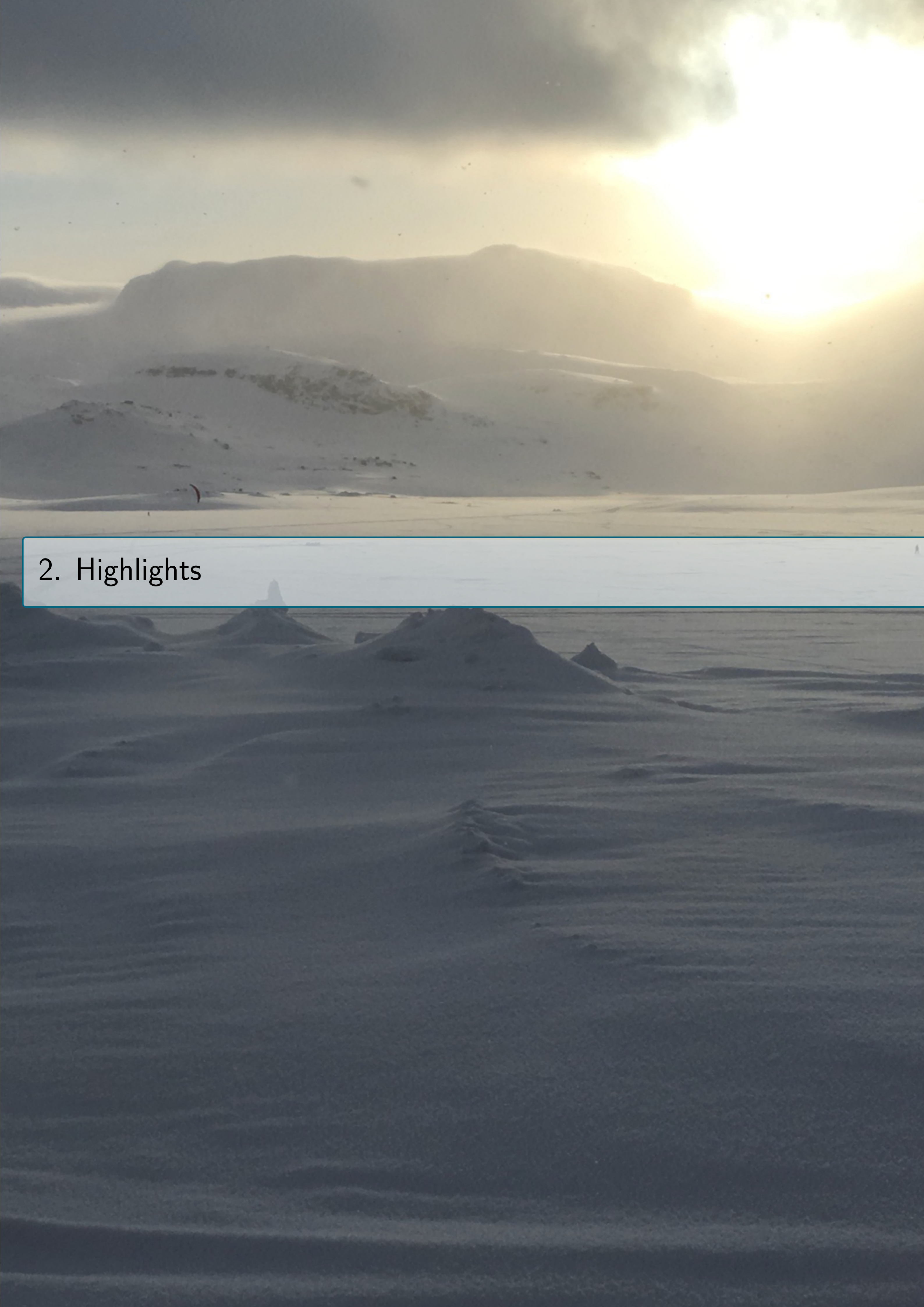
Precision imaging for better patient care

MMIV research is primarily related to six thematic areas with dedicated teams working closely together on projects related to:

1. Machine learning
2. Cancer imaging (focus on gynecologic cancer)
3. Neuroimaging (focus on fMRI and psychiatric disorders)
4. Advanced visualization
5. Research-PACS and workflow integrated machine learning
6. PRESIMAL – National Network for Precision Imaging and Machine Learning

The leadership group comprising principal investigators in these thematic areas meets monthly discuss scientific and administrative issues and share updates on progress and plans for projects. A monthly public MMIV seminar (duration 60 minutes) followed by coffee/waffles is hosted at MMIV in conjuncture with this leadership meeting. The daily management group at MMIV consisting of Ingfrid Haldorsen, Hauke Bartsch, Noeska Smit, Alexander Lundervold, Eli Eikefjord and Elin Myhrvold [secretary] shares the daily management tasks at MMIV/PRESIMAL through weekly meetings.

2. Highlights



MMIV retreat at Solstrand Hotel

To kick off the opening of the new location at Haraldsplass for the MMIV centre, we organized a retreat at the Solstrand hotel in order to get to know each other and further develop plans for the future of the centre. In the two-day meeting in March, every centre member gave a short presentation introducing themselves and their research activities. In addition to the scientific program, the social program enabled everyone to get to know their colleagues in the now co-located centre.

The MMIV team at Solstrand

MMIV Conference 2019

Photo: Randi Heggernes Eilertsen

The second annual MMIV Conference entitled "Convergence of medical data science for improved patient care" was held at Bikuben, Haukeland University Hospital. Over 150 participants listened to inspirational talks by both local as well as international speakers on topics related to core research activities at the MMIV.

Helse Vest funding to MMIV initiatives

Helse-Vest has allocated funds to 61 of the total 285 applications submitted by the deadline of September 15. Njål Lura, PhD candidate in the gynecological cancer imaging project, has received PhD funding from this competitive call. In addition, Satheshkumar (Sathiesh) Kaliyugarasan has received PhD funding for his project in machine learning.

Cecilie Brekke Rygh was awarded financial support for her project "Imaging biomarkers for precision medicine in Acute Myeloid Leukemia (AML)", in which Noeska Smit and Alexander Lundervold co-lead a workpackage on image data analyses and visualization.

Honorary Membership of the Norwegian Radiological Society

Ingfrid Haldorsen was awarded honorary membership of the Norwegian Radiologica Society at this year's Radiologisk Høstmøte in October. She presented a talk entitled 'Why research as a young radiologist?' at the meeting.

Prize for Best Teacher at the Faculty of Medicine

Arvid Lundervold was awarded the prize for Best Teacher at the Faculty of Medicine by the University of Bergen. In his courses BMED360 and ELMED219, he uses e-learning tools extensively to introduce his students to the course material, and granting them access to big data used for in the teaching.

The Fulbright Norway Research Prize 2019

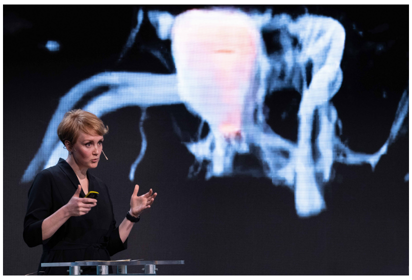
Leif Oltedal was awarded price for the best Fulbright Article of the Year: «Volume of the Human Hippocampus and Clinical Response Following Electroconvulsive Therapy» which was published in Biological Psychiatry i 2018 paper.

Best Article in Abdominal Radiology in 2018

The Norwegian Radiological Society has awarded Sigmund Ytre-Hauge with the best article in abdominal radiology in 2018 prize for his work "Preoperative Tumor Texture Analysis on MRI Predicts High-Risk

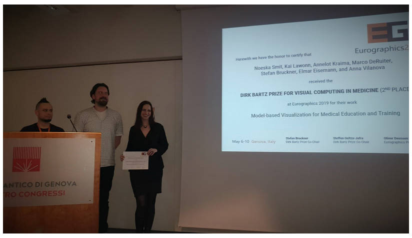
Disease and Reduced Survival in Endometrial Cancer" published in the Journal of Magnetic Resonance Imaging. The article is part of Ytre-Hauge's thesis "Advanced imaging biomarkers in endometrial cancer", which he defended in 2019.

MMIV at Christiekonferansen



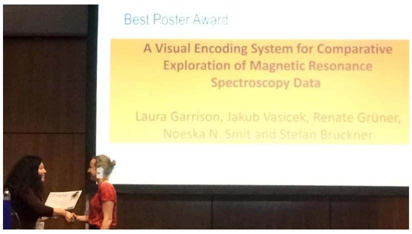
In the "Forsking i front" session from 11:30-12:00, Kristine Eldevik Fasmer presented a talk entitled "Kan vi lære maskiner å finne kreft i MR-bilder?". Kristine, who is a PhD student in the cancer imaging project, talks about her work on machine learning for cancer detection in MRI images. The machine learning project had a stand in the exhibition area, also. Here, they showcased a live demo of human action recognition using deep learning, and displayed how deep neural networks can be used to process and produce useful predictions based on medical images.

Dirk Bartz Prize for Visual Computing in Medicine



At Eurographics 2019, the 40th annual Conference of the European Association for Computer Graphics hosted in Genoa Italy, Noeska Smit and Stefan Bruckner were awarded with a Dirk Bartz Prize for Visual Computing in Medicine 2019 (Eurographics Medical Prize). They received this prestigious award for their work on model-based visualization for medical education and training with a team of researchers from the Netherlands and Germany.

Best Poster Prize at EuroVis 2019



Our poster on MRS visualization research entitled "A Visual Encoding System for Comparative Exploration of Magnetic Resonance Spectroscopy Data" by Laura Garrison, Jakub Vasicek, Renate Grüner, Noeska Smit, and Stefan Bruckner was awarded the Best Poster at the EuroVis 2019 Conference in Porto, Portugal.

MMIV and COVID-19

The COVID-19 outbreak at the beginning of 2020 allowed researchers of MMIV to focus on research efforts of disease prevention and characterization of patient data affected by the outbreak. The MMIV clinical response team created tools and procedures to manage the data capture of COVID-19 cases for image and assessment instruments. This included simple measures such as adjusting the radiology workflow at MMIV to allow all radiologists working at MMIV to occupy separate offices, limiting the potential effects of an outbreak. All MMIV seminars switched to a virtual solution.

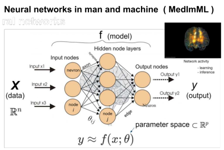
MMIV researchers awarded NOK 7m from NRC

In 2020 we received new funding for a project on workflow-related machine learning from the Norwegian Research Council. The project is headed by Hauke Bartsch, Alexander Lundervold, Ingfrid Haldorsen, Arvid Lundervold, Erlend Hodneland, and Erling Andersen. The primary objective of this project is to construct a robust, working prototype that receive a DICOM study pushed from the PACS system, setup and run it through deep learning-based image processing methods, and format and return the resulting information, segmentation mask, derived reports, and quantitative measures back into the PACS. The system will also facilitate the evaluation and further training of the deep learning model based on feedback from the user by storing such modifications as annotations in the PACS. The prototype workflow will be assessed by experienced radiologists from the relevant clinical domains. Secondary objective is to prove that our approach is generalizable. This objective is three-fold: the approach should generalize to other computational medical imaging methods, different medical applications, and provide a clear path to embed our product in production-level, widely used PACS and image reading systems.

Best Poster Prize

Best poster prize was awarded to MMIV postdoc Havjin Jacob at the CCBIO Conference at Solstrand May, 2019 for the poster entitled: "Radiogenomic signature in endometrial cancer predicts aggressive disease".

Computational medical imaging and machine learning - methods, infrastructure and applications (MedImML)



Computational medicine and machine learning

Over the past decade there has been a lot of interest in artificial intelligence or AI (loosely: "the theory, development, and application of computer systems able to perform tasks normally requiring human intelligence") across many disciplines and industries, including medicine. This was mainly caused by breakthroughs in what's called "deep learning", a collection of techniques that enable computers to uncover complicated patterns and connections in large data sets. Increased access to data ("big data") and increased computational power has made so-called *deep neural networks* useful for real-world, practical problems, and they have become the state-of-the-art approach to many key challenges in computer vision, language modelling and robotics.

These developments have a huge potential for medical imaging technology, medical data analysis, medical diagnostics and healthcare in general, slowly being realized (*An overview of deep learning in medical imaging focusing on MRI* [link ZMP])) That's not only true for deep learning methods, but also for the wider field of machine learning and data analysis, as part of *computational medicine*. There are however many inherent limitations and challenges with this approach to medical data analysis, ranging from technical limitations to issues related to workflow-integration, trust and regulation.

At the MMIV we work to develop, implement, disseminate and evaluate machine learning techniques in the analysis of medical data, emphasizing analysis of medical images and image-related data.

To successfully incorporate machine learning in medicine, doctors and medical specialists have to take a leading role in both research and development. The tight integration with our project and the hospital, where data is collected and decisions are made, is crucial for our success.

Since MMIV's inception, we've viewed educational activities as a crucial component of the center's current and future success. We've therefore created and taken part in a wide range of courses within *Medical AI*, from bachelor's to PhD, targeting students from medicine, life sciences, computer science and engineering. The goal of our investment in teaching and course creation is to recruit the next generation of researchers to the field, and to increase the general level of understanding of the rolel computational medicine and machine learning have for the future of medical imaging in particular and the future of medicine in general. Our courses include:

- ELMED219: "Artificial intelligence and computational medicine" [ELMED219], UiB & HVL. The course has been given since 2019 as part of the elective period at the medical studies of UiB. It is a collaboration between UiB and HVL and is targeted at medical students and engineers at the MSc level.
- DLN-AI: "A hands-on course on artificial intelligence in computational biotechnology and medicine", HVL. The course is part of the Digital Life Norway Research School, and is open for all interested PhD students in Norway.
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We also put considerable emphasis on dissemination and discussion of methods and results with a wide audience, as part of public and scientific presentations, participations in committees and boards, and the production of written material aimed at the general public.

Our main ambition is to contribute to an increased degree of *personalized medicine* and better decision support for diagnosis, prognosis and therapy in diseases and conditions where images are an important source of information.

The project is part of Centre for Digital Life Norway as an Associated Project. See the Digital Life Norway project MedImML website for more.

Team

Senior researchers: Hauke Bartsch, Erlend Hodneland, Arvid Lundervold, Alexander Selvikvåg Lundervold

PostDocs: Bharath Halandur, Noman Haleem, Marek Kociński, Piero Mana, Alexandra Vik

PhD fellows: Saruar Alam, Marion Berge, Sathiesh Kaliyugarasan, Peder Lillebostad, Samaneh Abolpour Mofrad

Current and former master students and medical research students: Malik Aasen, Ben René Bjørsvik, Jostein Digernes, Carsten Ditlev-Simonsen, Kjetil Dyrland, Ingrid Rye, Sondre Fossen-Romsaas, Anders Benjamin Grinde, Lionel Giriteka, Marianne Hannisdal, Viola Hansen, Bendik Johansen, Fredrik Fidjestøl Mathisen, Sean Murray, Adrian Storm-Johannessen, Sivert Stavland, Peder Lillebostad

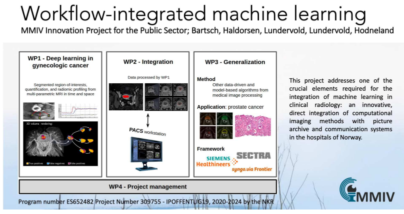
New funding 2020: Innovation Project for the Public Sector

Workflow-integrated machine learning

Recent years have seen exciting applications of machine learning in medical data analysis, from radiology and dermatology to electronic health records and drug discovery. This has led to great interest and enormous expectations from the medical profession. However, it is still early days for the evaluation and integration of artificial intelligence and machine learning-derived information in clinical practice. This proposal addresses one of the crucial missing elements required for implementation and integration in clinical radiology: an innovative, direct integration of computational imaging methods with picture archive and communication systems (PACS). To ensure the usefulness of our innovation, we will apply it to two of the most important health challenges in modern society: cancers in women (uterus) and men (prostate).

Modern machine learning algorithms integrated deep into clinical workflows can have immense impact by offering more personalized treatments and predictions of outcome for a wide variety of conditions. By producing accurate measurements, predictions and pre-processing in close to real-time, machine learning methods make it feasible to do advanced image and data-processing in the clinical setting, potentially lessening workload, empowering physicians, and reducing interobserver variability. If machine learning is able to show convincing results in the clinic this could potentially open the avenue for innovations based on other advanced computational methods that have the potential to improve our understanding and predict health and disease, facilitating a stronger clinical presence for the broader field of computational medicine, an area that holds great promise for the future of medicine.

Primary objective: construct a robust, working prototype that receive a DICOM study pushed from the PACS system, setup and run it through deep learning-based image processing methods, and format and return the resulting information, segmentation mask, derived reports, and quantitative measures back into the PACS. The system will also facilitate the evaluation and further training of the deep learning model based on feedback from the user by storing such modifications as annotations in the PACS. The prototype workflow will be assessed by experienced radiologists from the relevant clinical domains. Secondary objective: prove that our approach is generalizable. This objective is three-fold: the approach should generalize to other computational medical imaging methods, different medical applications, and provide a clear path to embed our product in production-level, widely used PACS and image reading systems.



A new project supported by the Norwegian research council.

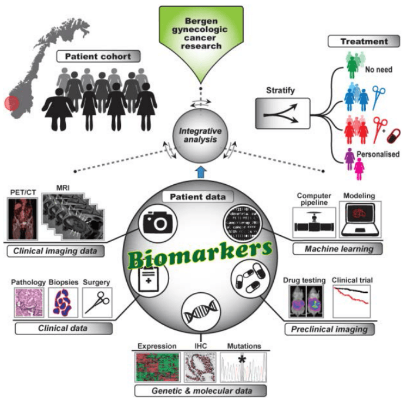
Team

Team leader: Hauke Bartsch
Partners: Ingfrid Haldorsen, Alexander Lundervold, Arvid Lundervold, Erlend Hodneland, Erling Andersen

From conventional and novel imaging markers to radiomic tumor profiling unraveling targets for therapy and personalized treatment strategies in gynecologic cancer

Precision imaging in gynecologic cancer

Research focus: Gynecologic cancers have characteristic structural and functional imaging features reflected in clinical phenotypes, and these imaging markers highlight pathogenic mechanisms potentially targetable by novel treatments. The focus in this project is to integrate imaging biomarkers into clinically relevant treatment algorithms by identifying molecular targets for treatment based on imaging biomarker profiles.



Project: Imaging- and molecular/tissue biomarkers in gynecologic cancer are studied in patients and in preclinical gynecologic cancer models (Figure). Potential imaging biomarkers are identified using machine learning algorithms applied to multiparametric and functional magnetic resonance imaging (MRI) and positron emission tomography/computed tomography (PET/CT) from patients and in mouse models during therapy. Furthermore, the molecular and genetic alterations in the same tumors as well as clinical phenotype and survival are studied in relation to the corresponding imaging biomarker profile. This setup provides a unique platform for identifying promising molecular targets for treatment and their corresponding imaging biomarker profiles.

Important results/milestones: Imaging based tumor textural features (radiomic signatures) predict aggressive disease in endometrial cancer. An AI platform for automated and accurate tumor segmentation in endometrial cancer for extraction of whole-volume radiomic tumor signatures has been developed (**Hodneland et al, Scientific Reports 2021**). Novel visualization tools for assessment of multidimensional imaging data has been developed (**Mörth et al, Computer Graphics Forum 2020, Advances in Computer Graphics 2020**).

Future plans/work in progress: Extend the AI platforms for automated tumor segmentation to other tumor types such as cervical cancer for extraction of whole-volume radiomic tumor signatures (in collaboration with Machine Learning Group/A. Lundervold).

Develop new visualization tools with which to explore and assess multidimensional imaging data in relation to clinical/tissue data in gynecologic cancer (in collaboration with Visualization Group/N. Smit).

Collect and analyze imaging data (for validation in "external" test sets) from gynecological cancer patients treated at different institutions using Research PACS (in collaboration with Hauke Bartsch).

Assess the radiogenomic tumor profile linking genetic signature to radiomic signature in gynecologic cancer (in collaboration with Bergen Gynecologic Cancer Research Group/Prof. Camilla Krakstad).

Current challenges in the field: Three major clinical challenges in gynecologic cancers are: **(1) Overtreatment** of low-risk patients (with early stage disease) who experience unnecessary surgical and/or radiotherapy-/chemotherapy-induced side effects and thereby **reduced quality of life**. **(2) Undertreatment** of patients falsely categorized as low-risk patients who will experience recurrence. **(3) Poor survival in metastatic disease** with no effective targeted therapy or response marker to conventional systemic therapies. **The role of imaging markers and radiomic tumor profiling for risk-stratified tailored treatment algorithms and development of targeted therapies is not yet defined.**

Focus in the coming years: Explore and exploit the potential of precision imaging to enable more targeted treatment strategies and improved patient care in gynecologic cancer.

Team

Team leader: Ingfrid Haldorsen
Senior researchers: prof. Camilla Krakstad, prof. Antonella Zanna Munte-Kaas, Erlend Hodneland, Erling Andre Høivik
PostDocs: Heidi Espedal, Mari Halle
PhD students and medical research students: Kristine E. Fasmer, Julie Dybvik, Njål Lura, Kari Strøno Wagner-Larsen, Hildegunn Aase, Ankush Gulati, Marion Lambrechts Berge, Sathiesh Kaliyugarasan, Hilde E Lien, Agnes J Eide, Jenny Lyngstad

Understanding treatment mechanisms and predictors of clinical response

Brain changes induced by electroconvulsive therapy (ECT)

Current challenges in the field

Major depression is a common and serious medical condition that may lead to profound suffering for affected individuals and families. Electroconvulsive therapy (ECT) is a procedure, done under general anesthesia, in which electric currents are passed through the brain, intentionally causing a brief seizure. Although ECT has remained the most effective acute treatment for major depressive episodes for nearly 80 years, how it works and why it is effective is not well known. Only a small proportion of patients with treatment resistant depression are offered ECT, and typically 60-80% experience a good response (> 50% symptom reduction).

Several neuroimaging studies of ECT have demonstrated volume increases of brain areas after treatment. The most consistent finding has been volume increase of the hippocampus. However, a link between the treatment induced brain changes and clinical improvement has not been established. An important reason for our knowledge gap is that single studies have limited samples and lack statistical power to reach firm conclusions. The Global ECT-MRI Research Collaboration was founded with a belief that collaboration and mega-analysis of combined data will lead to new knowledge that can be generalized across individual research sites.

The researchers at the global ECT MRI meeting 2019.

This project explores how ECT changes the brain, and if the structural (or functional) changes that are seen can explain the effect (or side-effects) of the treatment.

We do not understand how treatment-induced changes relate to outcome. Patients ask for evidence-based advice – prior to treatment – about their personal risk of side effects as well as the probability of good clinical response.

Important results

Local ECT-MRI study

Study protocol published in 2015 (PMID: 25927716), data collection (N=40 patients and 2 control groups with N = 20) was completed in ultimo 2018. The data include multimodal imaging, clinical assessments, neuropsychological testing, blood samples. Data are being shared in GEMRIC and with other collaborators, see below for GEMRIC results. One paper on the effect of electroconvulsive therapy (ECT) on serum tryptophan metabolites (PMID: 31176607) has been published in 2019 and we have promising unpublished results from analyses of neurocognitive effects, brain volume changes, radiological reading and GABA spectroscopy.

Global GEMRIC study

A consortium paper was published in 2017 (PMID: 28275543). Our first project investigated the effects of ECT induced volume change of the hippocampus was published in 2018 (PMID: 30006199). In 2019 we documented that the brain changes induced by ECT are broadly distributed in the brain and not specific for the hippocampus

(PMID: 31561859), and in a separate analysis we showed that the electrical field of the stimulus is correlated to the volume change (PMID: 31644424). By the end of 2019, 20 sites have contributed data giving a current potential for 911 subjects (including controls).

Future plans

Local ECT-MRI study

Publishing results from ongoing analyses. Contribute data to consortia such as the Genetics of ECT and severe Depressive Disorder international consortium (Gen-ECT-ic; PMID: 31802253). We are also planning a new local study which will adopt improved imaging protocols in accord with the GEMRIC recommendations.

Global GEMRIC study

GEMRIC will include more sites and increase sample size to 2000 within 3 years. With more the 20 ongoing analyses – we will further document the effects of ECT on the human brain. New studies will also include resting state fMRI and diffusion weighted imaging (e.g. Diffusion Tensor Imaging). Many will use machine learning algorithms – with a goal of predicting effects and-or side effects. We will also motivate new prospective studies and develop recommendations for harmonization of such studies.

Global GEMRIC consortium map overview.

Team

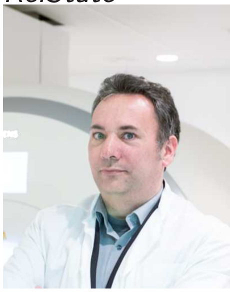
Team leader: Leif Oltedal. **Co-PIs:** Ute Kessler
Senior researchers: prof. Jan Haavik, prof Ketil J Ødegaard, Prof Åsa Hammar, Hauke Bartsch

Post Docs / researchers: Olga Therse Ousdal, Njål Brekke

PhD, medial research students and master students: Ole Johan Eventh Sørhaug, Vera Jane Erchinger, Ingrid Mossige, Jakob Schreiner, Giulio Brancati, Malin Blomberg

International collaborators (GEMRIC board members): Bogdan Draganski (Lausanne, Switzerland), Miklos Aryelan (New York, USA), Katherine Narr / Randall Espinosa (Los Angeles, USA), Christopher Abbott (New Mexico, USA), Amit Annand (Cleveland, USA) Indira Tendolkar / Philip van Eijndhoven (Nijmegen, The Netherlands), Annemieke Dols / Max L Stek (Amsterdam, The Netherlands), Louise Emsell (Leuven, Belgium), Pia Nordanskog / Paul Hamilton (Linköping, Sweden), Martin Balselv Jørgensen (Chopenhagen, Denmark) Ronny Redlich (Münster, Germany), Carles Soriano Mas (Barcelona, Spain), Akihiro Takamiya (Tokyo, Japan), Guido van Wingen (Amsterdam, The Netherlands), Joan Camprodon (Boston, USA), Maximilian Kiebs/Rene Hurlemeann (Bonn, Germany), Alexander Sartorius/Traute Demirakca (Mannheim, Germany), Linda van Diermen (Atwerpen Belgium), Jeroen van Warde (Arnhem, The Netherlands), Antoine Yrondi (Toulouse, France), Joan Prudic (Columbia, New York, USA), Iris Sommer (Utrecht, The Netherlands)

Re:State



When default is not default

When Default Is Not Default project is part of Karsten Specht's newly formed Re:State research group at the Institute of Biological and Medical Psychology, University of Bergen.

The Re:State research group.

This project addresses a very timely and highly important question of cognitive and clinical neuroscience studies: What factors influence the reliability of neuroimaging studies? What are the sources of individual variability? Which constraining factors may help predicting the outcome of a certain therapy?

Recent studies have estimated the reproducibility of psychological studies to be 39% or less and indicated a severe limitation of neuroimaging (fMRI) study reliability. Too small sample sizes, low to moderate effect sizes, and only partly understood neurophysiological mechanisms behind the BOLD/fMRI signal make it difficult to generalize results, thereby impeding the impact of highly needed neuroscience studies on theoretical (scientific), methodological, and clinical progress.

The overall objectives of this project are to (i) improve our understanding of the neurophysiological mechanism of the BOLD signal and its sources of variability, to (ii) extend current methods on effective and functional connectivity measures (Connectoms), to (iii) find a solution to the replication crisis by developing new Bayesian, topology-based, and machine-learning based analysis methods as alternative approaches to today's analysis strategies, and to (iv) induce a paradigm shift from the current focus on an easy to measure but susceptible BOLD signal to the underlying, but (partly) hidden neuronal states that are presumably more stable and reliable.

The project aims to generate new insights into the neurophysiological mechanisms of the BOLD signal, its variability, dependency on endogenous and exogenous parameter, and reliability, and it will advance the research field of basic and clinical neuroimaging by providing new analysis strategies.

Collaborating Partners

National Partners: Assoc. Prof. Morten Brun, Dept. of Mathematics, University of Bergen
Prof. Gaute Einevoll, Faculty of Science and Technology, Norwegian University of Life Sciences
International partners: Prof. Karl Friston, Wellcome Trust Centre for Neuroimaging, University College London
Prof. Viktor Jirsa, CNRS and Institut de Neurosciences des Systèmes, Aix-Marseille University.
Prof. Vince Daniel Calhoun, Mind Research Network and University of New Mexico

New Staff Members

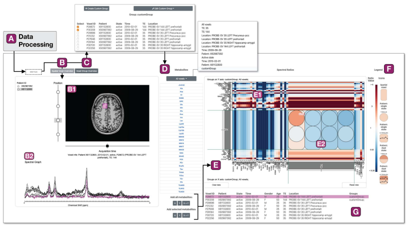
We are happy to announce that we start the year 2020 with two new PhD candidates in the Re:State group: Tania Martínez Montero and Vetle Hushagen, and in Mai Meng-Yun Wang will join us as PostDoc. We wish them welcome and best of luck in their endeavors.

Team

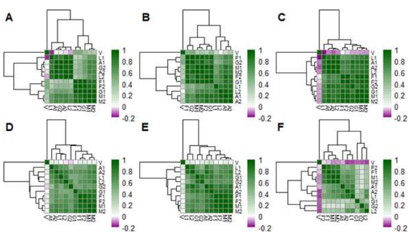
Team leader: Karsten Specht
Collaborators: prof. Morten Brun, prof. Gaute Einevoll, prof. Karl Friston, prof. Vince Daniel Calhoun, prof. Viktor Jirsa
PostDoc: Kjetil Vikene, Meng-Yun Wang
PhD candidates: Liucija Vaisvilaite, Katarzyna Anna Kazimierczak, Vetle Hushagen, Tania Martínez Montero
Senior research technician: Rune Andreas Eikeland
Master students: Guro Sjuls, Julia Tuominen

With medical imaging becoming increasingly multi-faceted (large, time-dependent, multi-dimensional, etc.), new opportunities and challenges emerge when aiming at an optimal utilization of modern imaging data for medical research and clinical patient care.

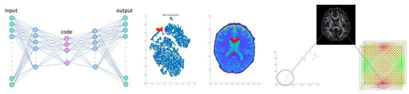
Visual data science for large scale hypothesis management in imaging biomarker discovery



Research focus: Data science is revolutionizing medicine. Rapidly improving medical imaging provides steadily growing and increasingly varied insight into medical conditions. The increased amount and complexity of imaging data leads to significant challenges in knowledge extraction and decision making. To optimally exploit this new wealth of information, it is crucial that the acquired imaging data is successfully linked to the medical condition of the patient. Analogous to biomarkers, which are molecular structures that are used to identify medical conditions, imaging biomarkers are information structures in medical images that can help with diagnostics and treatment planning, formulated in terms of features that can be computed from the imaging data. Successful imaging biomarker discovery is highly challenging and traditionally only a single hypothesis (for a new biomarker) can be examined at a time. This makes it impossible to explore a large number in reasonable time as well as more complex imaging biomarkers across multi-aspect data. In the VIDI project, we research and advance visual data science to improve imaging biomarker discovery through the visual integration of multi-aspect medical data with a new visualization-enabled hypothesis management framework.



Project goals: We aim at accelerating the discovery of new imaging biomarkers by enabling the study of structured sets of hypotheses through the well-balanced integration of computational approaches and interactive visual exploration. We also work on enabling the discovery of more complex imaging biomarkers, across multiple modalities, that potentially are able to more accurately characterize diseases. This may lead to a new way of designing innovative and effective imaging protocols and to the discovery of new imaging biomarkers.



Important results: Due to VIDI's interdisciplinary research, we could work out several relevant results, including:

Interactive Visual Exploration of Metabolite Ratios in MR Spectroscopy Studies – in the context of our work on MR spectroscopy data visualization, we extended our SpectraMosaic tool to enable the visual analysis of complex metabolic signatures.

Interactive Visual Exploration of Clinical Data – in collaboration with colleagues from Magdeburg in Germany, we developed new visual data science methods for hypothesis generation in multi-dimensional, heterogeneous clinical data, including (1) an extension of the dual analysis framework to high-dimensional qualitative data as well as (2) a new method (DimLift) for the interactive hierarchical data exploration through dimensional bundling.

Effects of Motion Correction and Sampling Rate in DCE-MRI data – our study of dynamic contrast enhanced MRI as potential diagnostic tool for Juvenile Idiopathic Arthritis (JIA) suggests the use of a high-level elastic motion correction scheme with a sampling rate of at least 4s.

Scan- and Patient-Specific Arterial Input Functions in a Longitudinal DSC-MRI Study – working with a large patient cohort, we found that AIFs should be chosen per partient, comparing also automatically and semi-automatically chosen AIFs.

Visual Data Science for Diffusion Weighted MR Images – we work on the integration of machine learning (in particular, an autoencoder network) with interactive visual data exploration and analysis to extract information from diffusion weighted MR images that goes beyond linear diffusion tensors.

Future plans: Next, we plan to explore causal model validation and research new visual data science methods to support medical decision making. We also aim to understand whether DSC-MRI can help with detecting early effects of Gamma Knife Surgery on brain metastases. Further, we study the opportunity of having machine learning can enable a semi-automatic delineation of critical fiber tracks in DWI data.

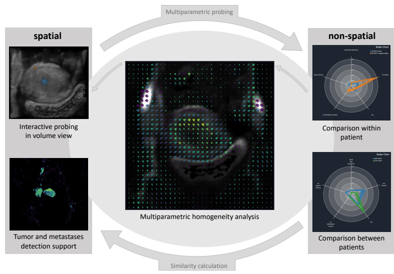
Team

Team leader (PI): Helwig Hauser
Senior researchers (co-PIs): Stefan Bruckner, Renate Gruner, Noeska Smit
PhD students: Laura Garrison, Fourough Gharbalchi, Lea Starck

Advanced interactive visualization of multimodal medical imaging data for visual analysis

Multimodal medical visualization

Research focus: Advances in medical imaging techniques are bringing more and more different contrasts that provide additional information. For instance, a single patient can have a CT scan, PET scan, as well as an MRI scan with different weighted images. When there is more than one modality acquired, mental integration of the different contrasts between the different images becomes more challenging. In this project, we aspire to develop novel interactive visualization approaches for improved exploration, analysis, and communication of multimodal medical imaging data. Our current focus in this context is on multi-parametric MR acquisitions.
Current challenges in the field: Most multimodal medical imaging visualization methods are targetting no more than two modalities at the same time. Our research aims to further improve methods so that a multitude of modalities can be analyzed at once.
Project: In this project, we are currently focusing on two application areas. Eric Mörth is researching novel interactive visualization approaches for the visualization of multimodal MR data in the context of gynecological cancer imaging in collaboration with the MMIV gynecological cancer imaging project and the Bergen Gynecologic Cancer Research Group. Sherin Sugathan researches novel interactive visualization approaches for the visualization of multimodal MR data in the context of MS in collaboration with the MMIV Advanced Neuroimaging project.
Important results: The developed methods are prototyped in software applications that can be used by researchers within MMIV. One example of this is the ParaGlyder application developed by Mörth for the analysis of multi-parametric MR in the context of gynecological cancer imaging.



The ParaGlyder application combines spatial and non-spatial visualization to enable multi-parametric analysis and exploration.
Future plans: The team is currently investigating novel tools for visual analysis of multi-modal data across cohorts of patients. In the future, we hope to further investigate time-varying multimodal data analysis.

Team

Team leader: Noeska Smit
Collaborators: Ingfrid Haldorsen, Erlend Hodneland, Kari Strøno Wagner-Larsen, Kai Lawonn, Stefan Bruckner, Hauke Bartsch, Frank Riemer, Renate Gruner
PhD candidates: Eric Mörth, Sherin Sugathan
Master students: Stian Soltvedt, Robin Grundvåg

The next generation of the radiography profession

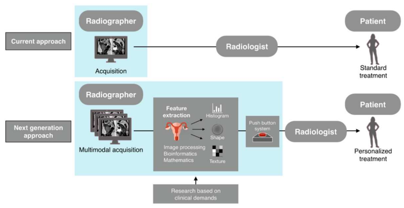
Innovation in image-based personalized medicine

Research focus: In this project we aim to bridge artificial intelligence (AI) with the radiography profession to advance MRI practice and patient care. The project will address the effects of patient and MRI acquisition parameter variations when using AI for quantitative image analysis, address reproducibility issues of AI driven quantitative image analysis, and evaluate the integration of AI driven quantitative image analysis in current radiology workflow.

Current challenges in the field: In clinical practice radiographers perform imaging procedures providing medical images that are used to detect and diagnose disease with only limited attempts to quantify what is visualized. Radiologists interpret images based on visual assessment and observer-driven pattern recognition. Despite the new era of quantitative imaging and the proven clinical potential of quantitative imaging biomarkers (QIB), very few QIBs are clinically used. Patient and image variability may have a major impact on the success of integrating image analysis algorithms and the accurate and reliable extraction of clinical useful biomarkers. The next generation radiography practice and research must take more consciously into account the quantitative nature of medical image data, from patient preparation, image acquisition and image analysis. In such way, enhanced diagnostic information will be provided and ensure more efficient image analysis workflows to improve patient care.

Project: The project is designed in four parts with related research questions: 1. What effect do different image related variables have on the success of AI-driven segmentation algorithms in gynaecological MRI? 2. What effect do pre-processing algorithms (image registration and motion correction) have on quantitative imaging biomarkers (tumour volume and apparent diffusion coefficient) reproducibility in gynaecological MRI data? 3. How do different stakeholders evaluate an innovative radiology workflow integrating AI driven quantitative imaging analysis according to user friendliness, accuracy, performance, and feasibility of integration into local workflow? 4. How can digital health innovations, including AI and machine learning, be purposefully integrated into the radiography professions education and clinical practice to enhance patient care?

To ensure usefulness of the proposed research and innovation project it will be applied to endometrial cancer, one of the most common gynaecological carcinomas in western countries.



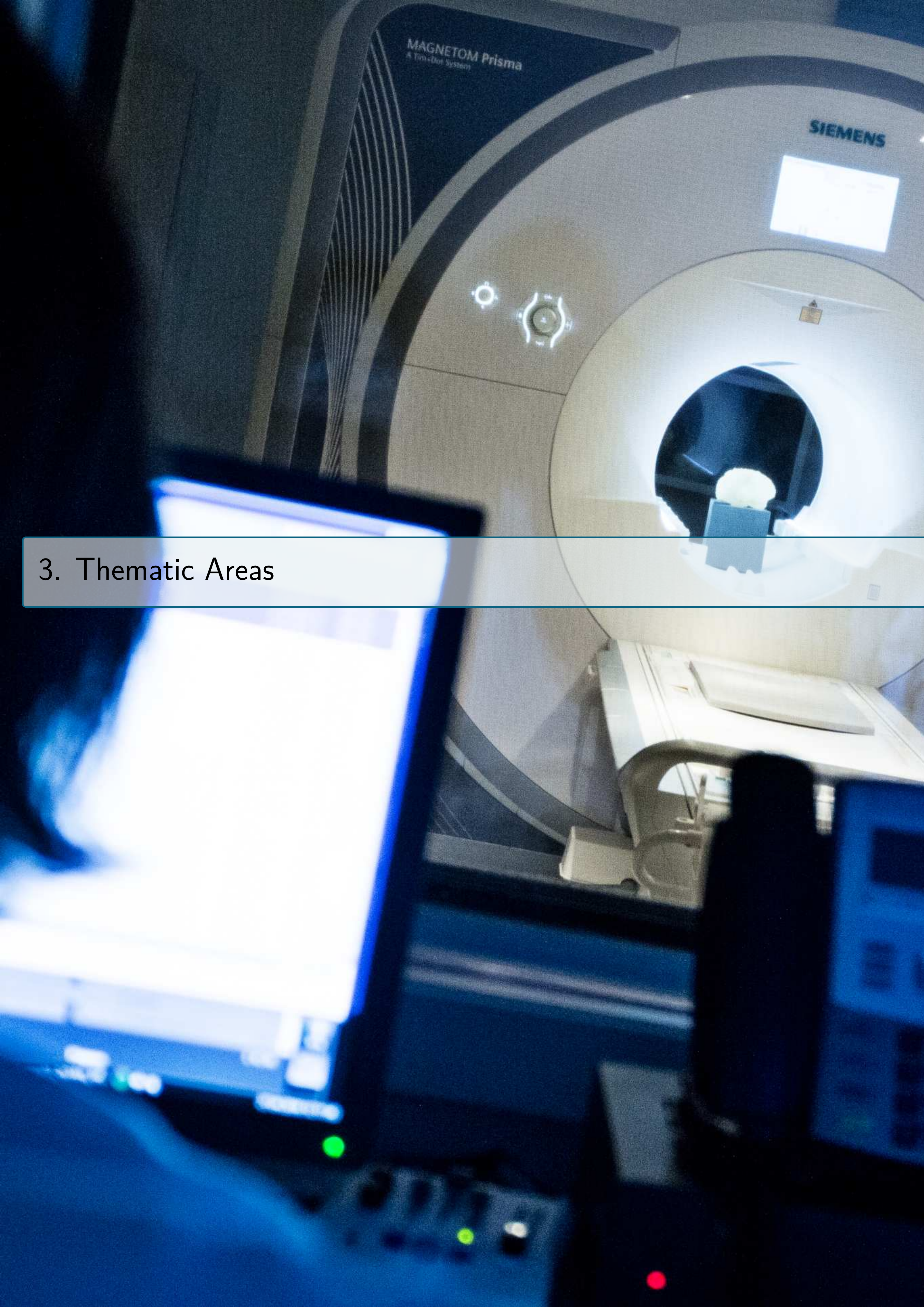
In the image above, the upper arrow describes the current decision-making process from image acquisition, through the radiologist's interpretation followed by a conclusion that influences the treatment the patients receive. The lower arrow illustrates the steps and improvements we aim to carry out in this project representing the next generation of radiography. A more automated feature extraction pipeline culminating in a push button system will enable more information to be drawn from the image datasets without increasing the radiologist's workload. The blue areas illustrate the radiographer's role in the current (top) and next generation (bottom) approach.

Future plans: the project has recently been launched and no results are currently available. The next-generation image acquisition represents a challenge to the status quo in the radiography profession. Radiography research can aid the translation and integration of AI into radiology workflow by addressing validation and standardization issues, and through innovative methods contribute to design the next generation radiology workflow.

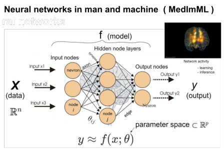
Team

Team leader: Eli Eikefjord
Collaborators: Alexander Lundervold, Cecilie B. Rygh, Ingfrid Haldorsen, Arvid Lundervold, Erlend Hodneland, Synnoeve N. Aasen
PhD candidate: Marion Lambrechts Berge

3. Thematic Areas



Computational medical imaging and machine learning - methods, infrastructure and applications (MedImML)



Computational medicine and machine learning

Over the past decade there has been a lot of interest in artificial intelligence or AI (loosely: "the theory, development, and application of computer systems able to perform tasks normally requiring human intelligence") across many disciplines and industries, including medicine. This was mainly caused by breakthroughs in what's called "deep learning", a collection of techniques that enable computers to uncover complicated patterns and connections in large data sets. Increased access to data ("big data") and increased computational power has made so-called *deep neural networks* useful for real-world, practical problems, and they have become the state-of-the-art approach to many key challenges in computer vision, language modelling and robotics.

These developments have a huge potential for medical imaging technology, medical data analysis, medical diagnostics and healthcare in general, slowly being realized (*An overview of deep learning in medical imaging focusing on MRI* [link ZMP])) That's not only true for deep learning methods, but also for the wider field of machine learning and data analysis, as part of *computational medicine*. There are however many inherent limitations and challenges with this approach to medical data analysis, ranging from technical limitations to issues related to workflow-integration, trust and regulation.

At the MMIV we work to develop, implement, disseminate and evaluate machine learning techniques in the analysis of medical data, emphasizing analysis of medical images and image-related data.

To successfully incorporate machine learning in medicine, doctors and medical specialists have to take a leading role in both research and development. The tight integration with our project and the hospital, where data is collected and decisions are made, is crucial for our success.

Since MMIV's inception, we've viewed educational activities as a crucial component of the center's current and future success. We've therefore created and taken part in a wide range of courses within *Medical AI*, from bachelor's to PhD, targeting students from medicine, life sciences, computer science and engineering. The goal of our investment in teaching and course creation is to recruit the next generation of researchers to the field, and to increase the general level of understanding of the rolel computational medicine and machine learning have for the future of medical imaging in particular and the future of medicine in general. Our courses include:

- ELMED219: "Artificial intelligence and computational medicine" [ELMED219], UiB & HVL. The course has been given since 2019 as part of the elective period at the medical studies of UiB. It is a collaboration between UiB and HVL and is targeted at medical students and engineers at the MSc level.
- DLN-AI: "A hands-on course on artificial intelligence in computational biotechnology and medicine", HVL. The course is part of the Digital Life Norway Research School, and is open for all interested PhD students in Norway.
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We also put considerable emphasis on dissemination and discussion of methods and results with a wide audience, as part of public and scientific presentations, participations in committees and boards, and the production of written material aimed at the general public.

Our main ambition is to contribute to an increased degree of *personalized medicine* and better decision support for diagnosis, prognosis and therapy in diseases and conditions where images are an important source of information.

The project is part of Centre for Digital Life Norway as an Associated Project. See the Digital Life Norway project MedImML website for more.

Team

Senior researchers: Hauke Bartsch, Erlend Hodneland, Arvid Lundervold, Alexander Selvikvåg Lundervold

PostDocs: Bharath Halandur, Noman Haleem, Marek Kociński, Piero Mana, Alexandra Vik

PhD fellows: Saruar Alam, Marion Berge, Sathiesh Kaliyugarasan, Peder Lillebostad, Samaneh Abolpour Mofrad

Current and former master students and medical research students: Malik Aasen, Ben René Bjørsvik, Jostein Digernes, Carsten Ditlev-Simonsen, Kjetil Dyrland, Ingrid Rye, Sondre Fossen-Romsaas, Anders Benjamin Grinde, Lionel Giriteka, Marianne Hannisdal, Viola Hansen, Bendik Johansen, Fredrik Fidjestøl Mathisen, Sean Murray, Adrian Storm-Johannessen, Sivert Stavland, Peder Lillebostad

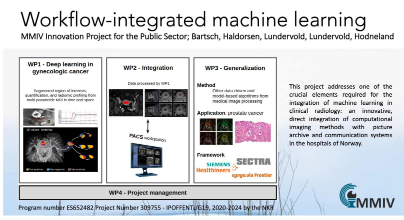
New funding 2020: Innovation Project for the Public Sector

Workflow-integrated machine learning

Recent years have seen exciting applications of machine learning in medical data analysis, from radiology and dermatology to electronic health records and drug discovery. This has led to great interest and enormous expectations from the medical profession. However, it is still early days for the evaluation and integration of artificial intelligence and machine learning-derived information in clinical practice. This proposal addresses one of the crucial missing elements required for implementation and integration in clinical radiology: an innovative, direct integration of computational imaging methods with picture archive and communication systems (PACS). To ensure the usefulness of our innovation, we will apply it to two of the most important health challenges in modern society: cancers in women (uterus) and men (prostate).

Modern machine learning algorithms integrated deep into clinical workflows can have immense impact by offering more personalized treatments and predictions of outcome for a wide variety of conditions. By producing accurate measurements, predictions and pre-processing in close to real-time, machine learning methods make it feasible to do advanced image and data-processing in the clinical setting, potentially lessening workload, empowering physicians, and reducing interobserver variability. If machine learning is able to show convincing results in the clinic this could potentially open the avenue for innovations based on other advanced computational methods that have the potential to improve our understanding and predict health and disease, facilitating a stronger clinical presence for the broader field of computational medicine, an area that holds great promise for the future of medicine.

Primary objective: construct a robust, working prototype that receive a DICOM study pushed from the PACS system, setup and run it through deep learning-based image processing methods, and format and return the resulting information, segmentation mask, derived reports, and quantitative measures back into the PACS. The system will also facilitate the evaluation and further training of the deep learning model based on feedback from the user by storing such modifications as annotations in the PACS. The prototype workflow will be assessed by experienced radiologists from the relevant clinical domains. Secondary objective: prove that our approach is generalizable. This objective is three-fold: the approach should generalize to other computational medical imaging methods, different medical applications, and provide a clear path to embed our product in production-level, widely used PACS and image reading systems.



A new project supported by the Norwegian research council.

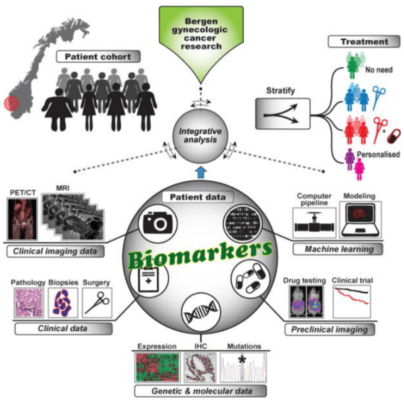
Team

Team leader: Hauke Bartsch
Partners: Ingfrid Haldorsen, Alexander Lundervold, Arvid Lundervold, Erlend Hodneland, Erling Andersen

From conventional and novel imaging markers to radiomic tumor profiling unraveling targets for therapy and personalized treatment strategies in gynecologic cancer

Precision imaging in gynecologic cancer

Research focus: Gynecologic cancers have characteristic structural and functional imaging features reflected in clinical phenotypes, and these imaging markers highlight pathogenic mechanisms potentially targetable by novel treatments. The focus in this project is to integrate imaging biomarkers into clinically relevant treatment algorithms by identifying molecular targets for treatment based on imaging biomarker profiles.



Project: Imaging- and molecular/tissue biomarkers in gynecologic cancer are studied in patients and in preclinical gynecologic cancer models (Figure). Potential imaging biomarkers are identified using machine learning algorithms applied to multiparametric and functional magnetic resonance imaging (MRI) and positron emission tomography/computed tomography (PET/CT) from patients and in mouse models during therapy. Furthermore, the molecular and genetic alterations in the same tumors as well as clinical phenotype and survival are studied in relation to the corresponding imaging biomarker profile. This setup provides a unique platform for identifying promising molecular targets for treatment and their corresponding imaging biomarker profiles.

Important results/milestones: Imaging based tumor textural features (radiomic signatures) predict aggressive disease in endometrial cancer. An AI platform for automated and accurate tumor segmentation in endometrial cancer for extraction of whole-volume radiomic tumor signatures has been developed (**Hodneland et al, Scientific Reports 2021**). Novel visualization tools for assessment of multidimensional imaging data has been developed (**Mörth et al, Computer Graphics Forum 2020, Advances in Computer Graphics 2020**).

Future plans/work in progress: Extend the AI platforms for automated tumor segmentation to other tumor types such as cervical cancer for extraction of whole-volume radiomic tumor signatures (in collaboration with Machine Learning Group/A. Lundervold).

Develop new visualization tools with which to explore and assess multidimensional imaging data in relation to clinical/tissue data in gynecologic cancer (in collaboration with Visualization Group/N. Smit).

Collect and analyze imaging data (for validation in "external" test sets) from gynecological cancer patients treated at different institutions using Research PACS (in collaboration with Hauke Bartsch).

Assess the radiogenomic tumor profile linking genetic signature to radiomic signature in gynecologic cancer (in collaboration with Bergen Gynecologic Cancer Research Group/Prof. Camilla Krakstad).

Current challenges in the field: Three major clinical challenges in gynecologic cancers are: **(1) Overtreatment** of low-risk patients (with early stage disease) who experience unnecessary surgical and/or radiotherapy-/chemotherapy-induced side effects and thereby **reduced quality of life**. **(2) Undertreatment** of patients falsely categorized as low-risk patients who will experience recurrence. **(3) Poor survival in metastatic disease** with no effective targeted therapy or response marker to conventional systemic therapies. **The role of imaging markers and radiomic tumor profiling for risk-stratified tailored treatment algorithms and development of targeted therapies is not yet defined.**

Focus in the coming years: Explore and exploit the potential of precision imaging to enable more targeted treatment strategies and improved patient care in gynecologic cancer.

Team

Team leader: Ingfrid Haldorsen
Senior researchers: prof. Camilla Krakstad, prof. Antonella Zanna Munte-Kaas, Erlend Hodneland, Erling Andre Høivik
PostDocs: Heidi Espedal, Mari Halle
PhD students and medical research students: Kristine E. Fasmer, Julie Dybvik, Njål Lura, Kari Strøno Wagner-Larsen, Hildegunn Aase, Ankush Gulati, Marion Lambrechts Berge, Sathiesh Kaliyugarasan, Hilde E Lien, Agnes J Eide, Jenny Lyngstad

Understanding treatment mechanisms and predictors of clinical response

Brain changes induced by electroconvulsive therapy (ECT)

Current challenges in the field

Major depression is a common and serious medical condition that may lead to profound suffering for affected individuals and families. Electroconvulsive therapy (ECT) is a procedure, done under general anesthesia, in which electric currents are passed through the brain, intentionally causing a brief seizure. Although ECT has remained the most effective acute treatment for major depressive episodes for nearly 80 years, how it works and why it is effective is not well known. Only a small proportion of patients with treatment resistant depression are offered ECT, and typically 60-80% experience a good response (> 50% symptom reduction).

Several neuroimaging studies of ECT have demonstrated volume increases of brain areas after treatment. The most consistent finding has been volume increase of the hippocampus. However, a link between the treatment induced brain changes and clinical improvement has not been established. An important reason for our knowledge gap is that single studies have limited samples and lack statistical power to reach firm conclusions. The Global ECT-MRI Research Collaboration was founded with a belief that collaboration and mega-analysis of combined data will lead to new knowledge that can be generalized across individual research sites.

The researchers at the global ECT MRI meeting 2019.

This project explores how ECT changes the brain, and if the structural (or functional) changes that are seen can explain the effect (or side-effects) of the treatment.

We do not understand how treatment-induced changes relate to outcome. Patients ask for evidence-based advice – prior to treatment – about their personal risk of side effects as well as the probability of good clinical response.

Important results

Local ECT-MRI study

Study protocol published in 2015 (PMID: 25927716), data collection (N=40 patients and 2 control groups with N = 20) was completed in ultimo 2018. The data include multimodal imaging, clinical assessments, neuropsychological testing, blood samples. Data are being shared in GEMRIC and with other collaborators, see below for GEMRIC results. One paper on the effect of electroconvulsive therapy (ECT) on serum tryptophan metabolites (PMID: 31176607) has been published in 2019 and we have promising unpublished results from analyses of neurocognitive effects, brain volume changes, radiological reading and GABA spectroscopy.

Global GEMRIC study

A consortium paper was published in 2017 (PMID: 28275543). Our first project investigated the effects of ECT induced volume change of the hippocampus was published in 2018 (PMID: 30006199). In 2019 we documented that the brain changes induced by ECT are broadly distributed in the brain and not specific for the hippocampus

(PMID: 31561859), and in a separate analysis we showed that the electrical field of the stimulus is correlated to the volume change (PMID: 31644424). By the end of 2019, 20 sites have contributed data giving a current potential for 911 subjects (including controls).

Future plans

Local ECT-MRI study

Publishing results from ongoing analyses. Contribute data to consortia such as the Genetics of ECT and severe Depressive Disorder international consortium (Gen-ECT-ic; PMID: 31802253). We are also planning a new local study which will adopt improved imaging protocols in accord with the GEMRIC recommendations.

Global GEMRIC study

GEMRIC will include more sites and increase sample size to 2000 within 3 years. With more the 20 ongoing analyses – we will further document the effects of ECT on the human brain. New studies will also include resting state fMRI and diffusion weighted imaging (e.g. Diffusion Tensor Imaging). Many will use machine learning algorithms – with a goal of predicting effects and-or side effects. We will also motivate new prospective studies and develop recommendations for harmonization of such studies.

Global GEMRIC consortium map overview.

Team

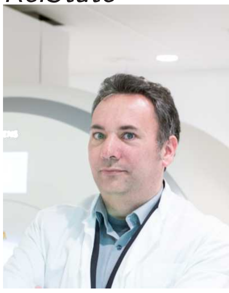
Team leader: Leif Oltedal. **Co-PIs:** Ute Kessler
Senior researchers: prof. Jan Haavik, prof Ketil J Ødegaard, Prof Åsa Hammar, Hauke Bartsch

Post Docs / researchers: Olga Therse Ousdal, Njål Brekke

PhD, medial research students and master students: Ole Johan Eventh Sørhaug, Vera Jane Erchinger, Ingrid Mossige, Jakob Schreiner, Giulio Brancati, Malin Blomberg

International collaborators (GEMRIC board members): Bogdan Draganski (Lausanne, Switzerland), Miklos Aryelan (New York, USA), Katherine Narr / Randall Espinosa (Los Angeles, USA), Christopher Abbott (New Mexico, USA), Amit Annand (Cleveland, USA) Indira Tendolkar / Philip van Eijndhoven (Nijmegen, The Netherlands), Annemieke Dols / Max L Stek (Amsterdam, The Netherlands), Louise Emsell (Leuven, Belgium), Pia Nordanskog / Paul Hamilton (Linköping, Sweden), Martin Balselv Jørgensen (Chopenhagen, Denmark) Ronny Redlich (Münster, Germany), Carles Soriano Mas (Barcelona, Spain), Akihiro Takamiya (Tokyo, Japan), Guido van Wingen (Amsterdam, The Netherlands), Joan Camprodon (Boston, USA), Maximilian Kiebs/Rene Hurlemeann (Bonn, Germany), Alexander Sartorius/Traute Demirakca (Mannheim, Germany), Linda van Diermen (Atwerpen Belgium), Jeroen van Warde (Arnhem, The Netherlands), Antoine Yrondi (Toulouse, France), Joan Prudic (Columbia, New York, USA), Iris Sommer (Utrecht, The Netherlands)

Re:State



When default is not default

When Default Is Not Default project is part of Karsten Specht's newly formed Re:State research group at the Institute of Biological and Medical Psychology, University of Bergen.

The Re:State research group.

This project addresses a very timely and highly important question of cognitive and clinical neuroscience studies: What factors influence the reliability of neuroimaging studies? What are the sources of individual variability? Which constraining factors may help predicting the outcome of a certain therapy?

Recent studies have estimated the reproducibility of psychological studies to be 39% or less and indicated a severe limitation of neuroimaging (fMRI) study reliability. Too small sample sizes, low to moderate effect sizes, and only partly understood neurophysiological mechanisms behind the BOLD/fMRI signal make it difficult to generalize results, thereby impeding the impact of highly needed neuroscience studies on theoretical (scientific), methodological, and clinical progress.

The overall objectives of this project are to (i) improve our understanding of the neurophysiological mechanism of the BOLD signal and its sources of variability, to (ii) extend current methods on effective and functional connectivity measures (Connectoms), to (iii) find a solution to the replication crisis by developing new Bayesian, topology-based, and machine-learning based analysis methods as alternative approaches to today's analysis strategies, and to (iv) induce a paradigm shift from the current focus on an easy to measure but susceptible BOLD signal to the underlying, but (partly) hidden neuronal states that are presumably more stable and reliable.

The project aims to generate new insights into the neurophysiological mechanisms of the BOLD signal, its variability, dependency on endogenous and exogenous parameter, and reliability, and it will advance the research field of basic and clinical neuroimaging by providing new analysis strategies.

Collaborating Partners

National Partners: Assoc. Prof. Morten Brun, Dept. of Mathematics, University of Bergen
Prof. Gaute Einevoll, Faculty of Science and Technology, Norwegian University of Life Sciences
International partners: Prof. Karl Friston, Wellcome Trust Centre for Neuroimaging, University College London
Prof. Viktor Jirsa, CNRS and Institut de Neurosciences des Systèmes, Aix-Marseille University.
Prof. Vince Daniel Calhoun, Mind Research Network and University of New Mexico

New Staff Members

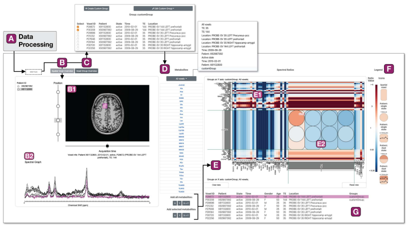
We are happy to announce that we start the year 2020 with two new PhD candidates in the Re:State group: Tania Martínez Montero and Vetle Hushagen, and in Mai Meng-Yun Wang will join us as PostDoc. We wish them welcome and best of luck in their endeavors.

Team

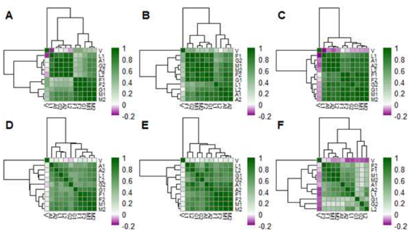
Team leader: Karsten Specht
Collaborators: prof. Morten Brun, prof. Gaute Einevoll, prof. Karl Friston, prof. Vince Daniel Calhoun, prof. Viktor Jirsa
PostDoc: Kjetil Vikene, Meng-Yun Wang
PhD candidates: Liucija Vaisvilaite, Katarzyna Anna Kazimierczak, Vetle Hushagen, Tania Martínez Montero
Senior research technician: Rune Andreas Eikeland
Master students: Guro Sjuls, Julia Tuominen

With medical imaging becoming increasingly multi-faceted (large, time-dependent, multi-dimensional, etc.), new opportunities and challenges emerge when aiming at an optimal utilization of modern imaging data for medical research and clinical patient care.

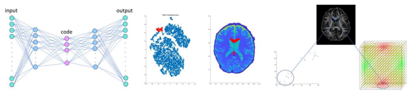
Visual data science for large scale hypothesis management in imaging biomarker discovery



Research focus: Data science is revolutionizing medicine. Rapidly improving medical imaging provides steadily growing and increasingly varied insight into medical conditions. The increased amount and complexity of imaging data leads to significant challenges in knowledge extraction and decision making. To optimally exploit this new wealth of information, it is crucial that the acquired imaging data is successfully linked to the medical condition of the patient. Analogous to biomarkers, which are molecular structures that are used to identify medical conditions, imaging biomarkers are information structures in medical images that can help with diagnostics and treatment planning, formulated in terms of features that can be computed from the imaging data. Successful imaging biomarker discovery is highly challenging and traditionally only a single hypothesis (for a new biomarker) can be examined at a time. This makes it impossible to explore a large number in reasonable time as well as more complex imaging biomarkers across multi-aspect data. In the VIDI project, we research and advance visual data science to improve imaging biomarker discovery through the visual integration of multi-aspect medical data with a new visualization-enabled hypothesis management framework.



Project goals: We aim at accelerating the discovery of new imaging biomarkers by enabling the study of structured sets of hypotheses through the well-balanced integration of computational approaches and interactive visual exploration. We also work on enabling the discovery of more complex imaging biomarkers, across multiple modalities, that potentially are able to more accurately characterize diseases. This may lead to a new way of designing innovative and effective imaging protocols and to the discovery of new imaging biomarkers.



Important results: Due to VIDI's interdisciplinary research, we could work out several relevant results, including:

Interactive Visual Exploration of Metabolite Ratios in MR Spectroscopy Studies – in the context of our work on MR spectroscopy data visualization, we extended our SpectraMosaic tool to enable the visual analysis of complex metabolic signatures.

Interactive Visual Exploration of Clinical Data – in collaboration with colleagues from Magdeburg in Germany, we developed new visual data science methods for hypothesis generation in multi-dimensional, heterogeneous clinical data, including (1) an extension of the dual analysis framework to high-dimensional qualitative data as well as (2) a new method (DimLift) for the interactive hierarchical data exploration through dimensional bundling.

Effects of Motion Correction and Sampling Rate in DCE-MRI data – our study of dynamic contrast enhanced MRI as potential diagnostic tool for Juvenile Idiopathic Arthritis (JIA) suggests the use of a high-level elastic motion correction scheme with a sampling rate of at least 4s.

Scan- and Patient-Specific Arterial Input Functions in a Longitudinal DSC-MRI Study – working with a large patient cohort, we found that AIFs should be chosen per partient, comparing also automatically and semi-automatically chosen AIFs.

Visual Data Science for Diffusion Weighted MR Images – we work on the integration of machine learning (in particular, an autoencoder network) with interactive visual data exploration and analysis to extract information from diffusion weighted MR images that goes beyond linear diffusion tensors.

Future plans: Next, we plan to explore causal model validation and research new visual data science methods to support medical decision making. We also aim to understand whether DSC-MRI can help with detecting early effects of Gamma Knife Surgery on brain metastases. Further, we study the opportunity of having machine learning can enable a semi-automatic delineation of critical fiber tracks in DWI data.

Team

Team leader (PI): Helwig Hauser
Senior researchers (co-PIs): Stefan Bruckner, Renate Gruner, Noeska Smit
PhD students: Laura Garrison, Fourough Gharbalchi, Lea Starck

Advanced interactive visualization of multimodal medical imaging data for visual analysis

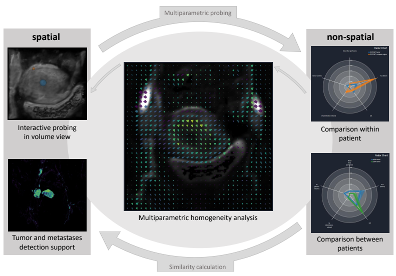
Multimodal medical visualization

Research focus: Advances in medical imaging techniques are bringing more and more different contrasts that provide additional information. For instance, a single patient can have a CT scan, PET scan, as well as an MRI scan with different weighted images. When there is more than one modality acquired, mental integration of the different contrasts between the different images becomes more challenging. In this project, we aspire to develop novel interactive visualization approaches for improved exploration, analysis, and communication of multimodal medical imaging data. Our current focus in this context is on multi-parametric MR acquisitions.

Current challenges in the field: Most multimodal medical imaging visualization methods are targetting no more than two modalities at the same time. Our research aims to further improve methods so that a multitude of modalities can be analyzed at once.

Project: In this project, we are currently focusing on two application areas. Eric Mörth is researching novel interactive visualization approaches for the visualization of multimodal MR data in the context of gynecalogical cancer imaging in collaboration with the MMIV gynecological cancer imaging project and the Bergen Gynecologic Cancer Research Group. Sherin Sugathan researches novel interactive visualization approaches for the visualization of multimodal MR data in the context of MS in collaboration with the MMIV Advanced Neuroimaging project.

Important results: The developed methods are prototyped in software applications that can be used by researchers within MMIV. One example of this is the ParaGlyder application developed by Mörth for the analysis of multi-parametric MR in the context of gynecological cancer imaging.



The ParaGlyder application combines spatial and non-spatial visualization to enable multi-parametric analysis and exploration.

Future plans: The team is currently investigating novel tools for visual analysis of multi-modal data across cohorts of patients. In the future, we hope to further investigate time-varying multimodal data analysis.

Team

Team leader: Noeska Smit
Collaborators: Ingfrid Haldorsen, Erlend Hodneland, Kari Strøno Wagner-Larsen, Kai Lawonn, Stefan Bruckner, Hauke Bartsch, Frank Riemer, Renate Gruner
PhD candidates: Eric Mörth, Sherin Sugathan
Master students: Stian Soltvedt, Robin Grundvåg

The next generation of the radiography profession

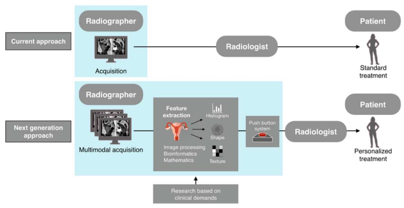
Innovation in image-based personalized medicine

Research focus: In this project we aim to bridge artificial intelligence (AI) with the radiography profession to advance MRI practice and patient care. The project will address the effects of patient and MRI acquisition parameter variations when using AI for quantitative image analysis, address reproducibility issues of AI driven quantitative image analysis, and evaluate the integration of AI driven quantitative image analysis in current radiology workflow.

Current challenges in the field: In clinical practice radiographers perform imaging procedures providing medical images that are used to detect and diagnose disease with only limited attempts to quantify what is visualized. Radiologists interpret images based on visual assessment and observer-driven pattern recognition. Despite the new era of quantitative imaging and the proven clinical potential of quantitative imaging biomarkers (QIB), very few QIBs are clinically used. Patient and image variability may have a major impact on the success of integrating image analysis algorithms and the accurate and reliable extraction of clinical useful biomarkers. The next generation radiography practice and research must take more consciously into account the quantitative nature of medical image data, from patient preparation, image acquisition and image analysis. In such way, enhanced diagnostic information will be provided and ensure more efficient image analysis workflows to improve patient care.

Project: The project is designed in four parts with related research questions: 1. What effect do different image related variables have on the success of AI-driven segmentation algorithms in gynaecological MRI? 2. What effect do pre-processing algorithms (image registration and motion correction) have on quantitative imaging biomarkers (tumour volume and apparent diffusion coefficient) reproducibility in gynaecological MRI data? 3. How do different stakeholders evaluate an innovative radiology workflow integrating AI driven quantitative imaging analysis according to user friendliness, accuracy, performance, and feasibility of integration into local workflow? 4. How can digital health innovations, including AI and machine learning, be purposefully integrated into the radiography professions education and clinical practice to enhance patient care?

To ensure usefulness of the proposed research and innovation project it will be applied to endometrial cancer, one of the most common gynaecological carcinomas in western countries.



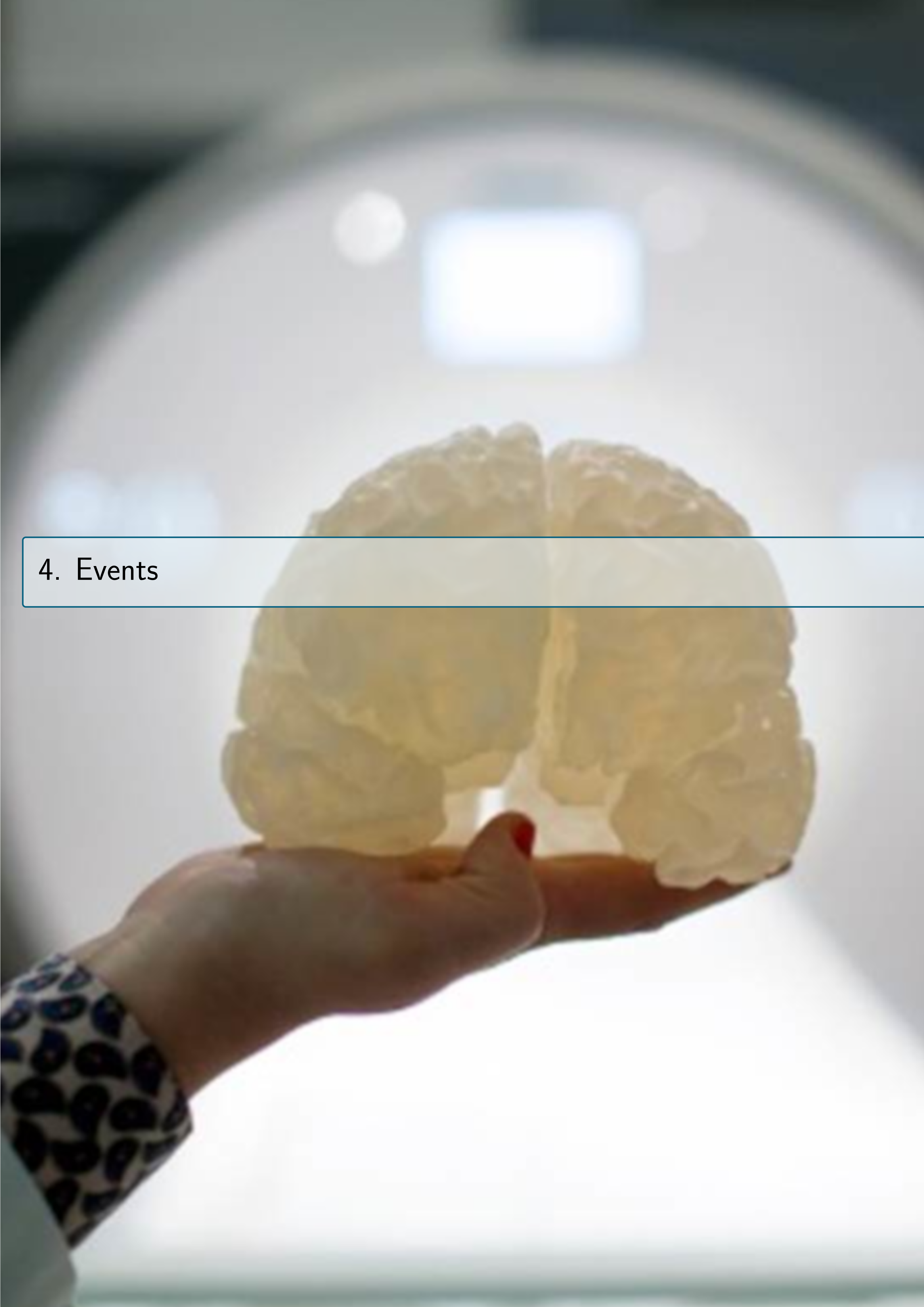
In the image above, the upper arrow describes the current decision-making process from image acquisition, through the radiologist's interpretation followed by a conclusion that influences the treatment the patients receive. The lower arrow illustrates the steps and improvements we aim to carry out in this project representing the next generation of radiography. A more automated feature extraction pipeline culminating in a push button system will enable more information to be drawn from the image datasets without increasing the radiologist's workload. The blue areas illustrate the radiographer's role in the current (top) and next generation (bottom) approach.

Future plans: the project has recently been launched and no results are currently available. The next-generation image acquisition represents a challenge to the status quo in the radiography profession. Radiography research can aid the translation and integration of AI into radiology workflow by addressing validation and standardization issues, and through innovative methods contribute to design the next generation radiology workflow.

Team

Team leader: Eli Eikefjord
Collaborators: Alexander Lundervold, Cecilie B. Rygh, Ingfrid Haldorsen, Arvid Lundervold, Erlend Hodneland, Synnoeve N. Aasen
PhD candidate: Marion Lambrechts Berge

4. Events

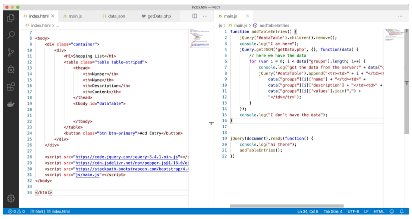


Hauke Bartsch, Dr. rer. nat.

The very basics of web-programming - without any gaps

A workshop in the without-any-gaps series of MMIV

No prior programing skills are required to participate in this class but, bring a laptop and actively participate. After this class you can create a single page web applications for your machine learning and visualization projects that run on all major web-browsers and have an interface that people are familiar with. Programming concepts are explained in class and step by step we will enhance our example application with interactive components.
Any web-application consists of two components, the web-server that provides the database and the client application component that is executed in the users browser. All programming logic is executed on the client application programmed in JavaScript - a programming language designed for the web. The minimal server component is programmed in our class in PHP, a simple programming language for the server that implements for example authentication (not covered in this class).



The concept of a single page web-application allows us to provide visualizations for the web.

We will focus our efforts on the client side programming and explain how events trigger actions that result in an update of the interface which creates reactive web experience for the user. The capabilities of styling the website using cascading style sheets (CSS) will allow us to generate custom interface components for special needs. For a basic styling framework we will use Bootstrap (v4). This library extends the HTML code describing the interface by an easy to understand grid-based layout that adapts to the size of the screen. Our applications will therefore adjust to large screens as well as cell-phones.

Summary

Tags: Programming, Web, Education, Workshop
Date: 2020-01-13
Location: MMIV
Audience: World

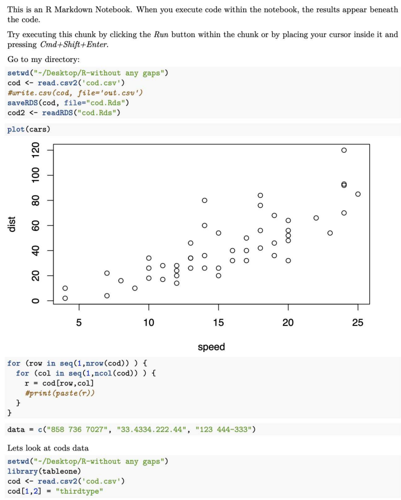
Hauke Bartsch, Dr. rer. nat.

The very basics of R-programming - without any gaps

A workshop of the without-any-gaps series of MMIV

No prior programming experience is required and everyone is welcome to our class, but bring a laptop. We start with an overview of tasks related to data imports and quality checks, cover basic visualization using ggplot2 and the simplest of regression models suitable as a baseline classification for your machine learning projects. Due to the complexity of the statistical models we will focus in this class on the data management part which starts any analysis task in the R-programming language.

R is especially suited as a programming language supporting data management tasks as well as basic and advanced statistical analysis tasks. With high-quality graphic generating packages all components of a scientific paper for bio-science can be created using R. In class we will use RStudio an integrated development environment that provides a convenient MATLAB-like interface for our class. The notebook feature is similar to python-notebooks and combines explanatory text, programming code and output generated by R.


This is an R Markdown Notebook. When you execute code within the notebook, the results appear beneath the code.

Try executing this chunk by clicking the *Run* button within the chunk or by placing your cursor inside it and pressing *Cmd+Shift+Enter*.

Go to my directory:

```
setwd("~/Desktop/R-without any gaps")
cod <- read.csv2('cod.csv')
#write.csv(cod, file='out.csv')
saveRDS(cod, file="cod.Rds")
cod2 <- readRDS("cod.Rds")
```

```
plot(cars)
```



```
for (row in seq(1,nrow(cod)) ) {
  for (col in seq(1,ncol(cod)) ) {
    r = cod[row,col]
    #print(paste(r))
  }
}
```

```
data = c("858 736 7027", "33.4334.222.44", "123 444-333")
```

Lets look at cods data

```
setwd("~/Desktop/R-without any gaps")
library(tableone)
cod <- read.csv2('cod.csv')
cod[1,2] = "thirdtype"
```

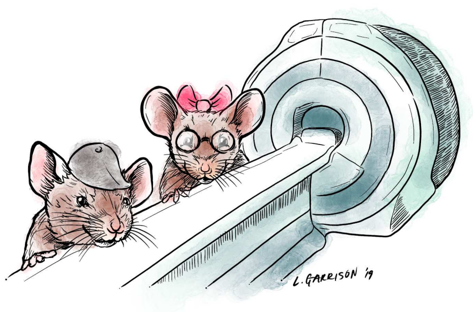
R language class for everyone.

Together with the RStudio environment the CRAN package store is a useful repository of many advanced packages that integrate with R. We will use the TableOne package to explain how R can be extended with CRAN software. In the last part of the workshop we will look at ggplot as a language for specifying graphics in R.

In a future workshop we will focus on the basic statistical packages for linear models up to the use of generalized additive mixed models (gamm4, mgcv). Such packages provide the tools for many life-science analysis tasks.

Summary

Tags: Programming, Education, Workshop
Date: 2020-02-24
Location: MMIV
Audience: World



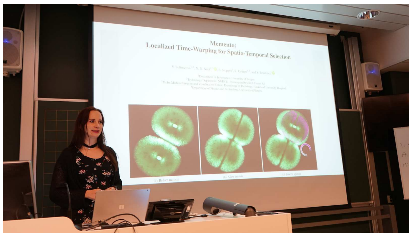
Seminar series October 2019

MR & I – Magnetic resonance imaging from different viewpoints within the MMIV

The seminar talks of Mohn Medical Imaging and Visualization center are organized by a committee composed of graduate student, PhD students and post-docs. The format of the seminars is that of an open forum for 4 talks per day of 20min each about work in progress research topics across all of the MMIV projects. Each seminar day combines research of all projects at MMIV and each talk ends with a short discussion and feedback for the presented work. The seminar day concludes with a social get-together at MMIV with waffles and coffee.

Especially the more informal format of the seminar invite lively discussions that bridge the projects and presenters usually leave with many helpful suggestions for future research and potential collaborations. The multi-project format of the seminars provide a valuable revenue to foster inter-group relationships at MMIV.

Memento: Localized Time-Warping for Spatio-Temporal Selection in fMRI data

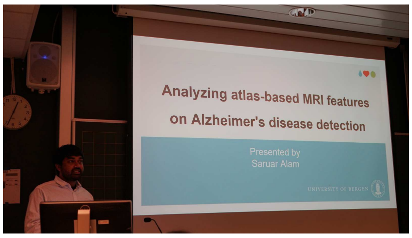


This talk was presented by Noeska Smit, Associate Professor at the Department of Informatics at the University of Bergen, and senior researcher at the MMIV. She writes: "Interaction techniques for temporal data are often focused on affecting the spatial aspects of the data, for instance through the use of transfer functions, camera navigation, or clipping planes. However, the temporal aspect of the data interaction is often neglected. The temporal component is either visualized as individual time steps, an animation, or a static summary over the temporal domain. We propose a novel technique that allows users to interactively specify areas of interest in the spatio-temporal domain. By employing a time-warp function, we are able to slow down time, freeze time, or even travel back in time, around spatio-temporal events of interest. The combination of such a (pre-defined) time-warp function and brushing directly in the data to select regions of interest allows for a detailed review of temporally and spatially localized events, while maintaining an overview of the global spatio-temporal data. In this talk, I will demonstrate an application of this technique to functional MRI (fMRI) data in particular."

MRI-assessed tumor size parameters predict mortality in uterine cervical cancer

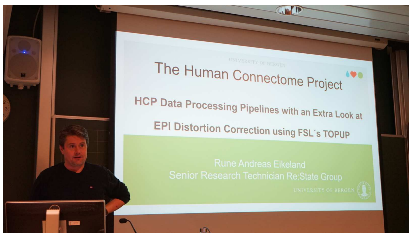
This talk was presented by Njål Lura, MD and PhD candidate at the MMIV. He introduced his talk with: "Uterine cervical cancer represents a major threat to female health worldwide; it is the fourth most common female cancer and one of the leading causes of cancer-related death in low-income countries. Important limitations in cervical cancer treatment are due to: 1) insufficient diagnostic tools with which to identify high-risk disease and 2) insufficient diagnostic tools with which to guide more individualized treatment. This project aims to address these limitations by focusing on the value of preoperative advanced imaging to provide functional and morphological tumor characteristics relevant for treatment and prognosis in uterine cervical cancer."

MRI-assessed tumor size parameters predict mortality in uterine cervical cancer



This talk was presented by Saruar Alam, PhD candidate at the MMIV. He introduced his talk with: "Alzheimer's disease (AD) can be distinguished using the features obtained from Magnetic resonance imaging (MRI), and a supervised classifier. Multi-atlas-based-likelihood fusion (MALF) algorithms extract the volumes features of subcortical regions of interest (ROI). The correlation among these ROI features from different brain regions may provide additional valuable information. Subsequently, these ROI-correlative features may affect the classification performance of a supervised classifier. We have classified AD and Mild Cognitive Impairment from cognitively normal subjects using these features and a Support Vector Machine classifier. This article investigates the difference in classification performance between the ROI and ROI-correlative features. Our work also reports the ranks of ROI and ROI-correlative regions. We have observed marginal differences in classification performance and ranking of the most effective regions."

The Human Connectome Project data processing pipeline and data visualization toolbox



This talk was presented by Rune Eikeland, Senior Research Technician at the MMIV. He introduced his talk with: "The Human Connectome Project (HCP) is a five-year project sponsored by sixteen components of the National Institutes of Health, split between two consortia of research institutions. The project was launched in July 2009 as the first of three Grand Challenges of the NIH's Blueprint for Neuroscience Research. The goal of the Human Connectome Project is to build a "network map" (connectome) that will shed light on the anatomical and functional connectivity within the healthy human brain, as well as to produce a body of data that will facilitate research into brain disorders such as dyslexia, autism, Alzheimer's disease, and schizophrenia. The data, processing and visualization tools are freely available for the HCP and I will present them in this talk with an in-depth focus on EPI data pre-processing to reduce susceptibility and motion artefacts with FSL's eddy tool (https://fsl.fmrib.ox.ac.uk/fsl/fslwiki/eddy)."

Summary

Tags: Education, Seminars
Date: 2019-10-04
Location: MMIV
Audience: MMIV

Seminar series September 2019

From mouse to man – Spatial and temporal medical imaging in different species and development phases

The seminar talks of Mohn Medical Imaging and Visualization center are organized by a committee composed of graduate student, PhD students and post-docs. The format of the seminars is that of an open forum for 4 talks per day of 20min each about work in progress research topics across all of the MMIV projects. Each seminar day combines research of all projects at MMIV and each talk ends with a short discussion and feedback for the presented work. The seminar day concludes with a social get-together at MMIV with waffles and coffee.

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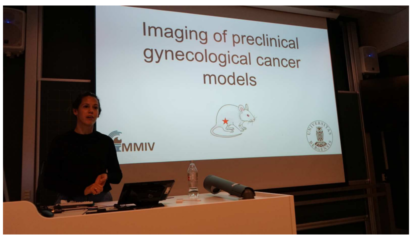
Imaging of preclinical gynecologic cancer models

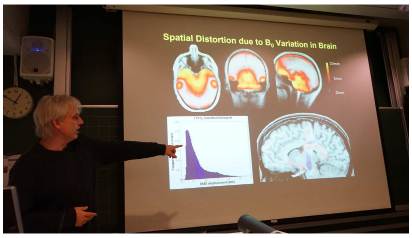


This talk entitled "Imaging of preclinical gynecologic cancer models" was presented by Heidi Espedal. She is a post-doctoral fellow working at the molecular imaging center (MIC) of Haukeland University Hospital. She writes "Endometrial cancer is the most common type of cancer of the female reproductive tract. Although prognosis is generally good for patients with low-grade and early-stage diseases, the outcomes for high-grade and metastatic/recurrent cases remain poor, since traditional therapy have limited effects. No targeted agents have been approved so far, although several new drugs have been tested without striking results in clinical trials. Patient-derived tumor xenograft (PDX) mouse models represent useful tools for preclinical evaluation of new therapies and biomarker identification. Preclinical imaging by PET-CT and MRI during disease progression enables visualization and quantification of functional tumor characteristics, which may serve as imaging biomarkers guiding targeted therapies. The primary objective for this presentation is to give an introduction of current and novel preclinical imaging methods relevant for endometrial cancer mouse models."

The Vitruvian Baby

This talk entitled "The Vitruvian Baby: Interactive reformation of 3D ultrasound data to a T-pose was presented by Eric Mörth, who is a PhD candidate in multi-modal medical visualization. He writes "Three-dimensional (3D) ultrasound imaging and visualization is often used in medical diagnostics, especially in prenatal screening. Screening the development of the fetus is important to assess possible complications early on. Performing the analysis in a 3D view would enable the viewer to better discriminate between artefacts and representative information. Additionally making data comparable between different investigations and patients is a goal in medical imaging techniques and is often achieved by standardization. "The Vitruvian Baby" incorporates a complete pipeline for standardized measuring in fetal 3D ultrasound. The input of the method is a 3D ultrasound screening of a fetus and the output is the fetus in a standardized T-pose. In this pose, taking measurements is easier and comparison of different fetuses is possible. In addition to the transformation of the 3D ultrasound data, we create an abstract representation of the fetus based on accurate measurements."

The Brain Imaging Data of the ABCD Study



This talk entitled "The Brain Imaging Data of the ABCD Study – an Introduction into Protocols and Tasks" was presented by Hauke Bartsch of the MMIV. The ABCD study is recruiting and following the brain development and health of over 10,000 9-10 year olds through adolescence. The imaging component of the study was developed by the ABCD Data Analysis and Informatics Center (DAIC) and the ABCD Imaging Acquisition Workgroup. Imaging methods and assessments were selected, optimized and harmonized across all 21 sites to measure brain structure and function relevant to adolescent development and addiction. This article provides an overview of the imaging procedures of the ABCD study, the basis for their selection and preliminary quality assurance and results that provide evidence for the feasibility and age-appropriateness of procedures and generalizability of findings to the existent literature.

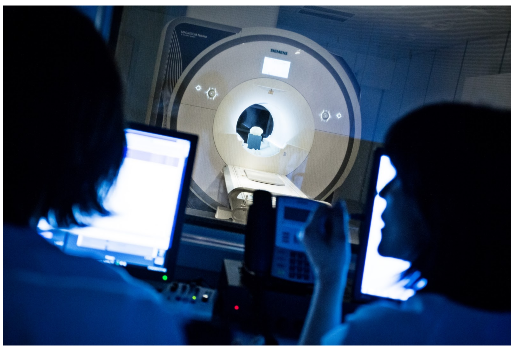
Hauke writes: " The Adolescent Brain Cognitive Development (ABCD) Study is the largest long-term study of brain development and child health in the United States. The ABCD Research Consortium have invited 11,878 children ages 9-10 to join the study. Researchers will track their biological and behavioral development through adolescence into young adulthood. Using cutting-edge technology, scientists will determine how childhood experiences (such as sports, video-games, social media, unhealthy sleep patterns, and smoking) interact with each other and with a child's changing biology to affect brain development and social, behavioral, academic, health, and other outcomes. As part of a research agreement, MMIV will obtain access to the raw data that includes an extensive MRI protocol as well as behavioral and environmental data."

Artificial intelligence in image diagnostics

This talk entitled "Artificial intelligence in image diagnostics – transfer learning and active learning for efficient use of data and radiologist's expertise" was presented by Sathiesh Kaliyugarasan of MMIV. Sathiesh is a PhD candidate at the MMIV. He writes: "A common stumbling block for supervised learning methods based on deep neural networks is the large number of labeled examples required for training. This is particularly troublesome when trying to use deep learning methods for segmentation in 3D medical image data. As creating labeled data for medical images is often a time-consuming, difficult and unreliable process, the amount of training data available is in general very small. To mitigate this problem we are looking into using design methodologies such as transfer learning and active learning for efficient use of data and radiologist's expertise."

Summary

Tags: Education, Seminars
Date: 2019-09-20
Location: MMIV
Audience: MMIV



Seminar series November 2019

From mouse to man – Behind the scenes – The people behind the machines and images

The seminar talks of Mohn Medical Imaging and Visualization center are organized by a committee composed of graduate student, PhD students and post-docs. The format of the seminars is that of an open forum for 4 talks per day of 20min each about work in progress research topics across all of the MMIV projects. Each seminar day combines research of all projects at MMIV and each talk ends with a short discussion and feedback for the presented work. The seminar day concludes with a social get-together at MMIV with waffles and coffee.

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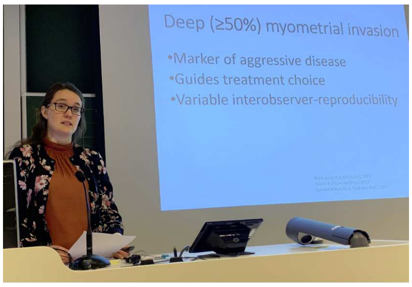
Firefly: Virtual Illumination Drones for Interactive Visualization

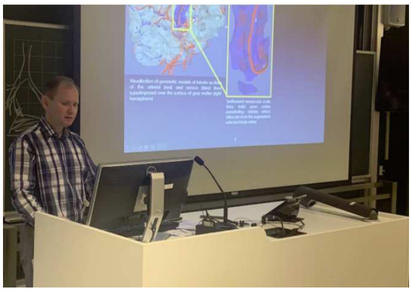
This talk entitled "Firefly: Virtual Illumination Drones for Interactive Visualization" was presented by Sergej Stoppel. He is a post-doctoral fellow in the Visualization Group at the University of Bergen. He writes "My current research interest is focused on the field of visual data science. By analyzing the intrinsic dimensionality of the data, I work on finding a suitable visual embedding for the data and thus create visualization methods tailored to specifically for the data. Additionally I am interested in high dimensional parameter space exploration and intuitive interaction techniques that support users with complex tasks, by predicting the users intention and providing appropriate support. My latest research projects focused on automatic and time efficient determination of parameter settings for larger algorithmic systems, by exploiting parallel computing and evaluating the parameter space."

MRI-assessed Tumor-free Distance to Serosa Predicts Deep Myometrial Invasion and Poor Prognosis in Endometrial Cancer



This talk entitled "MRI-assessed Tumor-free Distance to Serosa Predicts Deep Myometrial Invasion and Poor Prognosis in Endometrial Cancer" was presented by Julie Dybvik, who is a PhD candidate in gynecological cancer imaging. She writes "The diagnostic accuracy of preoperative magnetic resonance imaging (MRI) and MRI-based tumor measurements is important for prediction of pathological deep ($\geq$50

Quantitative analysis of 3D MR images



This talk entitled "Quantitative analysis of 3D MR images" was presented by Marek Kocinski, a postdoctoral fellow in machine learning at the MMIV. He writes "An accurate modeling of blood-vessel structures depicted in 3D raster images is a crucial issue in vascular disease diagnosis and treatment. Magnetic resonance imaging (MRI) includes several modalities allowing one to acquire 3D raster images in which blood vessels are visualized e.g. ToF, SWI, QSM. Using the image information about vasculature offers a possibility to create an accurate and comprehensive 3D geometrical model of arteries and veins for each individual patient with personalized geometry and structure of thick blood vessels. As vessel radius splits from thicker down to thinner, with range from centimeters to micrometers at capillary level, for different vessel thickness groups one should apply various quantitative algorithms. One should apply various quantitative algorithms: a 3D geometric model, texture analysis, and DCE-derived blood pharmacokinetics maps for respectively thick, medium and capillary blood vessels."

One box to fit them all: Diffusion microstructure imaging and the question of where to find water

This talk entitled "Artificial intelligence in image diagnostics – transfer learning and active learning for efficient use of data and radiologist's expertise" was presented. Dr Frank Riemer gave an introduction into microstructure diffusion imaging, what other methods exist and how that relates to the underlying acquired data. By making analogies and comparisons to general photography, the talk was designed to be accessible to a wider audience. Preliminary results of on-going research projects in diffusion imaging of Multiple Sclerosis here at Haukeland Hospital were given at the end.

Summary

Tags: Education, Seminars
Date: 2019-11-01
Location: MMIV
Audience: MMIV

Students, PhD candidates and Post-docs

Siv Hildegunn Aase

Siv Hildegunn Aase is a MD from the University of Bergen and a specialist in radiology, she also holds an MS in health economics from the University of Bergen. She is currently combining the position as a radiologist at the Breast Centre with a PhD project focusing on digital breast tomosynthesis (3D-mammography) in screening, with data from the Tomosynthesis Trial in Bergen (the To-Be-trial). Her research focuses on detection rates, reading times, doses, breast density and mammographic features, comparing results after screening with digital mammography (2D-mammography) versus digital breast tomosynthesis (DBT or 3D-mammography).

Malik Aasen

Malik Aasen has a bachelor's degree in software engineering from the Western Norway University of Applied Sciences. He is currently writing his master thesis in collaboration with MMIV about de-identification of medical images using generative adversarial networks.

Saruar Alam

Saruar Alam has a master's degree in information and communication from Chosun University, South Korea, and a Master of Research degree in Computing from Macquarie Univesity, Australia. Currently, he is a PhD candidate in the department of biomedicine at University of Bergen. His research activities are related to computational magnetic resonance imaging (MRI) and machine learning applied to neurodegeneration, brain tumor, and the irritable bowel syndrome.

Hauke Bartsch

Hauke Bartsch is a computer scientist by training and received his PhD from the Technical University Berlin, Germany. He has worked extensively in the medical industry in the fields of advanced visualization (8 years) and in academia on the largest adolescent brain and cognitive development study (ABCD) at UC San Diego (8 years). His current interest include technological developments for research information systems and the integration of machine learning methods into clinical workflows.

Marion Lambrechts Berge

Marion Lambrechts Berge has a master's degree from the University of Bergen in Health Sciences (Radiography). She is currently a PhD candidate at the Western Norway University of Applied Science. Her research is related to magnetic resonance imaging and the use of artificial intelligence in endometrial cancer.

Malin Ovat Blomberg

Malin Ovat Blomberg has a master's degree in clinical psychology from the University of Bergen. She's been researching cognitive functions in severely depressed patients undergoing ECT, in collaboration with the Bergen ECT-MRI group.

Giulio Emilio Brancati

Giulio Emilio Brancati is a MD from SantÁnna School of Advanced Studies (Pisa, Italy). He is currently working as a Resident in Psychiatry at Pisa University Hospital. Thanks to the Erasmus+ Traineeship Programme, Giulio took part in neuroimaging research at MMIV focusing on brain changes induced by electroconvulsive therapy.

Julie Andrea Dybvik

Born in 1985, M.D. from UiB and has been working as a resident in Radiology in Department of Radiology, Haukeland University Hospital after she completed her degree. Currently she is a PhD candidate in the Cancer Imaging group, working on functional imaging for individualized treatment of uterine cancer.

Agnes Eide

Agnes Jørgensen Eide is a medical student at the University of Bergen. As a student in the Medical Student Research Program at the Faculty of Medicine, she is affiliated with MMIV and Bergen Gynecologic Cancer Research Group. Her research focuses on CT-assessed abdominal fat distribution markers for prognostication and tailor of treatment in uterine cervical cancer.

Rune Eikeland

Rune Eikeland holds a masters degree in neuroscience from the Norwegian University of Science and Technology and is currently employed as a senior research technician in the Re:State research group.

Vera Jane Erchinger

Vera Jane Erchinger is currently completing her research track programme as a medical student. Her research is focusing on magnetic resonance spectroscopy.

Heidi Espedal

Heidi Espedal is a cell biologist with a PhD in neuro-oncology from University of Bergen. She is currently a postdoc at MMIV focusing on preclinical cancer imaging including PET and MRI.

Kristine Eldevik Fasmer

Kristine Eldevik Fasmer has a MS in physics from the University of Oslo and has since 2009 been working at Center of Nuclear Medicine and PET, at Haukeland University Hospital. From 2017 she has combined the medical physicist position with a 50% PhD in the Cancer Imaging Group at MMIV. Her research focuses on utilizing new and advanced MRI and PET-CT imaging techniques in order to improve patient treatment and outcome in endometrial cancer.

Sondre Fossen-Romsaas

Sondre Fossen-Romsaas got a bachelor's degree in software engineering from Western Norway University of Applied Sciences. He is currently writing his master thesis in collaboration with MMIV about generative adversarial networks and medical image synthesis.

Leila Marie Frid

Leila Marie Frid received here nursing degree in Stockholm by the Red Cross University College of Nursing in 1993. The last 4 years she has been working as a research nurse for the ECTMRI studies at the MMIV and the Research department, division of psychiatry at the Haukeland University Hospital. She is also currently working on a master's degree in nursing science at the University of Bergen where the master project theme is connected to ECT.

Laura Garrison

Laura Garrison joined the MMIV and the Visualization Research Group in the Department of Informatics at the Univ. of Bergen, Norway as a doctoral researcher in 2018. She received her M.Sc. in biomedical visualization in 2012 from the Univ. of Illinois. Her research focuses medical visualization and visual analytics, drawing from her background as a medical artist.

Fourough Gharbalchi

Fourough Gharbalchi received her MSc. in Biomedical Engineering from METU, Turkey. She is a PhD student at the University of Bergen. She is working in "Visualizing Data Science for Large Scale Hypothesis Management in Imaging Biomarker Discovery (VIDI)" project. Her current focus of study is Medical Image Processing, Machine Learning, Interactive Visual Analysis

Anders Grinde

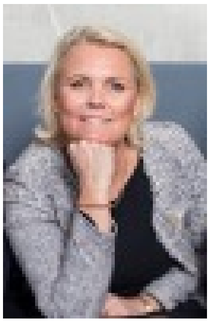
Anders Grinde has a bachelor's degree in software engineering from the Western Norway University of Applied Sciences. He is currently writing his master thesis in collaboration with MMIV about transfer learning in natural language processing.

Jan Haavik

Jan Haavik is a specialist in adult psychiatry and professor at Department of Biomedicine, University of Bergen. He is interested in fundamental and clinical aspects of brain functions, including psychiatric and neurodegenerative disorders.

He is leading the Neurotargeting Research Group, aiming to develop new therapies against brain disorders and is affiliated with the Bergen Center of Brain Plasticity at Haukeland University Hospital. Haavik is Co-PI for our ECT studies of Blood Biomarkers.

Åsa Hammar



Åsa Hammar, Ph.D. is Professor of Clinical Neuropsychology and a licensed clinical psychologist and specialist in clinical neuropsychology at the University of Bergen and at Haukeland University Hospital in Norway. Hammar has been focusing for more than 20 years on cognitive impairments in MDD, and have a long clinical experience and numerous research publications focusing on the longitudinal neurocognitive profile in MDD, the clinical impact of cognitive impairment in daily life functioning, including front-line interventions targeting cognitive residual symptoms.

Marianne Hjellvik Hannsidal

Marianne Hjellvik Hannsidal has her background from clinical radiography, and holds advanced courses in Computer Tomography from OsloMet (2011) and Medical Digital Imaging, from Bergen University College (2014). She is currently pursuing Masters in Science at UiB, The Faculty of Medicine. Her master project is about the use of quantitative imaging biomarkers and artificial intelligence as a novel method to detect and delineate glioblastoma in multispectral MRI.

Vetle Hushagen

Vetle Hushagen holds a Master's degree in Behavioural Neuroscience from the University of Bergen. He is currently pursuing a PhD focused on visual processing of depth cues and visualization of neuroimaging data. The project is a collaboration between NFR, Tenklabs AS, UiB and MMIV.

Havjin Jacob

Havjin Jacob obtained a PhD from University of Bergen, Norway, and is currently a postdoc. Her research is focused on molecular markers in endometrial cancer and their association with functional imaging features for individualized cancer treatment.

Bendik Johansen

Bendik Johansen has a bachelor's degree in software engineering from the Western Norway University of Applied Sciences. He is currently writing his master thesis in collaboration with MMIV about transfer learning in natural language processing.

Satheshkumar Kaliyugarasan

Satheshkumar Kaliyugarasan has a master's degree in software engineering from the University of Bergen/ Western Norway University of Applied Sciences. He is currently working as a researcher in the project Computational medical imaging and machine learning at MMIV. His research activities are mainly related to design methodologies in deep learning for efficient use of data.

Katarzyna Kazimierczak

Katarzyna Kazimierczak obtained her Master's Degree from Lodz University of Technology, Poland in electronics and telecommunication. She is currently a PhD candidate at the University of Bergen and part of the Re:State group at MMIV. Her research focuses on new strategies for analysis of task and resting-state fMRI.

Ute Kessler

Ute Kessler is a psychiatrist and received her PhD studying the effects of electroconvulsive therapy on depressive symptoms and cognitive function in bipolar depression patients. She is currently working at the Department of psychiatry, Haukeland University Hospital and as ass.prof at the UiB

Marek Kocinski

Marek Kocinski has a master's degree in electronics and telecommunication and a Ph.D. at Computer Science from the Lodz University of Technology (TUL) in Poland. From 2009 he has been working as an Assistant Professor at Institute of Electronics in TUL. His scientific interests concentrate on 2D, 3D and 4D biomedical image processing, 3D visualization, texture analysis and data mining. He has been involved in projects related to quantitative analysis and modelling of DCE MRI images for tissue characterization in kidney, prostate, endometrial carcinoma, as well as computer algorithms of vascular tree growth, blood flow computer simulation through vascular tree and compartmental model of exchange between blood vessel and surrounding tissue. He is currently working as a postdoctoral researcher in the project "Computational medical imaging and machine learning – methods, infrastructure and applications" at Mohn Medical Imaging and Visualization Centre (MMIV). His research activities are related to design methodologies for 3D biomedical image analysis with the use of deep learning.

Peder A. G. Lillebostad

Peder Lillebostad got a bachelor's degree in molecular biology from Department of Biological Sciences, UiB. In June 2019 he defended his master's thesis entitled "Exploring the IBS Brain: Resting State Functional Connectivity and Machine Learning" at Department of Biomedicine, conducted in collaboration with the Computational Medicine and Machine Learning group at MMIV and the [Brain-Gut group] at the Department of Medicine, Haukeland University Hospital. He is presently a researcher and python course developer planning for a PhD project related to network science at Neuro-SysMed / MMIV.

Alexander Selvikvåg Lundervold

Alexander Selvikvåg Lundervold is an Associate Professor at the Dept. of Computer Science, Electrical Engineering and Mathematical Sciences, Western Norway University of Applied Sciences, and a researcher at the Dept. of Radiology, Haukeland University Hospital.

His main research activities are within machine learning and data analysis, with a particular focus on medical image analysis. He is co-coordinating the Computational Medicine and Machine Learning research group at MMIV, and is also part of the center leadership team. A more detailed description of his research can be found [here].

Arvid Lundervold

Arvid Lundevold is professor in medical information technology and physiology, Department of Biomedicine, University of Bergen and prof. II at the Department of Health and Functioning, Western Norway University of Applied Sciences. He has a BSc in mathematics and MD from University of Oslo, and his PhD ("Multispectral analysis, classification and quantification in medical magnetic resonance imaging") from University of Bergen. Current research interests are in the fields of multimodal and functional imaging (in brain, kidney and in oncology); image segmentation; image registration; longitudinal imaging; imaging-based biomarkers; mathematical and statistical modeling including machine learning. He is PI in the Neural Networks research group at the Department of Biomedicine and is co-coordinating the Computational Medicine and Machine Learning research group at MMIV. More information about his research and teaching activities can be found [here], and at `https://github.com/arvidl`.

Njål Gjærde Lura

Njål Gjærde Lura, obtained the degree of medical physician, University of Bergen 2011.

He currently works as a radiological consultant at department of radiology at Haukeland university hospital and he has a position as a PHD-student at the cancer-imaging group, which is a part of the MMIV-center. His research focuses on the utility of MRI in patients with uterine cervical cancer.

Tania Martínez-Montero

Tania Martínez-Montero holds two masters degree in psychology and clinical neuropsychology, and an MSc in Cognitive and Behavioral Neuroscience from the University of Granada, Spain. She is currently a PhD Candidate at ReState research group project "When Default is not Default", at the University of Bergen. Her project focuses on vigilance and arousal fluctuations and how vigilance/arousal fluctuations affects the reliability of brain networks studies.

Fredrik Fidjestøl Mathisen

Fredrik Fidjestøl Mathisen has a bachelor's degree in software engineering from the Western Norway University of Applied Sciences. He is currently writing his master thesis in collaboration with MMIV about de-identification of medical images using generative adversarial networks.

Eric Mörth

Eric Mörth is researching in the area of multimodal medical visualization. He holds a master's degree in Medical visualization from the Medical University of Vienna, Austria and a master's degree in Biomedical Engineering from the Technical University of Vienna, Austria. Currently Eric is a PhD candidate in the Visualization

Group, University of Bergen. He is researching novel interactive visualization approaches for the visualization of multimodal MR data in the context of gynecological cancer imaging in collaboration with the MMIV cancer imaging project and the Bergen Gynecologic Cancer Research Group.

Samaneh Abolpour Mofrad

Samaneh Abolpour Mofrad's background is in mathematics and is currently involved in data analysis in the biomedical field. She has a master's degree in pure mathematics in the field of geometry from Polytechnique University of Tehran (Amirkabir University), and a master's degree in applied mathematics in the field of porous media and oil reservoir from university of Bergen (UiB). She has also attended the training program of master in system dynamics at UiB. Currently she is a Ph.D. candidate at the department of computer science, electrical engineering and mathematical sciences at Western Norway University of Applied Science, and collaborates with the MMIV center for her Ph.D. project. Her research topic is "Machine learning for biomedical data analysis". Currently she is using machine learning and statistical models to analyze different kinds of data such as MRI, DTI and some psychometric tests for measuring cognitive function to predict the risk of Alzheimer's disease.

Ingrid Mossige

Ingrid Mossige is studying Medical Technology at the University of Bergen, and is currently a Master student at MMIV. Her research focuses on exploring the effects of ECT on the hippocampal subfields.

Bharath Nagaraja

Bharath Nagaraja has a PhD in electrical engineering form KU Leuven, Belgium. Currently he is working as a postdoc in the Brain-Gut project. He has also worked as a Senior R&D Engineer at National Brain Research Centre, India and as a senior design engineer at WeP Peripherals Ltd, Mysore. He has supervised master- and intern students during his PhD. His research interests include machine learning, blind source separation and image processing for analyzing medical images and data.

Leif Oltedal

Leif Oltedal is a consultant in neuroradiology (Haukeland University Hospital) and Associate Professor of Radiology (University of Bergen, Norway). His background is from basic neuroanatomy and patch-clamp electrophysiology (PhD-2009). After starting training to become a radiologist he engaged in quantitative neuroradiological imaging of ECT both as a postdoc (2013-17) and as Fulbright visiting scholar to UC San Diego (2016-17). Oltedal initiated the Global ECT-MRI Research Collaboration in 2015. He focuses on neuropsychiatric imaging – with a main focus on depression and electroconvulsive therapy.

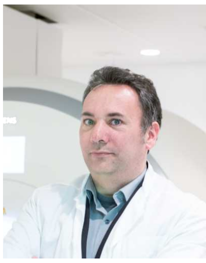
Frank Riemer

After graduating from the Department of Physics at King's College London, Frank Riemer obtained his PhD from University College London (UCL) in Neuroscience. Working at the Institute of Neurology at Queen Square London, he performed the very first human sodium imaging (23Na-MRI) in the UK and translated this method for the application in Multiple Sclerosis (MS) research. He then spent his formative years as a postdoctoral researcher in the Department of Radiology at the University of Cambridge further developing and applying his 23Na-MR imaging techniques for cancer. He is currently working in the Advanced Neuroimaging project at the MMIV. His research focusses on multiparametric MRI approaches with a focus on multinuclear and diffusion MR.

Ole Johan Evjenth Sørhaug

Ole Johan Evjenth Sørhaug is currently studying for a degree in medicine (MD) and is also a research track student (forskerlinjestudent) at the University of Bergen. His project involves investigating for structural changes in the human brain as seen on MRI following electroconvulsive treatment for depression.

Karsten Specht



Karsten Specht is a cognitive neuroscientist. In 1997, he received his M.Sc. ("Diplom") in Physics from the RWTH Aachen University, Germany, with a thesis focusing on optimising functional brain imaging using Positron Emission Tomography (PET). He worked as a neuroscientist at the University Hospital Aachen, the Research Centre Jülich, and the Otto-von-Guericke University Magdeburg, Germany. From the Otto-von-Guericke University Magdeburg, he received his PhD in Cognitive Neuroscience in 2003, and, in 2012, his Habilitation in General and Biological Psychology. Since 2004, he also works at the University of Bergen, Norway, where he got a professorship at the Department of Biological and Medical Psychology in 2012. In 2017, he became the head of the Bergen fMRI group, and he also holds a guest professorship at the Arctic University of Norway in Tromsø, Norway. His main research areas are on the neuroimaging studies of brain with a focus on auditory perception of speech and music, rehabilitation from speech and language disorders, brain connectivity and plasticity, clinical multimodal neuroimaging, and the development and implementation of new neuroimaging methods. Over the years, he published more than 100 peer-reviewed articles, received several research grants, and has supervised more than 10 PhD stipends.

Lea Starck

Lea Starck holds a MSc in medical physics and technology from the University of Bergen. She is currently a PhD in the visualization/Hauser and Smit group. Her research is about the use of perfusion MRI as a tool for measuring potential biomarkers.

Sivert Stavland

Sivert Stavland has a bachelor's degree in software engineering from the Western Norway University of Applied Sciences. He is currently writing his master thesis entitled "Machine learning and electronic health records" in collaboration with the Computational Medicine and Machine Learning group at MMIV.

Adrian Storm-Johannessen

Adrian Storm-Johannessen has a bachelor's degree in software engineering from the Western Norway University of Applied Sciences. He is currently writing his master thesis entitled "Medical image synthesis using generative adversarial networks" in collaboration with the Computational Medicine and Machine Learning group at MMIV.

Sherin Sugathan

Sherin Sugathan works in the area of medical visualization. He holds a Master's in Computer Applications from University of Kerala, India, and is currently a PhD candidate in the Visualization Group, University of Bergen. His research is focused on developing novel interactive visualization approaches for the visualization of multimodal MR data in the context of MS in collaboration with the MMIV advanced neuroimaging project.

Liucija Vaisvilaite

Liucija Vaisvilaite holds a MSc degree in Cognitive science with specializations in neuroscience and psychology from the University of Umeå, Sweden. She is currently a PhD stipend at ReState research group project "When Default is not Default", University of Bergen, Norway. Her research focuses on reliability of fMRI and various exogenous and endogenous parameters that influence individual BOLD signal variability.

Alexandra Vik

Alexandra Vik has an interdisciplinary education in cognitive neuroscience from NTNU. In a period of three years, she was a board member of MedIm (Norwegian Research School in Medical Imaging), a nationwide network for high quality training. She defended her PhD thesis entitled "Imaging the aging brain: From morphometry to functional connectivity" in 2019 at the University of Bergen. She is currently a member of the «Computational medical imaging and machine learning - methods, infrastructure and applications» project at the MMIV. In her postdoctoral position, she will follow up her previous interdisciplinary contribution in studies of the aging brain, believing that both scientific progress and improved care for older individuals are dependent on bridging the gap between the disciplines of psychology, medicine, informatics and mathematics.

Kari Strøno Wagner-Larsen

Kari Strøno Wagner-Larsen is a MD from the University of Bergen, and a specialist in radiology. She is currently working on a PhD project in the Cancer Imaging group at MMIV. Her research focuses on artificial intelligence guided imaging biomarkers in uterine cervical cancer.

5. Dissertations

Can we explain hallucinations using MRI?

Gerard Dwyer

Gerard Dwyer (f. 1985) har master i biomedisin med spesialisering i biomedisinsk avbildning fra Universitetet i Bergen. Doktorgraden ble utført ved Instituttet for biologisk og medisinsk pyskologi (IBMP), Det psykologiske fakultetet ved Universitetet i Bergen. Hovedveileder var Renate Grüner med biveiledere Kenneth Hugdahl og Lars Ersland.

Hva skjer i hjernen til folk som hører stemmer som ikke finnes? Hørselshallusinasjoner, ofte kalt «stemmer i hodet» er et av de sentrale symptomene som kjennetegner schizofreni, og er et kjent symptom ved en rekke andre psykiske lidelser.

Selv om den er best kjent som en avbildningsteknikk, finnes det andre anvendelsesområder for Magnetresonanstomografi (MRI) som har gjort teknikken til et viktig verktøy for å undersøke hjernen. Dette prosjektet fokuserte på to slike MRI-metoder, nemlig funksjonell MRI (fMRI) og magnetresonansspektroskopi (MRS), og hvordan de kunne potensielt brukes for å kartlegge hva som skjer i hjernen ved hørselshallusinasjoner.

Med fMRI kan man fremstiller endringer i nevronal aktivitet i forskjellige områder i hjernen som kan være involvert med ulike mentale oppgaver og prosesser. Med MRS kan man måle ulike kjemiske stoffer som glutamat og GABA, to av hjernens viktigste nevrotransmittere. Formålet med dette prosjektet har vært å prøve ut om MRS egner seg for å måle endringer i konsentrasjon av nevrotransmittere over tid, det vil si på en «funksjonell» måte som blir kalt «fMRS», og hvis fMRI og MRS kunne kombineres for samtidig måling av endringer i nevral aktivitet og assosiert endringer i nevrotrasmitter nivåer.

Den første studien ga oversikt av hvordan MRS brukes for å måle visse kjemiske forbindelser som er av betydning for forståelse av schizofreni. Den andre studien foreslo en ny tilnærming til fMRS, og testet ut den varianten for å måle biokjemiske endringer i respons til svak elektrisk stimulering (tDCS). Den siste studien prøvde ut en ny fMRS metode for samtidig måling av både aktivitet i hjernen og assosiert endringer i nevrotransmitter nivåer i respons til visuell stimulering.

Resultatene fra dette prosjektet foreslår nye muligheter for bruk av fMRS, og kan måle både aktivitet og assosierte endringer i nivå av signalstoff samtidig. De foreløpige resultatene er lovende, men trenger videre forskning for å validere metodene.

Author Information

Gerard Dwyer
Defense: 10/2019

Advanced imaging biomarkers in endometrial cancer

Sigmund Ytre-Hauge

Sigmund Ytre-Hauge (f 1978) er fødd i Bergen og oppvaksen på Sunnmøre. Han gjennomførte medisinsk embetseksamen ved UiB i 2004 og vart godkjend spesialist i radiologi i 2017. For tida arbeider han som overlege ved Radiologisk avdeling, Volda sjukehus. I perioden 2011-2015 arbeidde han som lege i spesialisering ved Haukeland Universitetssjukehus og frå 2015-2019 har han vore stipendiat med finansiering frå Helse Vest. Avhandlinga utgår frå Klinisk Institutt 1, Seksjon for radiologi, UiB.

I den vestlege verda, inkludert Noreg, har førekomsten av kreft i livmorslimhinna auka kraftig sidan etterkrigstida. Direkte årsak til livmorkreft er ukjent, men overvekt er ein risikofaktor. Sjukdomen rammar oftast kvinner etter overgangsalder, og underlivsblødning er som regel det symptomet som gjer at kvinnene oppsøkjer lege. Gynekologisk undersøking og utskrapingsprøve frå livmor gjev diagnosen. I dei fleste tilfelle kan sjukdomen kurerast ved å fjerne livmor og eggstokkar. Mange pasientar får òg fjerna lymfeknutar i bekkenet som del av behandlinga. Ca. 20 % får tilbakefall eller spreiing, som då vert behandla med stråling eller cellegift.

Nye radiologiske biletmetodar kan avdekke eigenskapar ved kreftsvulstane som gjer det mogleg å identifisere dei mest aggressive sjukdomstilfella i forkant av operasjon. Desse nye metodane kan gje grunnlag for å tilby meir skreddarsydd pasientbehandling, der kvinner med høg risiko for tilbakefall får meir omfattande kirurgi og etterbehandling, medan kvinner med låg risiko unngår unødvendig omfattande behandling.

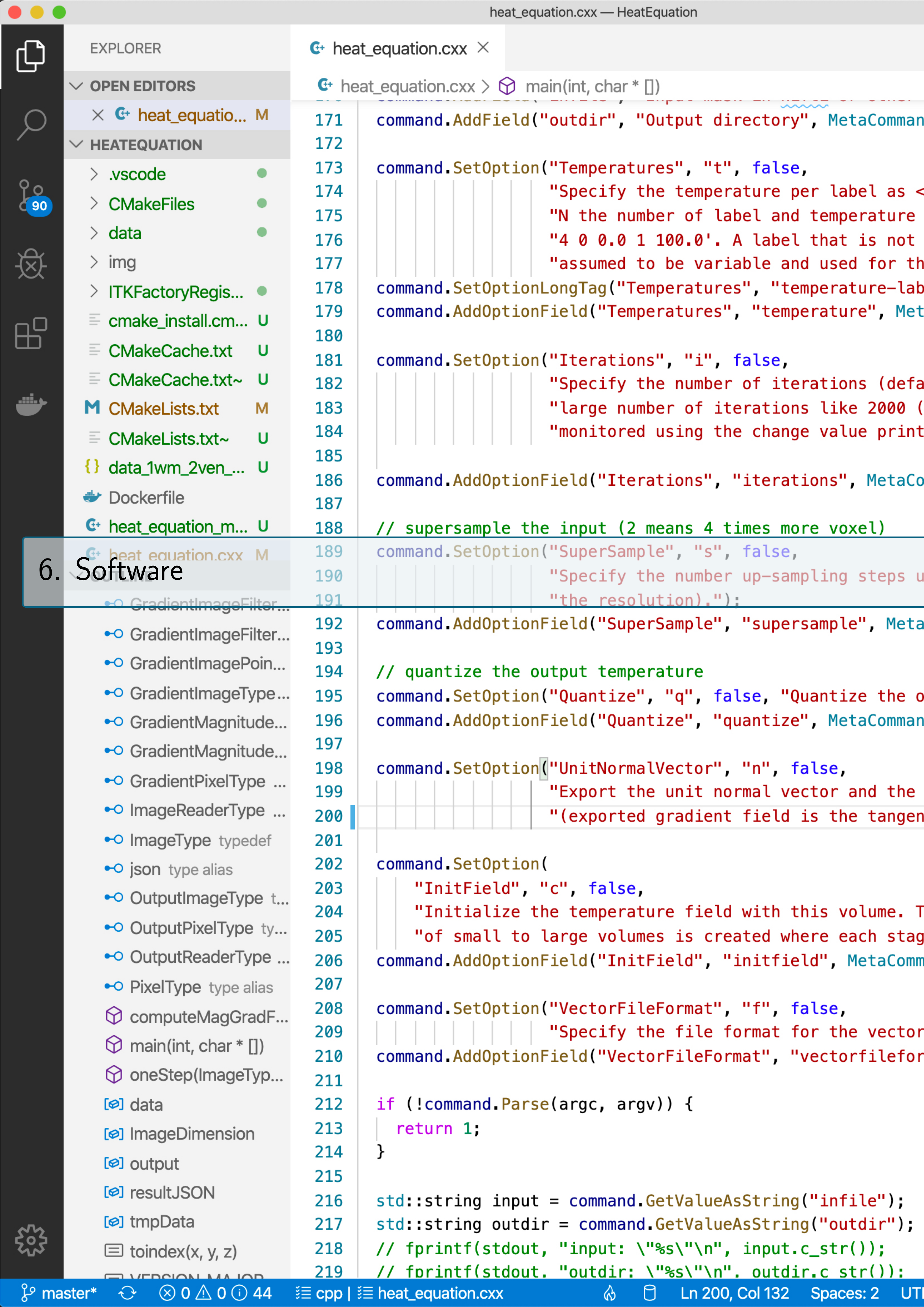
I studiane er det gjort analyser av CT- og MR-bilete i forkant av operasjon med mål om å identifisere aggressive kreftformer, dvs. svulstar med invasiv vekst, lymfeknutespreiing og/eller tilbakefall i oppfølgingsperioden på ca. 5 år. Svulstvolumet er målsatt på MR-bilete og fysiologiske/biokjemiske eigenskapar ved svulsten er undersøkt i funksjonelle bildeopptak med bl.a. data-assisterte bildeanalyser (teksturanalyse).

Resultata tyder på at nye typar biletanalyser – både relativt enkle målingar utført av røntgenlege og meir avanserte, data-assisterte analyser – kan gje nyttige bidrag i risikovurderinga i forkant av operasjon for kvinner med livmorkreft. Dette vil òg kunne vere eit steg i retning av å kunne utvikle meir målretta og skreddarsydd behandling for pasientar med livmorkreft.

Author Information

Sigmund Ytre-Hauge
Defense: 12/2019

6. Software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"the resolution).");
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"Specify the file format for the vector
command.AddOptionField("VectorFileFormat", "vectorfilefor
if (!command.Parse(argc, argv)) {
return 1;
}
std::string input = command.GetValueAsString("infile");
std::string outdir = command.GetValueAsString("outdir");
// fprintf(stdout, "input: \"%s\"\n", input.c_str());
// fprintf(stdout, "outdir: \"%s\"\n", outdir.c_str());
master* 0 0 44 cpp | heat_equation.cxx Ln 200, Col 132 Spaces: 2

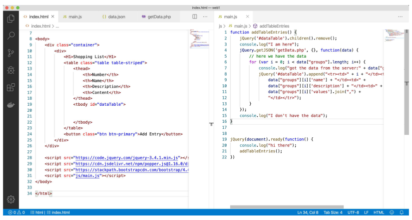
Hauke Bartsch, Dr. rer. nat.
https://github.com/mmiv-center/LungSegmentation.git

Geodesic distances in white matter

Curvilinear coordinates in human white matter

This module creates curvilinear coordinates from volumetric label fields. It simulates the heat equation and exports the temperature (potential) field and the gradient of the potential field (tangent unit vector). The gradient field represents the directions of geodesic lines connecting the fixed temperature regions.

This module can be used to compute the shorted path between points of the ventricles and points of the white/gray matter border using structural information (white matter) only. It can also be used to sample the white matter at a given distance perpendicular to the gray/white matter border.



A repository for software.

We share such source code to support similar research efforts internationally. The open-source nature of this research allows national and international researchers to test and verify our solutions, provide essential feedback and suggestions for improvement supporting advances in medical data handling.

Summary

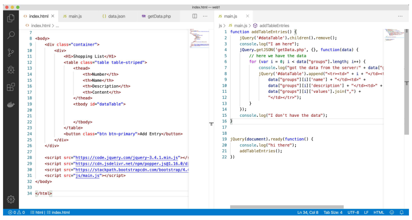
Tags: Programming, Software
Date: 2020-01-13

Hauke Bartsch, Dr. rer. nat.
https://github.com/mmiv-center/gen-id.git

Research PACS component Gen-ID

Generate random participant ID's from regular expressions

This repository provides access to program developed at MMIV that creates random participant identifiers based on a regular expression pattern. This feature allows research projects to use short participant identifiers that do not repeat and that blind the study to the order of enrollment. The generated participant identifiers remain concise and recognizable as belonging to the study. The software is part of the Research PACS at MMIV that provides a safe technical solution to perform medical data collection and data analysis.



A repository for software.

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Summary

Tags: Programming, Software
Date: 2020-03-10

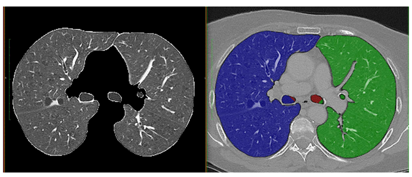
Hauke Bartsch, Dr. rer. nat.
https://github.com/mmiv-center/LungSegmentation.git

LungSegmentation package

Create lung-segmentation fields from spiral CT

This repository provides access to programs developed at MMIV for lung segmentation of spiral CT images. This program is using a series of labelling and morphological operations to extract the Lung volume intensity image from chest CT scans. It was tested with the data from the LIDC-IDRI (Lung Image Database Consortium) project and depends on ITK/cmake.

After the initial step of extracting the intensities of the lungs and airways the algorithm attempts to separate the two lungs and the airways.



Lung segmentation into airwairs (red), left (green) and red (blue) lung.

We share such source code to support similar research efforts internationally. The open-source nature of this research allows national and international researchers to test and verify our solutions, provide essential feedback and suggestions for improvement supporting advances in medical data handling.

Summary

Tags: Programming, Software
Date: 2020-03-10

Hauke Bartsch, Dr. rer. nat.
https://github.com/mmiv-center/RewritePixel.git

Sanitize DICOM image data

Machine learning algorithms for the removal of burned in image information

This repository provides access to programs developed at MMIV for the removal of burned in pixel information in secondary capture DICOM images.

Sharing medical images is most often straight forward as the DICOM format provides a globally agreed on file format for all reconstructed 2D, 3D, and 4D data generated by medical equipment. Special care has to be taken if DICOM data is generated as part of data analysis workflows. Such 'secondary-capture' DICOM images can contain burned in text information that might contain participant identifying information such as names. Before such data can be shared as part of research projects at Haukeland University Hospital the burned in image information needs to be removed. Previous approaches

This project uses the tesseract optical character recognition machine learning engine to identify text that is burned into DICOM images. For each text fragment (usually a word) a square black frame is written into the DICOM pixel information. The resulting DICOM file should be inspected - hopefully it is free of participant identifying information.

Warning: This program does not try to anonymize DICOM tags. Please check out the https://github.com/mmiv-center/DICOMAnonymizer project for a fast tag anonymizer.

Warning: There is no information yet on false/positive detection rates, verify the output by hand!

We share such source code to support similar research efforts internationally. The open-source nature of this research allows national and international researchers to test and verify our solutions, provide essential feedback and suggestions for improvement supporting advances in medical data handling.

Summary

Tags: Programming, Software
Date: 2020-03-10

Hauke Bartsch, Dr. rer. nat.
https://github.com/mmiv-center/DICOMAnonymizer.git

DICOM-Anonymizer

Fast-anonymization engine for DICOM meta-data

This repository provides access to programs developed at MMIV for the removal of participant identifying information in meta-data tags of DICOM files.

This source code demonstrates how to anonymize DICOM files based on the DICOM PS 3.15 AnnexE. I provide a Dockerfile that can be used to build the executable and to run anonymizations. Entries such as uid entries are replaced with hash values. This ensures that partial runs of a studies DICOM files can be merged afterwards. This project is written in C++ using the gdcm library and multiple threads to accelerate processing.

Warning: The operation performed by this tool is a 'soft' de-identification. Instead of a white list of allowed tags the tool keeps a list of tags known to frequently contain personal identifying information (PII) and replaces only those. On the command line you specify a patient identifier (PatientID/PatientName). Only if you do not keep a mapping of the new and the old identifier this is considered an anonymization. If such a list exists the operation performed is a de-identification (permits a later re-identification).

I suggest to review files generated by this tool for additional PII information that might be present in text fields.

For a more flexible anonymizer please see the CTP DICOM Anonymizer project.

Unique features

- fast de-identification (multi-threaded, C++)
- de-identifies data inside sequences instead of deleting them so overlays survive the procedure

Limitations

This tool has been written to work as an importer for a (vendor neutral) PACS system. In such a setup data de-identified from the same participant is expected to align with previous data for the same participant and study if the same participant ID and name is used. This is achieved by using study instance uids that are hashed. Series that comes later should therefore match at the study level. It is not possible to recover the original patient ID, patient name and study/series/image instance UIDs from the de-identified fields as no tracking information is stored in the DICOM files. But, identical input data will result in the same hashes. This can be seen as an implicit coupling list - a price we have to pay to be able to use the tool in our research PACS during the data capture stage of a project.

The used SHA256 algorithm for hashing per project is very fast to compute. This will allow an attacker to create many random tries for a brute-force attack. At the worst case this would allow the attacker to recover the original study/series/image instance UIDs. PatientID and PatientName tags are set manually and are therefore not exposed to such an attack.

We share such source code to support similar research efforts internationally. The open-source nature of this research allows national and international researchers to test and verify our solutions, provide essential feedback and suggestions for improvement supporting advances in medical data handling.

Summary

Tags: Programming, Software
Date: 2020-03-10

Hauke Bartsch, Dr. rer. nat.
https://github.com/mmiv-center/LesionProject.git

Identifying lesions in brain MRI

A software provided by MMIV

This repository provides access to programs developed at MMIV for the detection of brain lesions.

After detecting lesions in-painting can be used to synthetically create a version of the raw data were lesions are masked with assumed intensity values similar to the neighboring voxel in the data. Such synthetic data can be used for algorithms that are sensitive to the lesions otherwise - such as FreeSurfer.

The provided algorithm performs a region growing of initially 2 voxel to create a lesion border. This border might be affected by partial volume effect. Afterwards another 2 voxel morphological grow operation defines a region of background voxel used for the interpolation of the lesion and the lesion border voxel intensities.

For lesions that are close to the border of white matter the interpolation might not be correct as it would blurr intensities from different tissue types across the lesion volume. Instead it might be more appropriate to limit the intensities for interpolation to the voxel of a single material. For these pusposes you can provide an additional mask argument - limiting the sample points for the interpolation to the white matter material only.

In order to quantify the location of a lesion relative to the cortical surface an approach can be used that calculates curvilinear (geodesic) distances between two labels, the ventricles located in the center of the brain and the cortical gray to white matter surface. This approach mimics the general direction of the path neurons travel during cortex development.

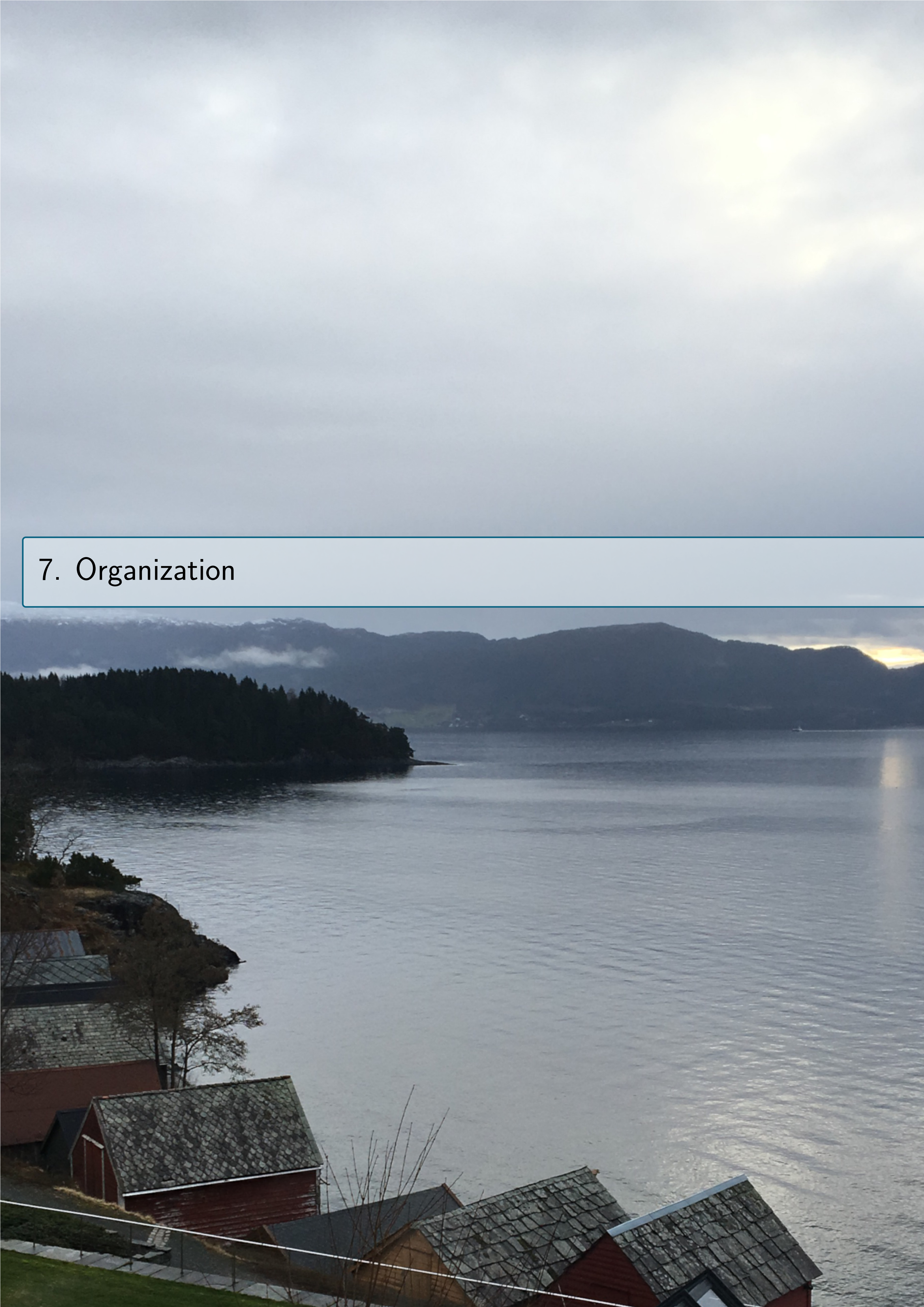
Please visit the https://github.com/ project that implements such a method.

We share such source code to support similar research efforts internationally. The open-source nature of this research allows national and international researchers to test and verify our solutions, provide essential feedback and suggestions for improvement supporting advances in medical data handling.

Summary

Tags: Programming, Software
Date: 2020-03-10

7. Organization



Organization

MMIV is organized as a unit within the Department of Radiology at HUS. Since March 2019 MMIV has been localized on the top floor of the new Haraldsplass building with spacious office facilities including 15 offices and additional meeting-/lunch rooms and mingling area.

The primary investigators (PIs) and researchers at MMIV hold their main positions at HUS, UiB, HVL or Norwegian Research Center (Norce), and some of the PIs also hold adjunct professorships/research positions at UiB/HUS.

HUS has PIs/researchers from Dep. of Radiology and Womens Clinic, and many collaborating partners at other hospital departments. The UiB has PIs/MMIV affiliated researchers from Faculty of Medicine (Depts. of Clinical Medicine, Clinical Science and Biomedicine), Faculty of Mathematics and Natural Sciences (Depts. of Informatics and Mathematics) and Faculty of Psychology (Dep. of Biological and Medical Psychology). HVL (Faculty of Engineering and Science) and NORCE (Dep. of Technology) are also represented with PIs.

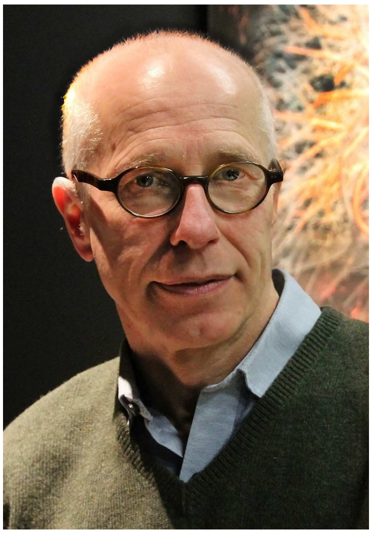
The leadership group comprising principal investigators of the teams meet monthly to discuss scientific and administrative issues and share updates on progress and plans for the different projects. A monthly public MMIV seminar (duration 60 minutes) followed by coffee/waffles is hosted at Haraldplass in conjuncture with this leadership meeting. The daily management group at MMIV (comprising the Head of MMIV, Ingfrid Haldorsen, senior researcher Hauke Bartsch, associate professor Noeska Smit and Elin Myhrvold [secretary]) have weekly meetings.

Guiding the scientific direction of MMIV, a scientific advisory board (SAB) has been appointed (page 53). They comprise highly acknowledged international scientists who push the limits of imaging sciences to transform medicine, and we are very enthusiastic to capitalize on close interaction with the SAB in the years to come.

Scientific Advisory Board

The scientific advisory board at the MMIV consists of four senior scientists who cover the research focus areas of the MMIV:

Anders Persson



Professor Anders Persson, PhD and MD, received his medical degree at Karolinska Institute, Faculty of Medicine, Stockholm Sweden in 1985 and completed his specialty radiology training in 1992. Since 2003 Director and cofounder of Center for Medical Science and Visualization (CMIV) and professor Department of Health Medicine and Care, University of Linköping Sweden. Guest Professor, Clinical Science Intervention and Technology Karolinska Institute Sweden. Senior physician Radiology Linköping university Hospital. CMIV conducts focused front-line research within multidisciplinary projects providing solutions to tomorrow's clinical issues. The mission is to develop future methods and tools for image analysis and visualization for applications within health care and medical research. CMIV is formally a center within Linköping University and is governed by its Board of Directors, with representatives from academia, health care and industry. CMIV is located in its own university premises, 7500 square meter, in the center of the university hospital where a large number of clinical examinations are performed using its own modalities. Medical, computer science and AI research projects bring a mixed group of people together. More than 130 Engineers, technical and medical researchers, etc. are all involved in the center and its research. Prof. Persson has been working in the field of medical image applications for over 30 years. Currently his research is focusing on algorithms for specific clinical investigations (Dual Energy, Photon Counting CT, Flow simulations and AI) mainly in the cardiovascular field. He has been a Visiting professor Mayo clinic's USA, May 2009 – lecturing forensic science. During 2014 -2020 member of the advisory board for the Photon-Counting CT at MAYO clinics. He has >200 Refereed journal and conference publications 2003-2020, >900 Invited talks and 10 book chapters. Large number of ongoing leadership, appointments and commissions of trust. European Institute of Bio Medical Imaging EIBIR (in Advisory board). Board member European ESR Research Committee. European Imaging Biomarkers Alliance, EIBAL. Board member Radiological Society of North America, Research & Education. Several international and national awards such as H.M. The Kings Gold Medal H.M. for special merit in Medical Image Science Research, 2017, RSNA Cum Lade and Lennart Nilsson Award. The Royal Photographic Society Award U.K. 2011, Athena award for best medical research in Sweden. The Royal College Society Combined Scientific Gold Medal in UK. 2013.

Bernhard Preim

Bernhard Preim is a specialist in human-computer interaction as well as in visual computing for medicine. He is currently professor of visualization at University of Magdeburg, Germany. Preim received the diploma in computer science in 1994 (minor in mathematics) and a PhD in 1998 from the Otto-von-Guericke University Magdeburg (PhD thesis "Interactive Illustrations and Animations for the

Exploration of Spatial Relations"). In 1999, he joined the staff of MeVis (Center for Medical Diagnosis System and Visualization, headed by Heinz-Otto Peitgen). In close collaboration with radiologists and surgeons, he directed the work on "computer-aided planning in liver surgery" and initiated several projects funded by the German Research Council in the area of computer-aided surgery. In June 2002, he received the Habilitation degree (venia legendi) for computer science from the University of Bremen. Since Mars 2003 he is full professor for "Visualization" at the computer science department at the Otto-von-Guericke-University of Magdeburg, heading a research group which is focussed on medical visualization and applications in surgical education and surgery planning. These developments are summarized in the textbook Visualization in Medicine (Co-author Dirk Bartz, 2007). Bernhard Preim was founding speaker of the working group Medical Visualization in the German Society for Computer Science (2003–2012). He initiated the Karl-Heinz-Höhne Medvis-Award in 2004 to honor excellent research results from Phd students. He is the chair of the scientific advisory board of ICCAS and was president of the CURAC (German Society for Computer- and Roboter-assisted Surgery (2013-2015)) and Visiting Professor at the University of Bremen where he closely collaborates with MeVis Research (now Fraunhofer MEVIS). Together with Charl Botha, TU Delft, he founded the VCBM Eurographics workshop series and co-authored the book "Visual Computing for Medicine" (2013). He authored and co-authored three textbooks on "Interactive Systems" (1999, 2010, 2015).

Bradley J Erickson

Bradley J Erickson, MD PhD, received his MD and PhD degrees from Mayo Clinic. He went on to be trained in radiology, and then a Neuroradiology fellowship at Mayo, and has been on staff at Mayo for 20 years, where he does clinical Neuroradiology, has been chair of the Radiology Informatics Division and is Associate Chair for Research. He has been awarded multiple external grants, including NIH grants on MS, brain tumors, polycystic kidney disease, and medical image exchange. He is a former president of the Society of Imaging Informatics in Medicine, is current Chair of the American Board of Imaging Informatics, and serves on the Board of the IHE USA. He recently won the nVIDIA Global Impact Award for his work on deep learning applications in medical images.

Anders Dale

Anders Martin Dale is a neuroscientist and Professor of Radiology, Neurosciences, Psychiatry, and Cognitive Science at the University of California, San Diego (UCSD) and the founding Director of the Center for Multimodal Imaging Genetics (CMIG) at UCSD. His research focuses on the development and application of advanced techniques for acquisition and analysis of multimodal structural and functional imaging data. Several of these methods have had major, and in some cases transformative, impact on their respective fields. Specific examples include 1) development of rapid event related experimental design and statistical analysis methods for fMRI; 2) development of fully automated methods for segmentation of the cortical surface, subcortical nuclei, and white matter tracts from MRI scans – instantiated in the FreeSurfer software package, used by more than 10,000 researchers around the world; 3) development of standardized image acquisition protocols and analysis procedures enabling use of quantitative imaging biomarker in large-scale, multisite research studies, as well as in clinical practice – these procedures were fundamental to the success of the Alzheimer's Disease Neuroimaging Initiative (ADNI), the Pediatric Imaging Neurocognition and Genetics (PING), and the Adolescent Brain Cognitive Development (ABCD) Study. He serves as the PI of the Data Analysis and Informatics Resource Center (DAIRC) of the ABCD Study. He has authored more than 500 peer-reviewed publications, with more than 118,000 total citations, an h-index of 148, and was recently listed among the top ten "most influential brain scientists of the modern era" (Science, 2016).

8. Publications

Table of Publications

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