2018 ANNUAL REPORT

CIUS

Centre for Innovative Ultrasound Solutions

sfi Centre for Research-based Innovation

CIUS

NTNU Norwegian University of Science and Technology

Academic Partners

NTNU
Norwegian University of Science and Technology

SINTEF

UiO : University of Oslo

USN University of South-Eastern Norway

Industry Partners

equinor

Archer

AUROTECH ultrasound

GE Vingmed Ultrasound

InPhase Solutions

KONGSBERG

HALFWAVE

MEDISTIM

XFAB MIXED-SIGNAL FOUNDRY EXPERTS

PHOENIX SOLUTIONS

Sensorlink

Health Sector Partners

HELSE MIDT-NORGE

HELSE NORD-TRØNDELAG

ST. OLAVS HOSPITAL TRONDHEIM UNIVERSITY HOSPITAL

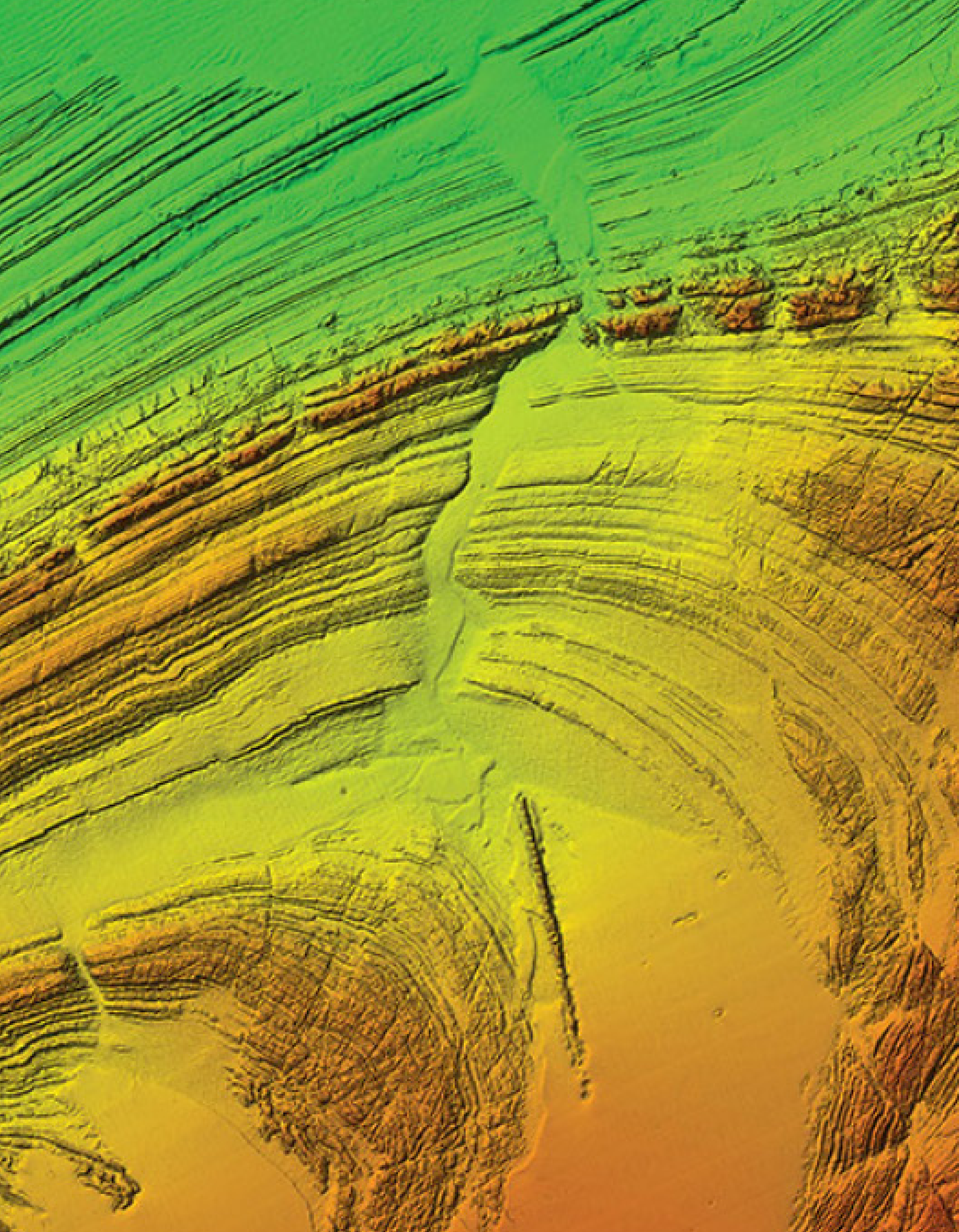
Levanger kommune

VERDAL KOMMUNE

Host

NTNU
Faculty of Medicine and Health Sciences
Department of Circulation and Medical Imaging

Contents



Asta Håberg
Centre Director

Dear CIUS family and friends, another year flew by for all CIUS researchers and partners.

We have experienced exiting days in the lab filled with promising results and breakthroughs as well as despair and piles of problems. Fortunately, there were more of the former, attested to by the very good results for CIUS in 2018 and the many exciting new projects starting in 2019. There are currently 15 PhD and 7 Postdoc candidates funded directly from CIUS, and 29 PhD and 4 Postdoc candidates funded from external sources, working on a total of 53 CIUS related projects. In 2018, CIUS was further strengthened with the hiring of an Innovation Manager, Dr. Tormod Njølstad. This position was awarded the Ultrasound group at ISB, NTNU, which is the academic core of CIUS, by NTNU rector's office. A strong and persistent focus on stimulating an innovation culture, as well as identifying and realizing the innovation potential in the thinking and work performed by CIUS' PhD candidates, postdocs and academic staff is necessary to ensure that CIUS is fulfilling the Research Council of Norway's vision for the Centres for Research-based Innovation. For more details on innovation work in CIUS see page 46.

2018 has also been a good year for furthering and adding to our international collaborations. For instance, the Ultrasound tool box started by CIUS personnel at UiO and NTNU is available in an updated version through a collaboration with 50 ultrasound researchers worldwide. Further, multisite clinical studies of methodology developed at NTNU are ongoing between CIUS and partners at SickKids, Toronto (Canada), and the Royal Brisbane and Women's Hospital (Australia). Moreover, ultrasound-enhanced delivery of nanoparticles and drugs in combination with microbubbles for improved cancer treatment went from the preclinical to clinical stage this year, which you can read more about in the story ? section. This research area has been further boosted by infrastructure support from the Research Council of Norway, funding a new ultrasound scanner including photoacoustic imaging, a small animal optical imager, detecting both infrared fluorescence and bioluminescence, and a PET insert for the preclinical 7T MRI scanner.

I thank all PhD, Postdocs, researchers and faculty in the CIUS family for their excellent work in 2018.

The CIUS spring and fall seminars continue to strengthen the bonds between the partners in CIUS as well as keep the many researchers involved in CIUS updated on the wide range of activates. The large number of CIUS seminar attendants attests to the importance for such meeting places, especially since CIUS is geographically spread. I would like to take this opportunity to thank all the speakers, presenters and organizers of the CIUS seminars. You all made a significant contribution to CIUS.

I would like to thank CIUS' scientific advisory board for their evaluation in the spring. It gave us the opportunity to reflect on our activites and pracitices, and valubale feedback on how to best proceed.

The CIUS administration and all academic personnel in CIUS thank our partners for their active participation in CIUS research and economic and in-kind support in 2018. We look forward to further collaborations in 2019.

◀ *Pliegues - Submitted by Equipo Cartografiado Marino SGP-Tragsatec | SECRETARÍA GENERAL DE PESCA-TRAGSATEC Kongsberg product: EM® 2040 | 11-60 m © Secretaría General de Pesca / Ministerio de Agricultura, Pesca y Alimentación*

Brita Pukstad
Vice Dean

2018 was an exciting and successful year for CIUS' host faculty, the Faculty of Medicine and Health Sciences (MH) at NTNU.

The studies offered by MH are very popular in Norway with a record number of applicants, and the admission bar increasing for all programs. The overall greater scientific activity at our faculty is partly reflected in the graduation of a total of 96 PhDs candidates in 2018, the highest number in history! Paralleling the increase in academic performance, the MH faculty has been highly successful in acquiring external resources from local, regional, national and international sources in 2018.

NTNU's new strategy for 2018 – Activities 2025 has been launched with "Knowledge for a better world" as the strategy objective. In accordance to this highly ambitious goal, the MH faculty is delivering "Health for a better world" as is own strategic vision aiming to develop knowledge, skills and solutions that contribute to good health in a regional, national and global perspective. The vision also expresses our aim to enable a fairer distribution of knowledge and resources. To realize our vision an increased focus on innovation and collaborations between academia, industry and public sectors is central. MH is pursuing these goals at every level in the organization, and has recently opened a new student lead health innovation lab (https://www.ntnu.no/mh/innovasjon/student-health-innovation-centre) for undergraduates in order to facilitate innovative activity also for our future health workers and academic colleagues and collaborators. We continue to support and contribute to an increasing demand in innovative skills and knowledge by supporting the School of Health Innovation (https://www.med.uio.no/english/research/school-of-health-innovation/) for PhD students and postdoctoral fellows, and allocate new funding opportunities connected to innovation projects. NTNU's central administration created 15 new innovation manager positions to help transform more research into benefits in practice this year. Two of these positions went to research groups at MH where one was allocated to the ultrasound group, which constitutes the core of CIUS. The centers for Research-based Innovation, such as CIUS, embody the culture NTNU aspires in its new strategy, and MH is proud to be CIUS' host. The very positive evaluation by CIUS' scientific advisory board this summer reinforces the MH administration's positive assessment of the centre.

We look forward to a further fruitful and engaging collaboration with CIUS in 2019!

Eva Nilssen
Board Leader

CIUS is now at the peak of activity, with lots of activities for all work packages. 2018 and the next couple of years are crucial for the success of CIUS

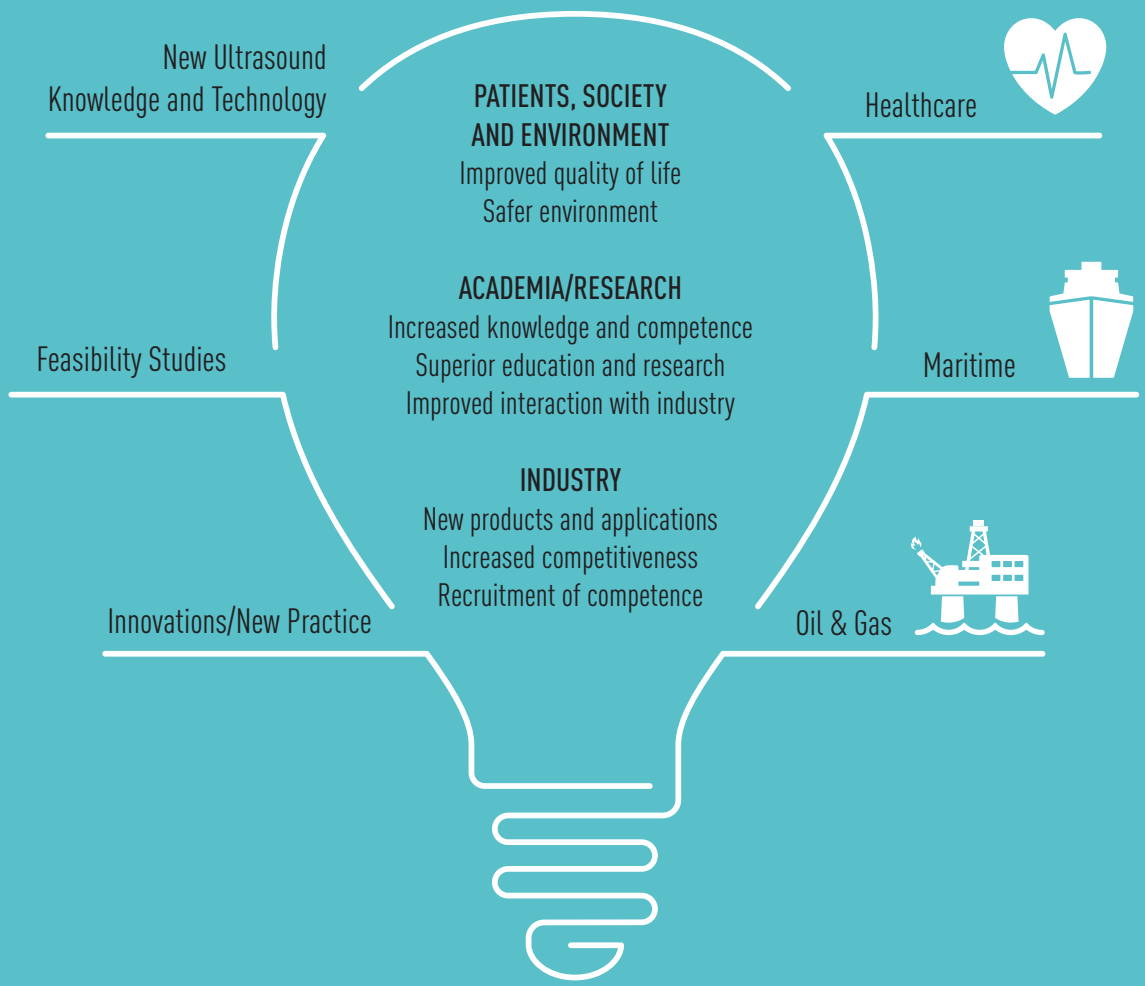
CIUS is now at the peak of activity, with lots of activities for all work packages. 2018 and the next couple of years are crucial for the success of CIUS. We need to make sure that we have clear line of sight for each of the projects, make sure the research results in new, ground-breaking solutions for the partners, both in industry and in health care. We need sufficient bandwidth to achieve this within the CIUS timeframe. Our most valuable assets are our PhD candidates and Post Doctorates. Their ingenuity and dedication to deliver innovations is key to our success. It is therefore very good that the CIUS academic partners have been able to secure additional, complementary funding for more resources and that more master students are participating directly on the projects. This improves both efficiency and bandwidth needed to secure successful outcomes. Engagement of master students doing their thesis directly on the projects is a win-win strategy: The students learn about ultrasound early on, contribute to the projects and they become part of the recruitment pool for PhD candidates and for business partner employment.

During 2018, the Deep Learning (DL) research in WP4 has really taken off. DL technology is utilized "all-over-the-place" with varying degrees of success throughout both academia and industry worldwide. WP4 focus on image processing and DL has been proven to work quite well for image recognition and analysis. This is a good starting point for Professor Lasse Løvstakken and his team who are utilizing the DL capabilities for a wide range of applications, for medical and now also Oil&Gas. For Oil&Gas, a team was put in place in 2018 working on DL for ultrasonic well logging. This project is progressing nicely, and the first results are expected in 2019.

For medical applications, Professor Løvstakken and team have come quite far and have already shown good results in areas such as image quality assessment, cardiac view classification, segmentation and automated measurements. These types of tools are likely to improve efficiency and accuracy of diagnosis. Currently, outcomes from the evaluation of the applications are quite good, comparable to interobserver variability. Also, in addition to achieving robust results, the team has focused on providing visual feedback and guidelines to the user, thus making sure the user has insight and control over the outcome of the ultrasound examination. This is an important factor to consider when commercializing this type of technology. The customer groups vary quite a lot; from high-end, experienced medical professional to novice users of hand-held ultrasound. The novice users need more guiding and automation, while the (existing) high-end customers are unlikely to accept results for which they have not be able to influence the outcome. The approach in WP4 addresses these scenarios quite well. Long term, these applications are likely to become more automated and without user intervention, but we are not there yet. Utilization of DL technology is only at the beginning – the "Digital Revolution" will impact both our professional and private lives more than we can imagine in the years to come. As a technologist, I am excited and optimistic about the possibilities. And proud of the work being done in this field in CIUS, both in academia and with our health care and business partners.

CIUS Idea

CIUS will deliver novel ultrasound technology solutions for the benefit of the involved partners, new diagnostic tools for the benefit of patients and the healthcare providers, important knowledge disseminated in highly recognized scientific journals, and skilled personnel to further exploit the future potential of ultrasound imaging in Norwegian industries, healthcare and academia.



The CIUS Concept

The Centre for Innovative Ultrasound Solutions (CIUS) combines frontier academic research in ultrasound technology development with innovation in leading Norwegian ultrasound companies working in medical, maritime, and oil & gas application areas.

The core of CIUS projects revolves around three main topics within the three application areas: Health care: Improvement of cardiovascular ultrasound; Maritime: Fisheries and seabed mapping; Oil & gas: Monitoring the integrity and safety of wells and pipelines.

The potential impact of CIUS innovations within these areas will be described by three examples from CIUS largest partners:

- Health care: Cardiovascular disease is the leading cause of death and morbidity worldwide. Ultrasound is the leading image modality for assessing cardiovascular disease. GE Vingmed Ultrasound is the world leader in cardiovascular ultrasound, and their systems are on a daily basis used to investigate more than 200.000 people.
- Maritime: More than 90% of the global fleet mapping the world's fisheries resources, and therefore determining quotas for fishing, use SONAR's from Kongsberg Maritime Subsea. Also, 99 percent of the ocean floor is still unexplored and KM is a world leader in SONAR's and AUV's for seabed mapping.
- Oil & gas: Equinor is going to plug & abandon (P&A) thousands of wells on the Norwegian Continental Shelf in the next twenty years. Assessing the integrity and safety of operating wells, and verifying that the downhole well barriers are fit for permanent P&A both rely heavily on sonic and ultrasonic borehole logging and imaging. Advances within these domains enables cost-efficient abandonment methods and ensures that the plugged wells are environmentally safe for the generations to come.

Ultrasound technology as used in the three sectors has a tremendous unexplored potential for meeting future challenges. In CIUS, industry, academia, public institutions, and private research foundations join forces and explore synergies across disciplines, leveraging next-generation ultrasound technology for a better world. Key ultrasound research tasks will be within transducer design, acoustics and image formation, Doppler and deformation imaging, as well as image analysis and visualization. By applying these technologies to specific innovation goals within each sector, significant business opportunities in the international market will be achieved. CIUS will by unique competence and innovations, secure long-term
competitive advantage within areas where Norway is internationally recognized for excellent research, innovation, and product deliveries.

CIUS is hosted by the Department of Circulation and Medical Imaging, Faculty of Medicine and Health Sciences at the Norwegian University of Science and Technology (NTNU), Norway's largest university. The ultrasound group at NTNU is known for their expertise within ultrasound research and innovation in healthcare through 40 years. Expertise and research facilities are joined in a virtual laboratory organization including selected Norwegian academic institutions and important cornerstone enterprises as well as several small-to-medium enterprises (SMEs) in Norway. CIUS encompasses 4 research partners, 11 industrial/corporate partners and 5 healthcare user partners.

Research Methodology

The research methodology in CIUS is an iterative process between curiosity-driven technological development and user-involved feasibility studies in laboratories in maritime and oil & gas settings, and in the clinic.

A close interaction with user partners will ensure that all projects initiated are based on the future needs in the different sectors. A large multidisciplinary research environment is now established across geographical locations (NTNU, Trondheim– UiO, Oslo – USN, Horten), which include scientists and engineers with backgrounds in acoustics, physics, mathematics, electronics, and computer science. Medical doctors and other healthcare personnel are included in clinical studies. Most of the budget is allocated to researcher training at the PhD and Postdoc level.

The aim of these activities is to identify new innovations that can be brought to the market by our corporate partners. The ultimate goal is that the new innovations created in CIUS will generate a large positive impact for Norwegian ultrasound research, the CIUS corporate partners and the healthcare sector.

Overarching Goals

1. To be a world-leading centre for research and innovation in next-generation ultrasound imaging, improving patient care, harvesting of ocean resources, and for environmental monitoring and safety.

2. To extend and strengthen the innovation culture with emphasis on rapid translation from idea to practical applications and solutions needed to facilitate new growth for the industries.

3. To be the main educational and knowledge centre for ultrasound technology to ensure sufficient competence and recruitment needed by Norwegian industries, academia, and the healthcare sector.

Organization and Location

SFI CIUS is hosted by the Faculty of Medicine and Health sciences (MH) at the Norwegian University of Science and Technology (NTNU), and localized to the Department of Circulation and Medical Imaging.

Physically the academic research activity is divided across four institutions: NTNU, University of South-Eastern Norway (USN), University of Oslo (UiO), and SINTEF. SFI CIUS has 11 corporate partners; GE Vingmed Ultrasound, Medistim, Aurotech and Phoenix Solutions within the medical sector; and Equinor, Halfwave, Sensorlink, Inphase Solutions and Archer BTC within the oil & gas sector; Kongsberg Maritime within the martime sector and X-Fab for advanced analog and mixed-signal process technologies. In addition there are five user partners within the medical health provision sector; St. Olavs hospital, Mid-Norway Regional Health Authorities, Nord-Trøndelag Hospital Trust plus Levanger and Verdalen Community Health Services.

The research activity is divided into 9 work packages (WPs). USN is responsible for WP1, UiO for WP2 while WP3-7 are located to NTNU. WP8-9 are in collaboration with the industrial partners and headed by CIUS' industrial liaison. Activity connected to WP1 and WP2 is also localized to the CIUS host. There is extensive collaboration across WPs, and an iterative process between development of new technologies in WP1-4 and their validation and feasibility testing in WPs 5-9 is critical to SFI CIUS' success.

The daily activity of the centre is overseen by centre Director Professor Asta Håberg. Further, the CIUS administration includes Industry Liaison Svein-Erik Måsøy, the Project Coordinator and Administrator Christina Kildal, Communication and Web Officer Kari Williamson and Karl Jørgen Marthinsen, Intranet responsible Sigrid Berg and Financial Advisor/Project Economist Vegard Nyhus. Innovation in CIUS has been further strenghtened by the new innovation manager Tormod Njølstad.

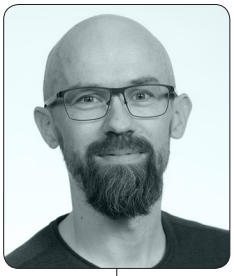
Each WP has a primary investigator (PIs) who oversees the respective WP's research activity. All CIUS activities are supervised and directed by a working Board of Representatives consisting of nine members with a majority from the corporate partners. The Board Chair is Eva Nilssen, Director of R&D GE Vingmed Ultrasound.

Board Leader Eva Nilssen, GE Vingmed Ultrasound

Dean Bjørn Gustafsson, NTNU

Centre Director Asta Håberg, NTNU

Industry Liason Svein-Erik Måsøy, NTNU



MANAGEMENT

Elected Board Representatives among the Corporate Partners

Erik Swensen, Medistim

Dag-Haakon Frantzen, BTC Archer

BOARD

CIUS

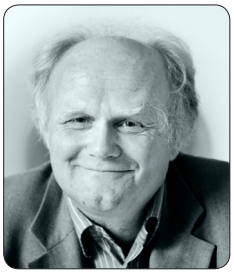
Appointed Board Representatives

Dag Økland, Equinor

Frank Tichy, Kongsberg Maritime

Gunnar Morken, St. Olavs hospital

Olav Haraldseth, NTNU



Berit L. Strand, NTNU

Dr. Iacob Mathiesen, CSO, Otivio, Oslo

Professor Jenny Dankelman, MISIT Group, Delft University of Technology

Dr. Philippe Blondel, Senior Lecturer, University of Bath

Anna Shaughnessy, previous Director of Earth Resources Laboratory, MIT

SCIENTIFIC ADVISORY BOARD

WORK PACKAGE LEADERS

Professor Lars Hoff (USN)

Professor Sverre Holm (UiO)

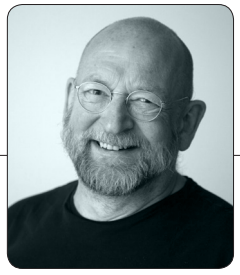
Professor Hans Torp (NTNU)

Professor Lasse Løvstakken (NTNU)

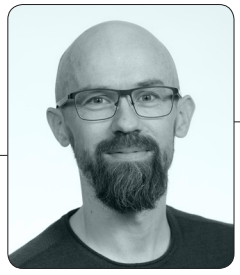
Professor Asta Håberg (NTNU)

Professor Bjørn Olav Hauge (NTNU)

Professor Asbjørn Støylen (NTNU)



Industry Liason
Svein-Erik Måsøy (NTNU)



INNOVATION TEAM

Tormod Njølstad

WORK PACKAGE SUPERVISORS

Hefeng Dong (NTNU)

Trond Ytterdal, NTNU

Tonni Franke Johansen (NTNU/Sintef)

ADMINISTRATION

Christina Kildal

Kari Williamson

Vegard Nyhus

Karl Jørgen Marthinsen

Sigrid Berg

Partners and Collaborations

CIUS has partnered with important cornerstone enterprises, SMEs, academic institutions, and the healthcare sector.

Industry Partners

Archer - Bergen Technology Center
AUROTECH ultrasound
GE Vingmed Ultrasound
HalfWave
InPhase Solutions
Kongsberg Maritime Subsea
Medistim
Phoenix Solutions
Sensorlink
Equinor
X-FAB

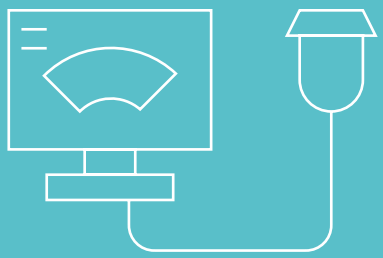
Health Sector Partners

Helse Midt-Norge
Helse Nord-Trøndelag
Levanger Municipality
St. Olavs hospital
Verdal Municipality

Academic Partners

SINTEF
Norwegian University of Science and Technology (NTNU)
University of South-Eastern Norway (USN)
University of Oslo (UIO)

Centre for Innovative Ultrasound Solutions



CIUS 2018

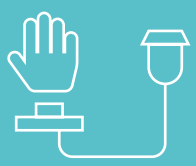
INNOVATION STATISTICS

1 PATENT APPLICATION

12 DISCLOSURE OF INVENTION

167 JOURNAL AND PROCEEDINGS ATRICLES

113 CONFERENCE CONTRIBUTIONS



11 NEW APPS FOR HANDHELD USL

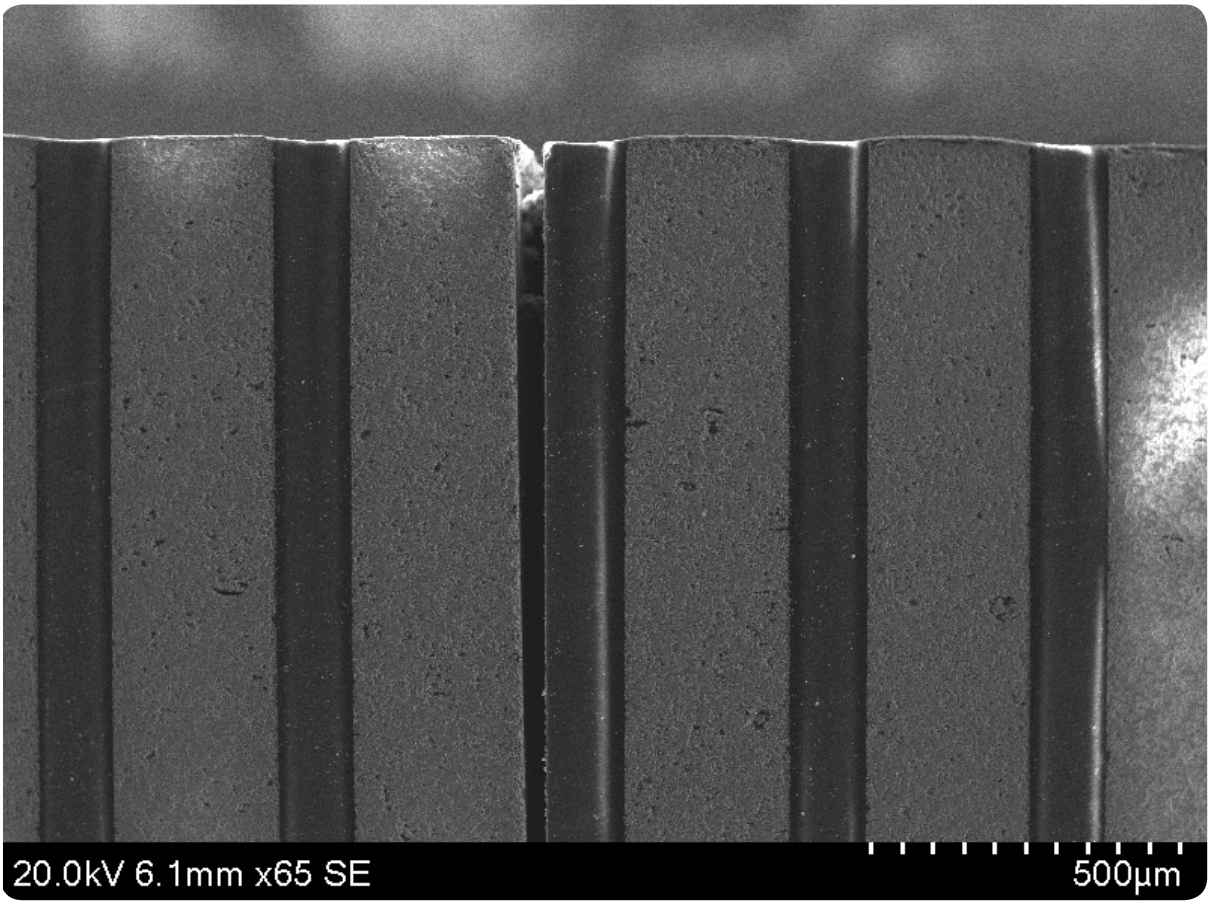
2 SPINOFF COMPANIES

1

Lars Hoff, Professor, University of South-Eastern Norway (USN)
WP leader

Transducer and Electronics

▼ *A scanning electron microscope (SEM) image of an in-house made piezo-polymer 2-2 composite with a defect: The piezo ceramic (wide posts) has separated from the polymer (narrow posts). With a SEM, defects are possible to examine using destructive testing. Photo: Courtesy of Kenneth Kirkeng Andersen*



This work package covers joint research for design, fabrication, characterization and modelling of 1D and 2D transducer arrays, integration of high-density arrays with electronics, ultrasound transducers for high pressure and high temperature environments, and multi frequency band transducers. These tasks are fundamental and highly overlapping for all applications, and of relevance for all CIUS partners.

WP1-1: Acoustic source characterization and optimization

WP1-2: Integrated high-performance transducer array electronics

WP1-3: Embedded ultrasonic sensors

WP1-4: Dedicated high-frequency and multi-bandwidth transducers

Well established transducer lab

The transducer lab is now well established and sees a lot of activity. We constantly develop and improve our methods.

PhD-collaboration with the Industry

Three of our PhD-students will finish their thesis in 2019. One has started a company, ReLab, based on his PhD-activities. We see this as a wanted spin-off from CIUS and a valuable addition to our lab.

These three PhD-students work closely with the industry partners Kongsberg Maritime, Phoenix Solutions, and GE Vingmed Ultrasound, with appointed supervisors from the industry. They have published four articles in 2018, and were strongly represented at the IEEE IUS, with 6 contributions.

The CIUS-funded researchers are invaluable for our activity. We also experience increasing involvement in the PhD-projects from the industry. Employees at the industry partners contribute actively to the supervision of the PhD-students, confirming that that they find our work directly relevant for their activities.

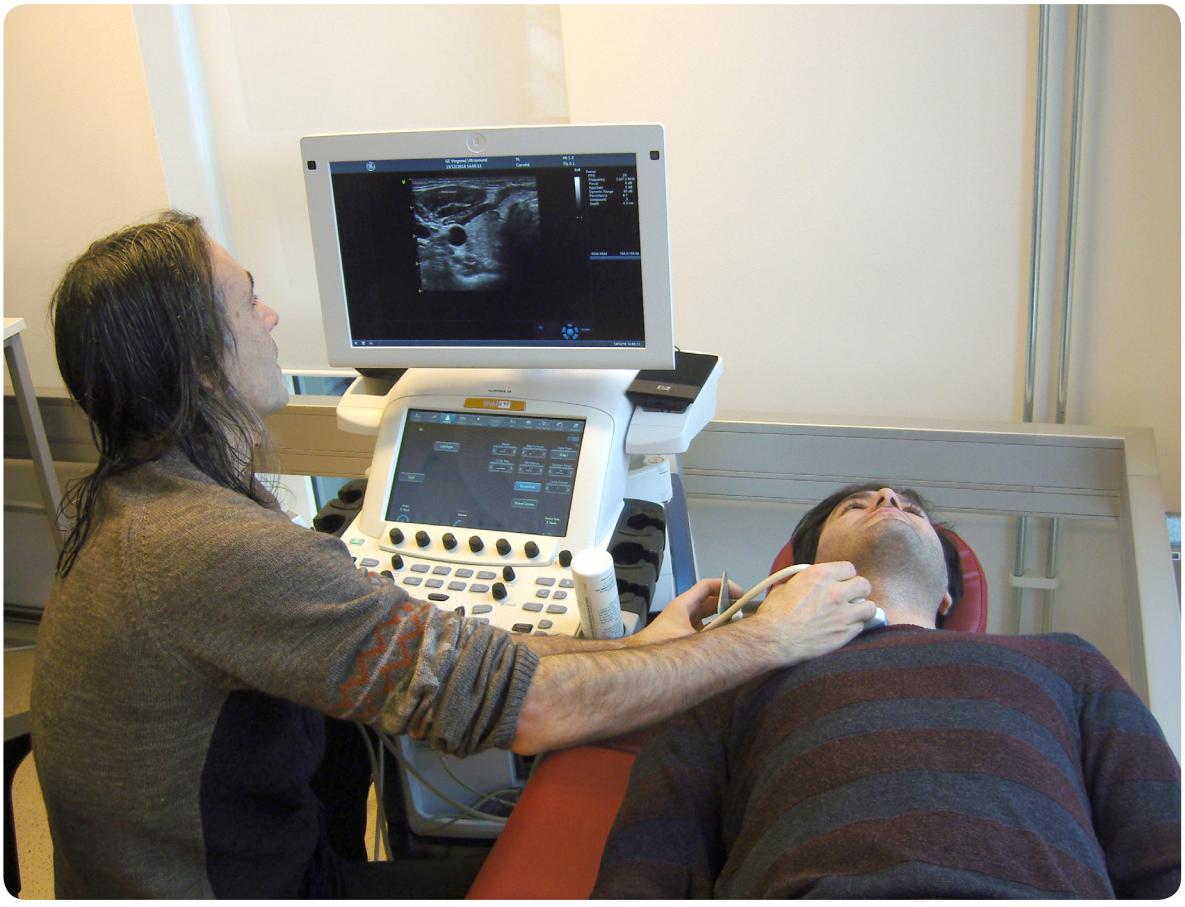
2019

The multi-band transducer developed in one PhD-project will be used in animal studies on ultrasound mediated drug delivery at several centers. A postdoc will develop new transducer fabrication and characterization methods, and the PhD-project on transducers for harsh environments will strengthen our collaboration with oil & gas partners.

2

Acoustics and Beamforming

Sverre Holm, Professor, University of Oslo
WP leader



▼ *Fabrice Prieur (Post Doc) recording elastography data from Yücel Karabiyik (Post Doc) at UiO. Photo: Sverre Holm*

This work package covers the fundamentals of acoustic wave propagation and image formation common to all applications. Research systems at academic laboratories as well as computer simulations are used to investigate next-generation imaging based on channel data processing that provides a strong basis for innovation for the user partners.

WP2-1: UltraSound Toolbox

Further development of open software toolbox developed jointly between UiO, NTNU and international collaborators. The end product is software for research scanners, useful for research groups all over the world. Currently more than 50 researchers worldwide have requested to be part of the development team.

WP2-2: Ultrasound Non-destructive Testing Methods

Verification of our work on transmitting and receiving ultrasonic waves through steel is the next step in our plan to include WP3 activity to detect flow through a steel layer. This concept could be of high value for the oil & gas industry for the potential of detecting leakages in oil wells and for evaluation of wells before plug and abandon operations.

WP2-3: Multibeam Sonar Imaging with Nonlinear Acoustics

We will continue to investigate the feasibility of utilizing nonlinear propagation of sound in water. This has the potential of improving image quality of multibeam sonar images, rendering features on the seabed more clearly.

WP2-4: Adaptive Image Formation for Improved Image Quality

This work focuses on developing a method for adaptively improving image quality in echocardiography. This mean using patient dependent processing in the ultrasound system, adapting the image quality and processing in the ultrasound scanner to each individual patient. The goal is to improve image quality with the potential of improving diagnosis and patient follow-up.

WP2-5: Improved Mapping Rate in Seabed Mapping with Sonar

A re-visit of the fundamentals in signal processing in certain advanced sonar applications is studied. Our aim is to improve performance in sonar products, in particular with respect to mapping speed of the seabed. This has the potential of reducing the cost of performing seabed mapping surveys. Coded excitation techniques are investigated for improved mapping rates.

WP2-6: Suppression of Reverberation Artifacts in Ultrasound Imaging

This project aims at understanding and correcting the factors that lead to reverberation artifacts, such as secondary out-of-plane reflections from ribs/lungs. This effect causes a haze like noise in the ultrasound images, rendering them harder to interpret. The goal is an improved method for cardiac ultrasound through the ribs for ultrasound scanners, improving diagnosis and patient follow-up for hard to image patients.

WP2-7: Ultrasound Elastography with Harmonic Source for Cardiology

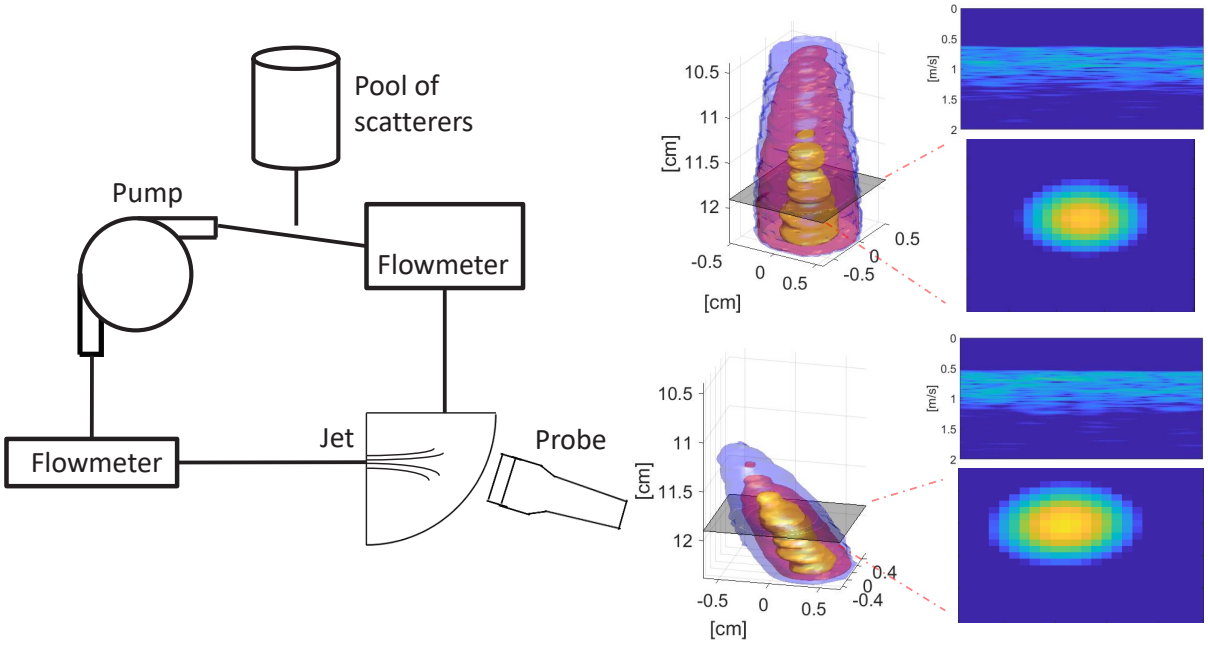
We explore the potential of the MR approach for ultrasound elastography. It has the potential for deeper penetration and more accurate reconstruction, and we are developing a new mode for characterizing the heart with ultrasound based on this method.

3

Doppler and Deformation Imaging

Hans Torp, Professor, NTNU
WP leader

▼ *Experimental flow setup and renderings of jet flow produced from 3-D high frame rate ultrasound acquisitions. Illustration: Jørgen Avdal*



We work on technology to improve methods for detecting and measuring flow and displacements in ultrasound (US) images. This ability is considered one of the main strengths of US compared to other image modalities, and is fundamental for several of the CIUS innovation goals.

WP3-1: 3D Vector-flow Imaging

The traditional Doppler imaging approach is limited in terms of measurement range and is inherently one-dimensional. We will develop and utilize next-generation multi-dimensional imaging of blood velocities, enabled by utilizing the increased data information available using parallel acquisition techniques. The main focus will be on achieving real-time 3D (full velocity vector) imaging of blood velocities, based on spectral- and color-Doppler imaging.

An interesting combination of 3D vector flow and 3D tracking Doppler has been developed for improved assessment of aortic stenosis. A similar technique for vascular applications has also been developed and published.

WP3-2: Flow Measurement in Non-stationary and Noisy Surroundings

Development of methods used to detect and measure flow in noisy surroundings, e.g. coronary flow in the beating heart or low flows due to leakage in cemented well isolation layers. This includes adaptive filtering approaches that utilize properties of the received signal to better separate flow from other signal sources, as well as the use of a priori information of cyclic behavior of flow characteristics in medical applications.

WP3-3: High Frame Rate Tissue Deformation Imaging

Development of acquisition strategies and processing algorithms for high frame rate 3D tissue deformation imaging, utilizing the increased data information available using parallel acquisition techniques. The overall aim is to evaluate regions with specific properties such as increased stiffness or reduced muscle contraction. Methods will be based on Doppler, speckle tracking, and acoustic radiation force principles (e.g. shear wave elastography). 2018 has been devoted to further development of "Clutter wave imaging", a method to quantify myocardial stiffness. Clinical study with patients with myocardial fibrosis has started, and pilot results is under publishing. Sebastien Salles, a (now former) CIUS Postdoc, received the 2018 Innovation Award at the IEEE IUS for this invention.

WP3-4: Doppler Imaging of Flow in Cement Behind Steel Casing

For the oil & gas well integrity logging operations, detecting flow in the cemented zonal isolation layers is of vital interest. Currently this is not possible with state-of-the-art US logging tools. This project will use lab models of cemented wells and develop new ultrasound Doppler techniques for flow detection in the cement behind steel casing for this purpose. Lab experiments are planned for 2019.

Promising in Vitro Experiments

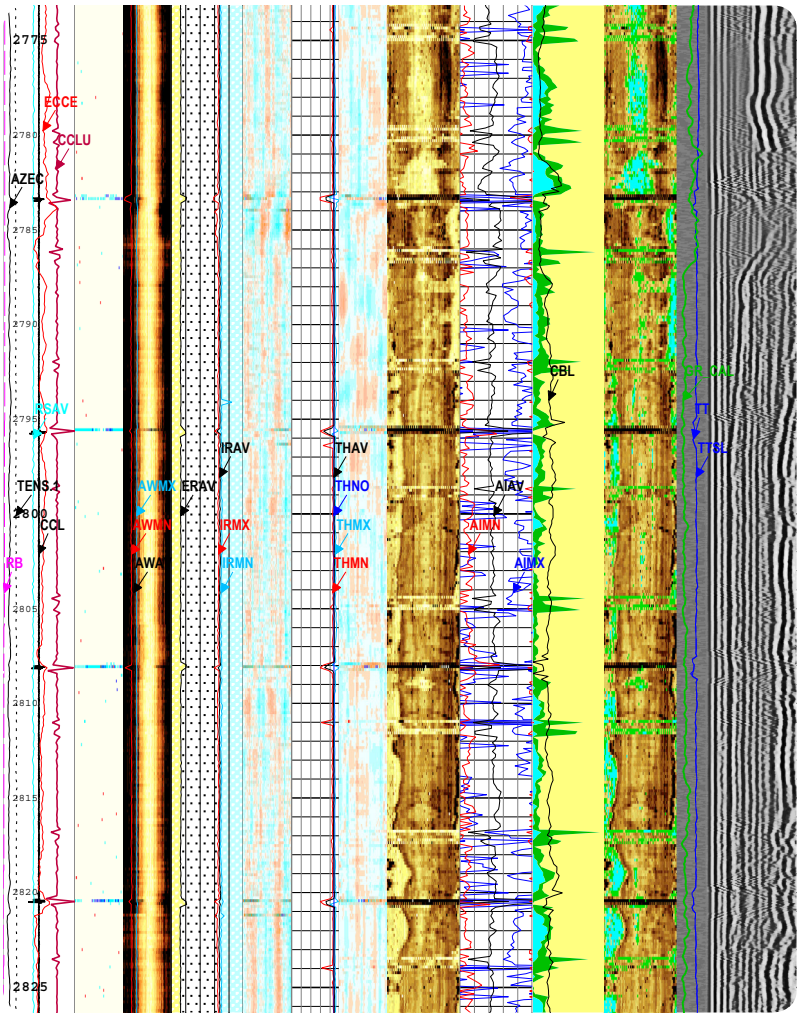
A classical problem in Doppler echocardiography has been picked up this year, using the latest 3D ultrasound technology: Volume flow measurement in insufficient heart valves (see illustration). In vitro experiments show promising results, and in vivo patient data has been acquired. Preliminary results were presented at the IEEE Ultrasonic Symposium.

4

Image Analysis and Visualization

Lasse Løvstakken, Professor, NTNU
WP leader

▼ *A pairwise comparison of processing algorithm implementations for ultrasonic well logging measurements. Results from the CIUS implementations (not normalised) are shown on the left, and results from closed reference implementations on the right. The data was taken from Volve Data Village, an open data set provided by Equinor.*



This work package covers the development of image processing and analysis methods to extract the most relevant and contextual information from ultrasound image data, to improve measurement quality, and to provide a more efficient workflow to reduce the time to decision or diagnosis. These tasks are also coupled to enhanced data visualization to improve data exploration and interaction.

WP4-1: Real-time 3D image segmentation of all heart chambers

WP4-2: Patient and image registration for improved workflow and ease-of-use

WP4-3: Improved processing of corrosion pittings in external pipe inspection

WP4-4: Improved detection of pores and cracks in downhole logging

WP4-5: Model-based acquisition for high frame rate medical ultrasound imaging

Common Challenges

These sub-WP´s share common challenges and can be addressed by common data and image processing approaches. An initial aim will be to establish a state-of-the-art framework and expertise in machine learning algorithms, trained to recognize and segment relevant image or data features. Further, we aim to develop a model-based estimation framework for regularization and reconstruction of noisy and potentially missing image information based on physical models, a pathway towards more robust measurements. Finally, we will explore how these methods can provide context for improved data acquisition and measurements.

Achievements

The activity in 2018 has proceeded rapidly and nicely, as documented by the many scientific contributions and innovations delivered. For medical applications, we have developed several innovations for automatic measurements in echocardiography, as well as a general software for physics-based measurement regularization with initial use in blood flow imaging. For industrial applications we have a team in place working on machine learning for ultrasonic well logging. This project is progressing nicely, and the first results are expected in 2019.

2019

Going forward, 2019 will be the year when CIUS demonstrates how machine learning can help make echocardiography more efficient and more accurate. We are currently gathering sufficient image data for high impact results and more clinical publications for 2019.

We will strengthen our international collaboration, by starting a joint effort on using machine learning in the echo lab both at St. Olav´s and Leuven University Hospital. We will submit joint papers with CREATIS, INSA Lyon on the use of deep learning for cardiac image segmentation. And, together with several research groups in echocardiography, we will be part of a recommendations paper for the future use of machine learning in cardiology.

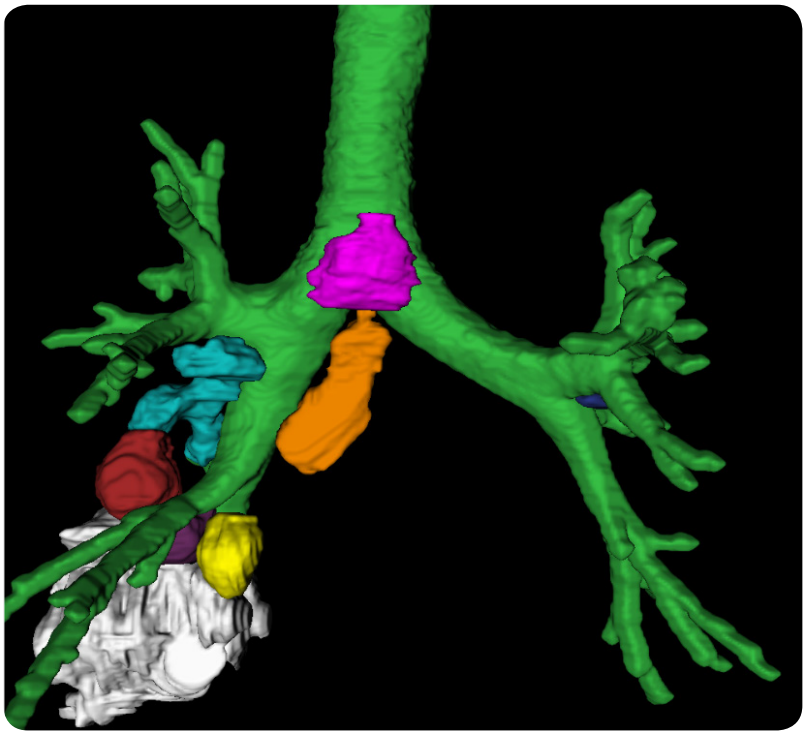
In oil & gas, we will establish the first results on using machine learning for automatic interpretation of ultrasonic oil well logs, based on a unique dataset released by Equinor to CIUS.

5

Multimodality and Interventional Imaging

Asta Håberg, Professor, NTNU
WP leader

▼ *Automatic segmentation for lung cancer staging performed by postdoc David Bouget in WP5. Illustration: David Bouget*



Multimodal imaging combines the strengths of different modalities such as US, MR, CT, and PET for diagnosis and follow-up, as well as for guidance during surgery, targeted drug-delivery and other therapeutic procedures. More accurate diagnosis, for instance by better staging of cancer, precise surgery removing only diseased tissue and novel ways of targeted delivering cancer drugs to the diseased tissue will greatly improve patient care.

WP5-1: Multimodal Imaging and 3D Volume Registration in Cardiology

Today x-ray based methods are used for assessment of coronal vessels, but it is an important goal in the health care system to reduce exposure of both patients and staff to x-rays. This can be achieved by replacing current methods with ultrasound technologies developed in this project.

We are also working on developing ultrasound-based markers for cardiac fibrosis in place of the current contrast enhanced MRI methods, and on ultrasound 3D Doppler methods for assessing cardiac valve pathology.

WP5-2: Multimodal Imaging for Image Guided Surgery

To select the best treatment for cancer patients, it is of utmost importance to identify whether the cancer has spread to the lymph nodes, and also identify spread to other organs. In CIUS, an automated method for lymph node detection and anatomical location assignment in lung cancer is under development. Likewise, methods for identifying cancer spread to the liver for localized treatment of such lesions has started in 2018.

WP5-3: Multimodal US and PET-MR for Improved Diagnosis in Brain and Heart Disease

We investigate the added value PET-MRI for the diagnosis of inflammation of the heart and brain, as well as the usefulness of different tracers for showing which parts of brain tumors are the most dangerous. To set a diagnosis of inflammation with certainty can be very difficult in tissues where biopsies cannot be obtained without great risks such as heart and brain. The results will lead to better diagnosis and ensure appropriate treatment of very serious medical conditions.

WP5-4: Ultrasound Imaging and Manipulation in Targeted Drug Delivery

A prerequisite for successful cancer therapy is for the therapeutic agent to reach all tumor cells and kill them. Unfortunately, cancer drugs have low uptake in tumors. One way of improving tumor uptake is to incorporate the drug into nanoparticles, but this alone is not sufficient. By combining nanoparticle treatment with focused ultrasound combined with microbubbles, improved tumor uptake and therapeutic effects have been shown. A study assessing the feasibility and effect of this type of treatment in cancer spread to the liver started in 2018 at St. Olavs hospital (see also WP5-2). Given the substantial public health burden of cancer (21 million people estimated to be diagnosed with cancer in 2030 worldwide) the project will have a major social impact both nationally and internationally.

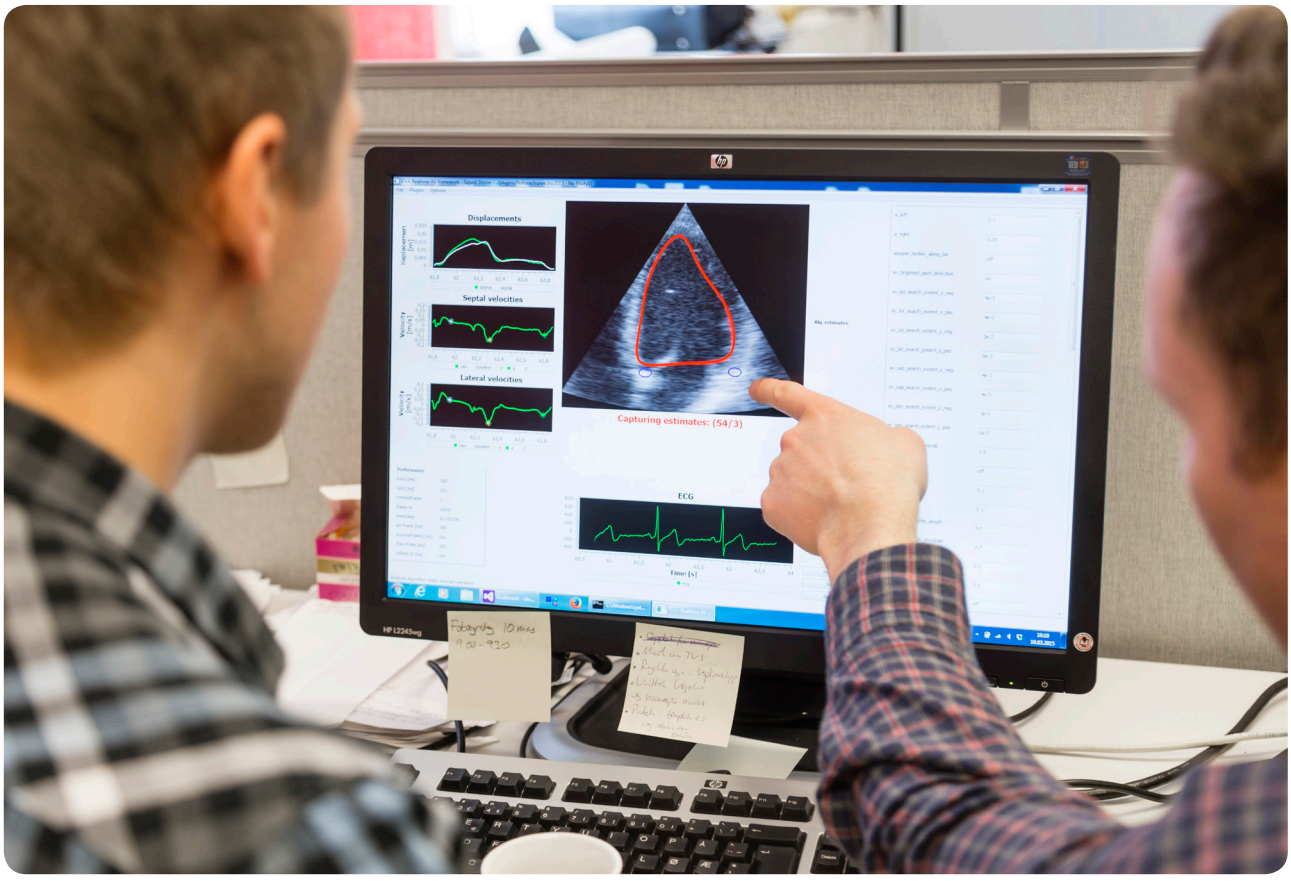
2019

Several clinical studies started in 2017/18 will continue into 2019 when results will start to be analyzed and methods scientifically validated and published in international journals. The first PhD on PET-MR methodology in Norway will be defended, and the new clinical study under WP5-4 on pancreas cancer started.

6

Ubiquitous Ultrasound

Bjørn Olav Haugen, Professor, NTNU
WP leader



▼ *Real time application for automatic anatomic measurement of the heart. Photo: Thor Nielsen*

Pocket-sized ultrasound devices are extremely portable and can increase the use of ultrasound imaging as part of the diagnostics of patients - from rural district hospitals to nursing homes. Development of easy-to-use ultrasound technology has significant innovation potential and can be paradigm altering for practices in the healthcare sector, where the goal is to offer patients quicker diagnosis outside hospitals as well as to avoid unnecessary hospital admissions.

WP6-1 Multi–Purpose Ultrasound Imaging for Non-experts

Technical development and clinical feasibility of using automated methods for navigational aid and (semi-) automatic measurements (e.g. organ size, displacements). Methods will be adapted for non-expert personnel but will also find use in high-end systems when successful.

In collaboration with WP4 and GE-Vingmed Ultrasound, we participate in the project "Computer-aided acquisition, workflow and measurements in echocardiography". The aim is to provide non-expert users with aid during scanning to achieve images with sufficient quality for measurements and diagnosis

WP6-2 Clinical Benefit of use of Pocket-sized Ultrasound Imaging in Nursing Homes

This project will evaluate the clinical benefit of automated detection of dehydration, fluid retention and urine bladder volume by pocket-sized ultrasound in a nursing home. This is common but difficult to assess clinically and can be treated at the point of care instead of hospitalization. This project has also relevance to low-to-middle income countries were dehydration and hemorrhage an leading causes of mortality among children and women.

WP6-3 Automatic Detection of Signs of Rheumatic Heart Disease

Approximately 8 million children worldwide are affected by rheumatic fever and rheumatic heart disease. These are conditions that lead to significant valvular regurgitation and stenosis. This project will evaluate pocket-sized ultrasound for screening of children in Australia or other countries with high incidence of infectious valvular disease.

Productive Year for Industrial Partner

Our industrial partner GE-Vingmed Ultrasound had a very productive year. They validated and released for research purposes the AV Plane app that was developed in the BIA "Smartscan" on Vscan Extend. They also commercially released Vscan Extend R2 software with 10 new apps for broadening use of hand-held ultrasound.

2019

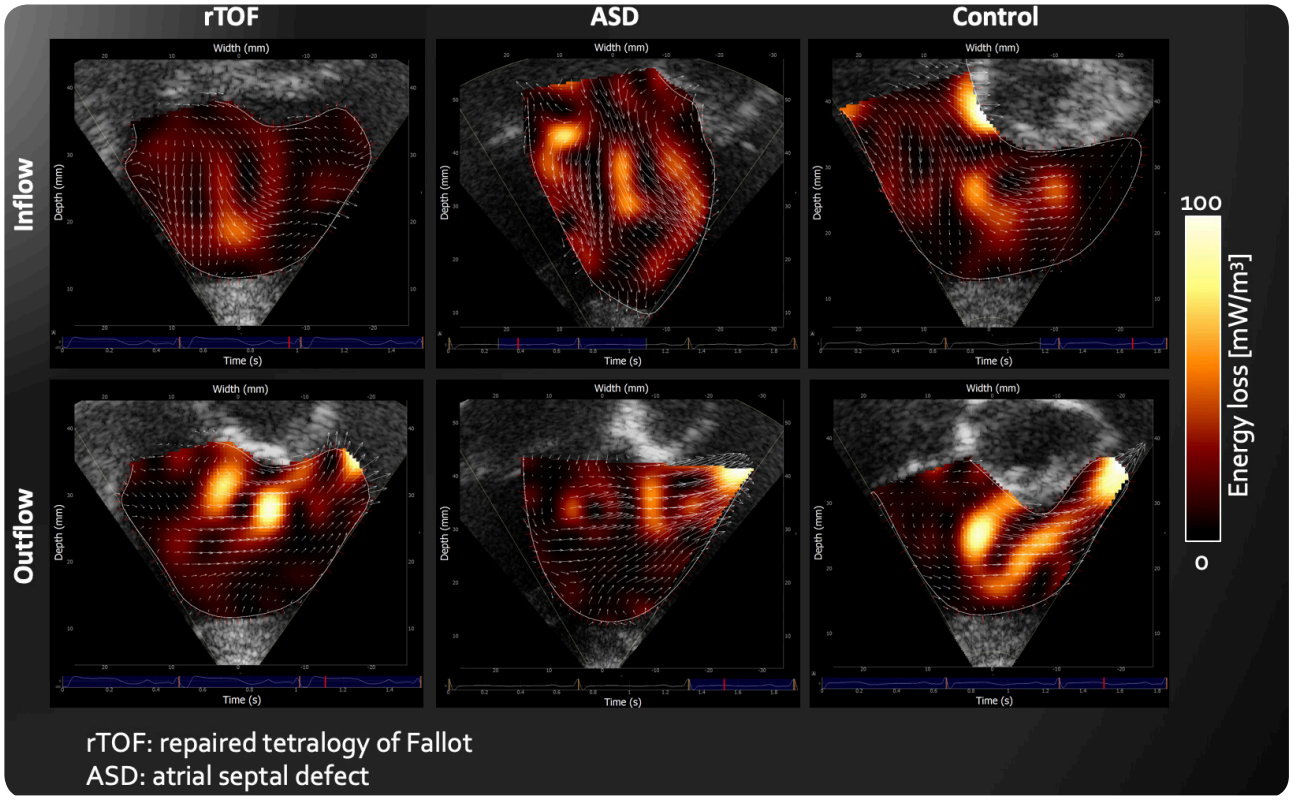
This year a technical PhD working with machine learning and AI will start. In cooperation with Professor Lasse Løvstakken (NTNU) in WP4 and Sigmund Frigstad (GEHC), technology for quality assurance of echo images will be developed.

7

Clinical Feasibility

Asbjørn Støylen, Professor, NTNU
WP leader

▼ *Flow of blood during the inflow (upper panel) and outflow (lower panel) phase in the hearts of child with repaired tetralogy of Fallot, and atrial septal defect in the middle, compared to a healthy child to the right. Courtesy of PhD candidate Wadi Mawad.*



Coronary heart disease is still the largest single cause of death, as well as being treatment cost intensive. Early invasive treatment in the acute phase of an infarct is the main cause for treatment related reduced mortality. The challenge is both to develop more effective diagnostic modalities to assess infarcts, both in the acute and late phase, to select patients to the appropriate treatment in the acute phase to minimize organ damage and at the same time reduce the number of unnecessary procedures. Congenital heart defects are the most common type of birth defect. Improved diagnosis, understanding of its physiology and long-term consequences are needed as increasingly more children born with such conditions are treated and grow up.

Development Potential

Our emphasis is on quantitative ultrasound methods, using new imaging technology, especially 3D/4D ultrasound for deformation and flow imaging. This has significant development potential, and can be a paradigm for quicker pre- and early in-hospital assessment and patient selection. In addition, the identification of viable myocardium after an infarct is of importance for maintaining optimal heart function, while at the same time identifying patients who will not profit from invasive treatment to avoid unnecessary treatment.

WP 7-1 3D Coronary Imaging

Traditional coronary imaging has been with invasive heart catheterization, but is now increasingly being done non-invasively by CT. This still uses ionizing radiation and X-ray contrast, which represents a potential risk. Functional assessment has been done by fractional flow reserve, based on invasive pressure measurement, but is now possible to do by CT based on mathematical modeling. Ultrasound, on the other hand, is non-invasive and ultrasound contrast is near risk free. Functional assessment can be done by Doppler flow reserve based on pulsed wave and color Doppler, as well as myocardial regional function during stress. The main aim is to develop a combined ultrasound imaging and functional assessment of the coronaries.

WP 7-2 and 7-3 Acute Ischemia and Viability

Originally two work packages, the projects have been merged. In the acute phase, acute infarcts may present without characteristic ECG changes, although research have shown that at least 1/3 of patients without these changes have an occluded infarct related artery. Due to the lack of specific ECG changes, they will miss early invasive treatment, which will lead to larger infarcts and worse prognosis. Using newer physiological markers of ischemia, in combination with 3D deformation imaging, will make it possible to quantitate "myocardial area at risk", to select these patients for early treatment. The same parameters can be used to evaluate the extent of myocardial scarring, where extensive scarring in the late phase precludes effect of invasive treatment. The aim of this WP is to validate the assessment of acute ischemia and scarring in 3D reconstructed images against references (coronary angiography and MR scar imaging). The further aim is to take this into real time 3D deformation imaging.

Congenital Heart Defects

In this clinical work package, a project based on 2D and 3D vector flow imaging (cf. WP 3.1) to visualise abnormal intracardiac flow in children has started in collaboration with the Sick Kids hospital in Toronto, Canada. The methods are evaluated clinically in a collaboration lead by researcher and consultant in paediatric cardiology, Siri Ann Nyrnes. In addition, the technique is being tested for feasibility in adults. This project also follows up the potential of the Blood Speckle Imaging technology in the clinic, launched by CIUS industry partner GE Vingmed Ultrasound last year, with support from CIUS.

2019

Going forward we will be finishing the stress echo speckle tracking study. We also intend to finish the analysis of the acute infarct study, and take the findings into a new infarct study based on 3D high frame rate deformation imaging. Finally, we aim to do a complete pilot study of intracardiac flow in heart failure patients.

8 | 9

Feasibility, Pilot, and Validation within the Maritime and Oil & Gas Sector

Svein-Erik Måsøy, Industry liaison and Researcher, NTNU, WP leader

This work package follows feasibility, piloting, and validation of CIUS developed innovations in the maritime and oil & gas sector. In these fields, field trials, demos, equipment, and systems are very expensive and require the partners to take the lead with support from CIUS researchers.

2018

This year we saw the first projects within CIUS reaching feasibility and piloting within the maritime sector. The project Multibeam sonar imaging with nonlinear acoustics from WP2 has now moved on to our partner Kongsberg Maritime Subsea for the first pilot in a realistic setting. Simulations and measurements in the lab have validated the potential of this technique, and a larger scale field trial is now required for further progress.
Also, developments of knowledge and methods on how to characterize piezoelectric rods, in particular their response to temperature, in WP1 is now being introduced into Kongsberg Maritime Subsea design processes of SONAR transducers and arrays.

2019

The goals of 2019 are to have the first large scale pilot of nonlinear imaging in SONAR applications. We also hope to evaluate the effect of transducer design improvements on end product or prototype quality, and for potential cost reduction in manufacturing.

In 2019 we also aim to have a first lab test with the Archer – BTC downhole oil and gas tool on improved imaging through steel casing in oil wells.

▶ *FRACTURES AT THE PERLE AND BRUSE HYDROTHERMAL-VENT FIELD ON THE MID-ATLANTIC RIDGE*
Submitted by Ole Lorentzen | FFI Kongsberg product: HISAS 1032 on HUGIN AUV | 560 m
© Ole Lorentzen, Norwegian defence research establishment (FFI).
Data courtesy of the University of Bergen

The overall greater scientific activity at our faculty is partly reflected in the graduation of a total of 96 PhDs candidates in 2018, the highest number in history!

- Brita Pukstad, Vice Dean

Photo: Karl Jørgen Marthinsen

Profiles and Stories

Stories
In CIUS we are devoted to find out how ultrasound can be used to help others. This innovative work is the very core of CIUS, and it is all because of the talented researchers working with us.

A new generation of researchers
CIUS is affiliated to some of the best ultrasound researchers in the world.

Read about our profiles:
Ellen Katrine Sagaas Røed is designing new ultrasound transducers for use under water. Erlend Magnus Viggen find new ways to analyze the health of petroleum wells. Morten Smedsrud Wigen is working on new techniques to estimate the blood flow through a human heart.

Partners
Our partners are important to us in many ways, not just for their economic and intellectual support. They are significant in the process of taking an idea and transforming it into a product.

Cimon Medical is developing new ways to continously monitor newborns with ultrasound, detecting sepsis and peripheral atrerial disease in an early stage.

NTNU and Phoenix Solutions is researching how to target the delivery of drugs with ultrasound in cancer patients. This reduces the risk of side effects

PhD, Kongsberg Maritime

Ellen Katrine Sagaas Røed

Improving Underwater Transducers

Photo: Andreas Henriksen

Ellen Katrine Sagaas Røed has been working as an acoustical transducer designer for Kongsberg Maritime since 2002. – We design and manufacture transducers for underwater applications, such as fishery, sea bed mapping, positioning and communication, says Røed. Her job is to design the sound generating part of the transducer, using piezoelectric material that expands and contracts when subjected to an electric field. Ellen is now starting an Industrial PhD project for Kongsberg Maritime in collaboration with CIUS.

Transducer Performance

– Transducer performance is essential to image quality. The transducer frequency and sensitivity decide what kind of fish that can be detected or what kind of sea bed that can be mapped, and at what range. The frequency bandwidth is important for spatial resolution and communication. The size of the transducer is also an important factor, as the transducers are more and more often mounted on small vehicles like gliders and autonomous underwater vehicles (AUVs).

Alternative to Single Crystals

– Today we mostly use the piezoelectric ceramic PZT as the active material. PZT is a polycrystalline material, Røed explains. Lately, single crystal materials have become popular in high end medical transducers. Single crystals have a very large electromechanical coupling coefficient compared to PZT and may thus significantly increase bandwidth. Use of single crystals may also reduce transducer size. – However, the material has a very high-volume cost, she points out. – Underwater transducers typically operate in the kHz range. Thickness and diameter of the active part of a transducer scale with resonance frequency, so the active part of a 100 kHz underwater transducer will have approximately 1000 times the volume of a 1 MHz medical transducer. A new type of material called textured ceramics is now being developed. This material is expected to possess some of the benefits of single crystals, but at a lower volume cost.

Academic Collaborations

One of the large research centers in this field is the Applied Research Laboratory at Pennsylvania State University. Their head of textured ceramics research, professor Richard Meyer, is co-supervisor on her project, and her main supervisor is Lars Hoff, professor at USN and leader of WP1 in CIUS. – We at Kongsberg Maritime find it very exciting to be able to explore high coupling piezoelectric materials in cooperation with these very competent academic groups with lots of transducer experience. CIUS has really been a catalyst for increased cooperation between Kongsberg and USN, and it was also the establishment of CIUS that made me think of the possibility for in depth studies of my design tasks through a PhD project.

Multidisciplinary Field

Transducer design is a multidisciplinary field and the in-house manufacturing at Kongsberg Maritime makes Røed´s job even more diverse. – I really enjoy working with experts on different fields, from soldering and dicing to mechanical engineering, signal processing and testing. It makes me want to provide the best answers to their acoustic design related questions, and there are never lack of exciting and challenging design tasks. In this regard, the national ultrasound expertise available in CIUS is very valuable.

Informed Exploitation of the Ocean

– I hope that my PhD project will contribute to underwater transducers being used in even more applications and providing even better information, Røed says and adds:
– Informed exploitation of the oceans is increasingly important and high coupling materials in transducers may contribute to more efficient monitoring.

Postdoc, CIUS

Erlend Magnus Viggen

The Health of Petroleum Wells

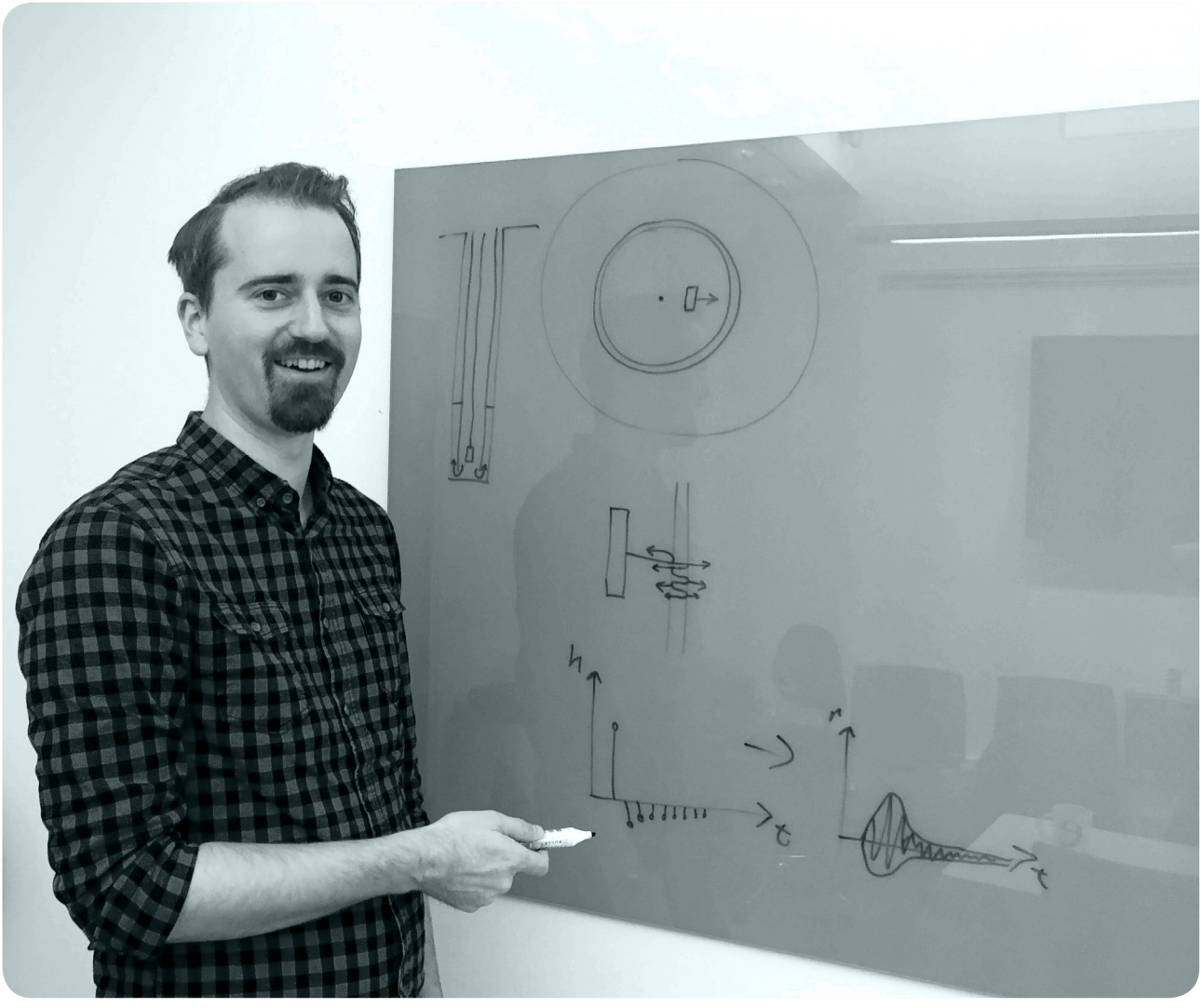


Photo: Kari Williamson

How do you check that a petroleum well is leak-proof, so that it cannot endanger the environment or the platform staff? You would have to investigate a narrow hole, kilometers below the ground, where the temperatures can reach well above 100°C and the pressure is crushing. This is a difficult procedure, but the petroleum industry has been doing this for almost a century, and over the past four decades they have increasingly been using ultrasonic techniques.

Measuring the Health of Petroleum Wells

– There are a number of different types of measurements that can be done in a well, Erlend Magnus Viggen, a CIUS postdoc explains. – Ultrasonic, sonic, radiometric, mechanical, electromagnetic, and so forth. Based on this information, experienced log interpreters can get a very good idea of the health of a well. For example, for a well with a steel pipe with cement on the outside, they can tell whether the pipe is corroded or otherwise slightly deformed, and whether there are any fluid channels between the cement and the pipe through which oil or gas could leak.

Data set from CIUS Collaborator Equinor

As part of the CIUS collaboration, Equinor has released a large well log data set to CIUS, in addition to the data set that they have released to the general public. These data sets include both raw measurement data and previously processed data based on the different measures explained above. – With these data sets and our expertise in ultrasonics and machine learning, we want to help give log interpreters an even better basis for making their evaluations, Viggen says of his and his colleagues' role in the project.

Motivating Surroundings

– CIUS is a very friendly and social environment, and it's very motivating to be surrounded by so many smart and capable people, Viggen boasts about his colleagues and continues: – I appreciate CIUS giving me the opportunity to work for three years on a topic that I already have a significant head start on, having worked with a similar field before, says the former physics student, who got tired of theoretical physics courses and interested in sound.
– I took a PhD in computational physical acoustics at NTNU, which lead me to the acoustics group at SINTEF before coming here.

Spreading the Knowledge

– I think most researchers find that carrying out the research is more exciting than explaining their results afterwards. For me, it's the other way around, he says eagerly. Viggen enjoys communicating his knowledge so much that he spent three years of his free time writing a collaborative textbook on the method he did his PhD on: – I feel that the process of finding a well-structured and understandable way to explain something is very satisfying. The way that I need to shift things around in my mind when I am looking for a good way to explain them also helps my understanding of them, and to expose flaws in my own thinking. And of course, it also feels good to give people an understanding of something they did not know before.

The Future of Well Log Interpretation

Viggen points to several directions going forward. – By developing better data processing techniques, we can provide log interpreters with more information so that they can make evaluations with (even) more certainty. We also want to help by giving them extra decision support, for example through automatic suggestions for well log interpretations. By doing this we let them change the focus of their work towards the more challenging situations that require an experienced human to evaluate.

He also highlights the economic perspective: – The Norwegian government is currently facing expenses of hundreds of billions of NOK to safely plug and abandon the petroleum wells when we cannot get more out of them. Anything we can do to make this process cheaper, without negatively impacting safety, will mean that our government will be able to save a lot of money. Thus, money that would otherwise go to pay international oil service companies can be used for something that benefits our society more directly.

Postdoc, CIUS

Morten Smedsrud Wigen

3D Blood Velocity Estimation in the Heart

Photo: Karl Jørgen Marthinsen

Conventional ultrasound has been used for blood velocity estimation since it was first developed, by utilizing the Doppler principle. Velocity estimation is used for quantitative measurements using Pulsed Wave Doppler and for qualitative imaging with color flow. The latter is available in both two and three dimensions on clinical scanners today. However, neither can capture the true complex blood trajectories present inside the heart.

Vector Flow Imaging (VFI)

The term vector flow imaging is often used for methods that seek to measure the true velocity direction and magnitude of blood flow. – The research conducted during my PhD involved development and application of new principles of high frame rate volumetric acquisition and velocity estimation for VFI applied on the human left ventricle, Morten Smedsrud Wigen, a CIUS Postdoc explains.

Increased Collaboration with Clinicians

One article in Wigen's PhD-thesis involved measurements of both velocity estimation of the blood and mechanical waves in the heart walls. – The propagation velocities of these waves are hypothesized to be related to tissue stiffness, and hence cardiac function. We demonstrated that these measurements can be estimated simultaneously from the same dataset. Flow-tissue interaction is therefore a topic we want to dig further into, he says eagerly.

Wigen continues his investigation of technical feasibility of 4D (3D+time) VFI method in his Postdoc: – During my PhD I have learned about the strength and weakness of the methology which I want to investigate further. We also want to increase collaboration with clinicians, and for that we will develop a more streamlined analysis software.

Drawn to the Novelty

– When I started working on my PhD, I had limited knowledge on the topic of blood flow measurements using ultrasound. I was, however, drawn to the novelty of the project and the previous work which led towards it. Through the last years I have really enjoyed the many aspects of the project, including both the technical and the clinical dimensions.

From Concept to Implementation

Wigen recently moved to Oslo, and due to the close collaboration with the Department of Informatics (UiO), a CIUS partner, he now works from there. – I clearly see how my research can benefit from other projects research, and the close collaboration with CIUS industrial partner GE Vingmed has given me the very valuable opportunity to work with technology from concept to implementation.

When asked about what excites him in his work, he mentions the small breakthroughs which leads you to towards bigger goals. – And digging into known limitations and find solutions to those. The creative process of forcing you to think of alternative solutions than those currently used, he adds.

What's Next?

As of today, the method Wigen has developed can be used to investigate complex blood flow in the heart. However, there is a need for further validation studies to map the reliability of the method before it can be implemented and validated for clinical use. – In the long run, if the method matures and proves helpful for patients, it could be an alternative to existing state-of-the-art methods using phase-contrast MRI. Ultrasound has the advantage of being cheap and bedside available, giving it a huge advantage over MRI if the same information can be extracted, he explains. – A great accomplishment of my research would be to contribute to expanding the use of ultrasound for blood flow measurements.

Today he has a part time position at GE Vingmed where he implements a similar method for 2D, developed by his supervisor Professor Lasse Løvstakken. – It would be very exciting if my research one day could contribute to development of a 3D method available on ultrasound scanners, Wigen summarizes.

Photo: Ole Jørgen Larsen/TYD (www.cimonmedical.com) Martin Leth-Olsen, Sigrid D. Vik, Hans Torp and Siri Ann Nyrnes.

Cimon Medical
– Ultrasound Circulation Monitoring

Our vision is to develop products for a wide range of clinical applications related to continuous monitoring of blood flow within newborn intensive care, peripheral arterial disease and sepsis diagnosis, says Christian Gutvik, CEO.

Local Invention

CIMON Medical, founded in early 2019, is based on technology from the Department of Circulation and Medical Imaging (ISB) at the Norwegian University of Science and Technology (NTNU). This particular technology is invented by Professor Hans Torp, a driving force in the Trondheim ultrasound community, and a WP-leader in CIUS.

– At ISB, innovation in ultrasound goes back a long time. Already in the early 70's the department developed the first instrument that could non-invasively measure blood flow in the aorta, replacing catheter-based measurements of pressure drops in heart valve stenosis, Torp explains.

NTNU at the Forefront of Ultrasound Innovation

The innovation was picked up by Vingmed, and by 1986 spun out into Vingmed Sound. Since then, Trondheim and NTNU have been at the forefront of ultrasound innovation, developing Doppler ultrasound with color in the 1980's and in vivo 3D embryo imaging in the 1990's.
Presently, CIMON Medical is industrializing ultrasound innovations from NTNU, allowing for the first time continuous monitoring of blood flow for a variety of applications.

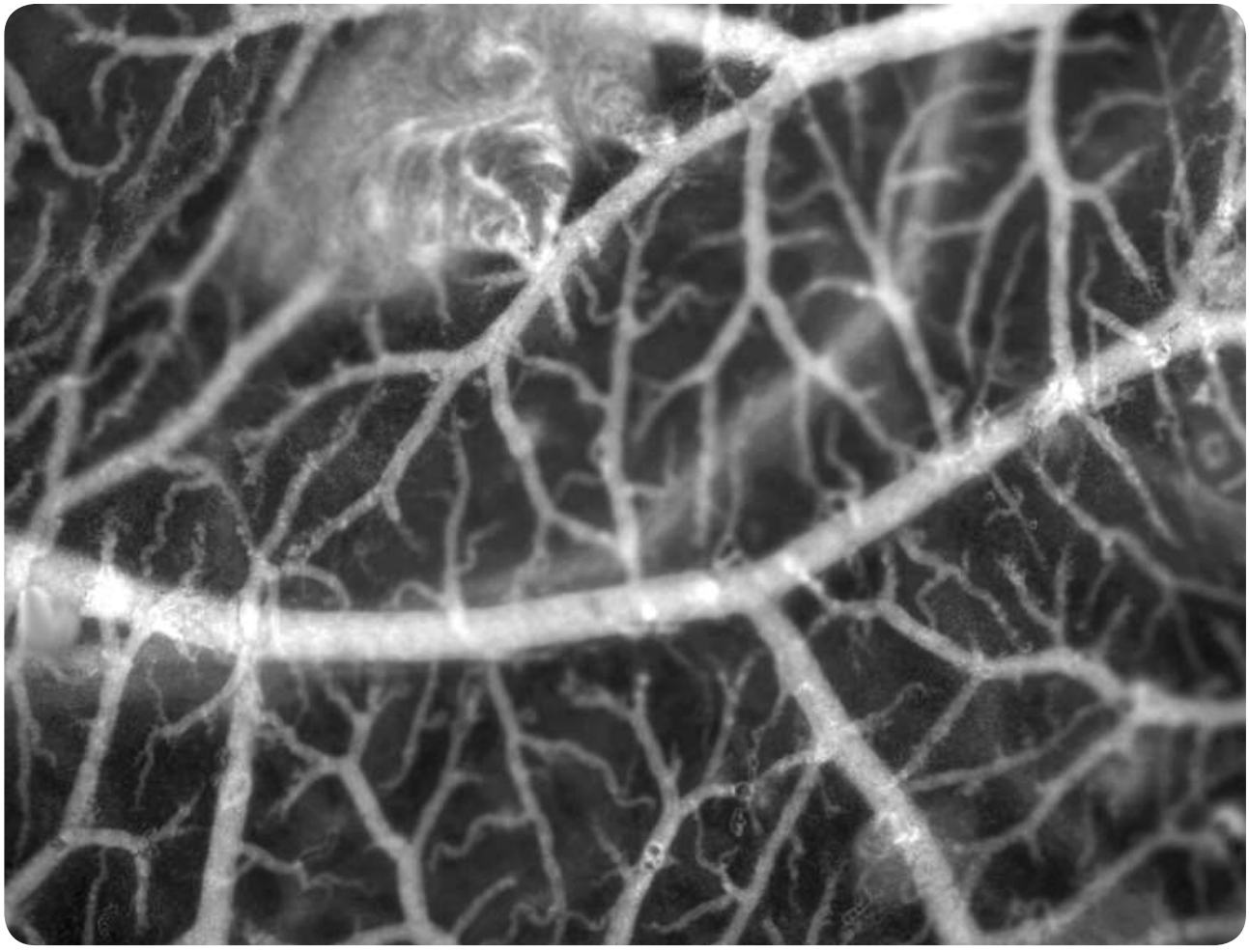
Going Forward

1 in 10 children is born prematurely each year, and the risk of brain damage is substantial. Cimon medical is currently performing studies in the neonatal intensive care units at St. Olav´s Hospital and Oslo University Hospital.
– Using a new non-invasive method, we can measure and detect changes in cerebral blood flow in real-time. This allows clinicians to act early to prevent brain damage, Torp says eagerly. – We have also initiated several studies in peripheral arterial disease and sepsis, Christian Gutvik adds.

Øystein Risa, Head of Department of Circulation and Medical Imaging, congratulate professor Hans Torp who received NTNUs Innovation Prize 2018. Photo: Hans-Petter Grav.

Targeted Drug Delivery – First Clinical Trial in Progress

The clinical utility of a wide range of drugs, especially within oncology, is very restricted by dose limiting toxicities. Dosed systemically, the entire body is treated and typically, less than 0.01% of the injected dose reaches the tumor. As a rule, these therapeutic regimes are not terminated because the patient is cured, but because of excessive systemic toxicity. 2019 is the year of the first clinical Proof of Concept study, treating hepatic metastases from colon and pancreatic cancer using Acoustic Cluster Therapy (ACT).



The chorioallantoic membrane (CAM) of chicken embryos is a useful model for studying the effects of ultrasound and microbubbles with a microscope. Increased extravasation of model drugs and nanoparticles can be observed, as well as changes in blood flow. Cortney of professor Catharina Davies. Image: Anders Hagen Jarmund/NTNU Department of Phsyics

- Needless to say, this is by far the most important milestone reached to date, says CEO of Phoenix Solutions, Per Christian Sontum. The CIUS industry partner have been working hard since 2013 with this and are very excited on the prospect of finally getting data, showing whether ACT works in a clinical setting. - The next 18-24 months will be thrilling indeed, he says eagerly.

Acoustic Cluster Therapy

By using microbubbles in combination with ultrasound, a drug can be steered directly to the tumor. The clinical procedure is straight forward: In addition to a small injection of the ACT microbubble formulation directly into the blood, the anti-cancer drug is administered in a regular manner. When the microbubble is exposed to standard medical imaging ultrasound at the targeted tumor, the microbubbles transfer acoustic energy to the attached droplets, which undergo a liquid-to-gas phase shift. The resulting vapor bubble instantly expands and quickly deposits in the targeted capillary network. Further ultrasound insonation then generates a range of purely biomechanical effects which increase the permeability of the vascular barrier and improve the extravasation, distribution and uptake of drug in the tumor tissue.

Phoenix Solutions

Phoenix Solutions is currently optimizing and exploring various applications. This is a unique approach to ultrasound mediated, targeted drug delivery – capable of significantly enhancing the clinical utility of a wide range of therapeutic molecules and nano-drugs for a wide range of clinical diseases.
- We are currently focusing on the cancer segment, looking in particular at pancreatic, liver, triple negative breast and prostate cancers. Other medicinal areas, such as diseases in the CNS and infection are also being explored, says Sontum.

NTNU Collaboration

Phoenix Solutions and the NTNU research group working with delivery of nanoparticles in tumor tissue and across the blood-brain barrier have a long-standing collaboration.
- In many respects, the collaboration with Professor Catharina Davies and her team at the Department of Physics at NTNU has been instrumental in bringing the ACT technology to the point we are today. Phoenix has no pre-clinical capability and therefore has a close to perfect fit with Davies` resourceful group, which is very knowledgeable in the use of ultrasound for therapeutic purposes. The collaboration has enabled us to understand, develop and optimize the concept, Sontum explains.

Professor Davies also speaks positively about the collaboration and highlights the knowledge and experience of the founders of Phoenix Solution: - When we got involved the ACT concept was well characterized and Phoenix Solutions had a very clear aim of bringing ACT to the clinic. This made the collaboration very exciting, not only being a scientifically and academically interesting project, but the possibility to make a clinical difference was inspiring, she says, adding that ACT shows very promising preclinical results. It is therefore important to bring this novel concept to the clinic to the benefit for patients. - Our collaboration now has two directions: Phoenix testing ACT clinically and we at NTNU are, with support from the Research Council of Norway, studying the underlying mechanisms which are necessary to understand in order to optimize the therapy.

Going Against the Blood-brain Barrier

And what is next for Professor Davies and her team?
- The most promising clinical application is enabling therapy of brain diseases. The blood-brain barrier limits delivery of therapeutic drugs to the brain and focused ultrasound in combination with drugs or nanoparticles can really make a difference, she explains. - Furthermore, improving the treatment of patients with non-resectable pancreatic cancer using standard chemotherapy combined with focused ultrasound and microbubbles can make a difference. Such a clinical study, not using ACT but microbubbles used in ultrasound imaging, will start at St. Olav's hospital. In parallel we need to study the underlying mechanisms in vitro and in preclinical models, to be able to optimize ultrasound mediated delivery of drugs and nanoparticles.

The Future of ACT

There are several strategic opportunities for a company like Phoenix Solutions and the ACT technology. – It is mostly data-driven, and where these will take us is not written in stone, by far, says Sontum. - We`re starting to look at other medicinal segments such as ACT and biologics for cancer, and ACT for treatment of CNS and infectious diseases. Ultimately, ACT *could* be relevant for treatment of localized pathologies as such, not only within oncology.

The ultimate objective for both Phoenix and the researchers at NTNU would of course be that ACT, in the not so far future, will be used for increasing therapeutic efficacy for a wide range of drug molecules within a wide range of disease segments.

The CIUS Innovation Game

Svein-Erik Måsøy, CIUS Industry Liaison

CIUS represents a unique opportunity for our researchers to have their work being put to good use. We have partners ranging from oil companies to hospitals, they really want to put to best use the results of CIUS common research efforts. Whether it is new knowledge for improved patient care, a better method for mapping the seabed at reduced cost, or detection of cracks in large gas transport pipes on the seabed floor - Our partners are eager to know about the results of our research.

Andeas Østvik, David Bouget, Svein-Erik Måsøy and Erik Smistad in discussions.
Photo: Kari Williamson

How About that Idea of Yours?

Wouldn't it be great if something you have put a lot of effort into, something you truly believe in, ends up being used by many people every day?

CIUS Innovation Definition

In CIUS we define innovations as anything our partners can use in a product or in their daily operations, being an industrial company, a university, or a hospital. Since we work mainly with technology development, our innovations mostly consist of new technology, but may also include knowledge for improved production of technology, or improved workflow in a hospital.

A System and a Culture: The Innovation Game

Like many organizations, we have also developed a formal system for how to report an innovation to the consortium. Whenever some of our researchers have a great idea, they write it down in a pre-specified form, a so-called Declaration of Invention or DOFI. Then, a formal process of recognition, approval, IPR investigations, and follow-up starts. But how does a researcher, consumed in her or his work, understand when there is something to report? This is the big challenge, particularly when you work in an organization that is driven by, and mandated to, publishing research.

The way we have solved this in CIUS is by continuously developing and building a culture for innovation. The ones responsible for this is me and my colleague Tormod Njølstad, who started as an Innovation Manager in the ultrasound group at NTNU in September this year.

The main mode of operation for building a culture thinking about innovation is simply to continuously talk about it, inspire people to see opportunities for their work in end products or systems, meet people where they are, get them to talk about their projects and discuss opportunities for and with our partners. We call this The CIUS innovation game.

This basically boils down to a lot of communication. Tormod and I are trying to engage all the researchers and partners in CIUS as often as possible. In practice this is solved by a range of arenas where we meet individual researchers, teams focusing on a specific problem, partners, or everyone together in the bi-yearly CIUS conference. The most important are listed below:

1. CIUS bi-yearly seminars where everyone in CIUS meets and provides updates. Our role here is to present status of the innovation work and talk to as many as possible.
2. PhD & Post Doc innovation lunches – we meet with groups of researchers from our university partners at least once a year discussing potential new innovations.
3. Direct partner meetings - physical or digital meetings regularly regarding project status – at least once per year in addition to other meeting arenas.
4. Monthly academic group meetings where WP leaders report status on all projects.
5. Yearly Industry partner meeting – meeting between all industrial partners, CIUS Chair of the Board, and the CIUS Industry Liaison and Innovation Manager.
6. Direct participation in regular partner and researcher meetings, most of our projects have such meetings on a regular basis.
7. Specific meetings with partners organized by Industry Liaison and Innovation Manager, or initiated by partners.
8. Point-of-contact – we serve as a point of contact for all partners and researchers in CIUS and regularly attend a variety of meetings, video conferences, telephone calls, conferences, and seminars where subgroups or individuals of CIUS personnel are present.

In addition, we have developed an Innovation Tracker, available for all partners and researchers with all relevant and updated information about our already reported innovations and how these projects are progressing.

Finally, we have created a DOFI competition where the best DOFI from the past year receives a cash price of 25.000 NOK share among the inventors.

May a Hundred Innovations Blossom

There are currently 15 PhD and 7 Postdoc candidates funded directly from CIUS, and 29 PhD and 4 Postdoc candidates funded from external sources, working on a total of 53 CIUS related ongoing projects. CIUS has so far published 167 journal and proceedings articles, and given 113 conference contributions, recorded 12 innovations, 1 patent application, supported of 2 spin-off companies (ReLab, Cimon Medical), been part in the introduction of a new product (GE Vingmed Ultrasound Blood Speckle Imaging) and several new apps for handheld ultrasound imaging of the heart. Nine of the reported innovations are currently in pilot testing in collaboration with our industry partners.

CIUS is becoming good at playing the innovation game!

Innovation Manager, ISB, NTNU

Tormod Njølstad is the newly appointed Innovation Manager at the Department of circulation and medical imaging (ISB), and he is very optimistic on CIUS´ behalf.

Since starting up as Innovation Manager in the fall of 2018, Njølstad has spent his time meeting colleagues and collaborators to discuss and learn. Getting an overview of past and current innovations at ISB has been useful, and he is already in the process of applying for funding for a new project. In October, he participated at the IEEE International Ultrasound Symposium to get a better understanding on how the researchers position themselves internationally. — That was a great experience, which made me very optimistic.

Unique Partner Collaboration

In addition to working closely with the Ultrasound group at ISB, Njølstad will facilitate innovation in CIUS: — It is of great value for the society if this research can contribute to solve important problems in the world. I think the collaboration models and the research partnership agreements in the CIUS' consortium are rather unique, Njølstad points out. He plans to gradually involve himself with the partners of CIUS, and he is already invited to visit some of them. — I want to understand what they can contribute with towards CIUS and NTNU, and what they needs from us. Please contact me if you have some ideas for improvement of the collaboration and for increasing the innovation results, he urges.

Discovering the Potential

– My role is to help discover the innovation potential in an early stage. I can assist the researchers to clarify whether their idea is an invention or not, and if it is ready for patenting. Together we can explore what is required, because a strong patent application needs to be detailed and clear, and should not be submitted with insufficient substance, Njølstad says. He wants to be a sparring partner in the next stages, like in contact with TTO, planning of technology demonstrations, partnership search and commercialization. –I will be a facilitator for contacting other groups at NTNU and external resources or companies. I will work closely with NTNU TTO, but I think of my role as more "early stage" than TTO's role, he explains. – My hope is that the CIUS project can result in a number of solid and granted patents which will strengthen the industry partners.

A Bright Future for Ultrasound

– Ultrasound makes us able to survey, map and measure static objects, moving targets and flowing fluids which cannot be perceived by our eyes or by camera. Ultrasound is proven to be very important in medical, marine and industrial applications. These technologies can be made compact and lightweight by further miniaturization, and the price of the components can be reduced while the complexity and functionality can increase. Therefore, the future of ultrasound is bright, and new innovative ultrasound solutions can improve and simplify medical, marine and industrial procedures, Njølstad summarizes.

Background

As a recent graduate Njølstad became a part of Bjørn Angelsen's medical ultrasound group during his civil service in the 80´s. He then moved on to Seatex Kongsberg, where he contributed to the development of ultrasound instrumentation for subsea ROV operations. The road led back to NTNU and a position as an Associate Professor at Department of Electronic Systems. — My technical background covers detailed design of electronics and firmware design as well as system solutions, industrialization, small scale and large-scale production of electronic and optical parts, modules and complete systems.

No Stranger to Taking Chances

Njølstad has personal experience with innovation and start-ups: — In 2003 I left my safe university position at NTNU to establish the start-up company New Index. I decided to commercialize my patented idea of an interactive pen and projector, he says. New Index merged with EPSON in 2011, the biggest projector company in the world, and Njølstad was appointed Chief Technology Officer in the R&D subsidiary. Today there are 9 EPSON projector models in the world-wide market with Trondheim-based interactive projector technology. — In my new role as Innovation Manager I want to contribute to good teamwork, help develop new ideas and explore possibilities. To contribute to something which can impact the society, Njølstad says enthusiastically.

Innovation Statistics 2018

CIUS researchers have delivered 7 Declaration OF Inventions (DOFI) to the CIUS consortium in 2018.

The topics cover new transducer development and characterization, improved seabed mapping and several machine learning algorithms within cardiology.

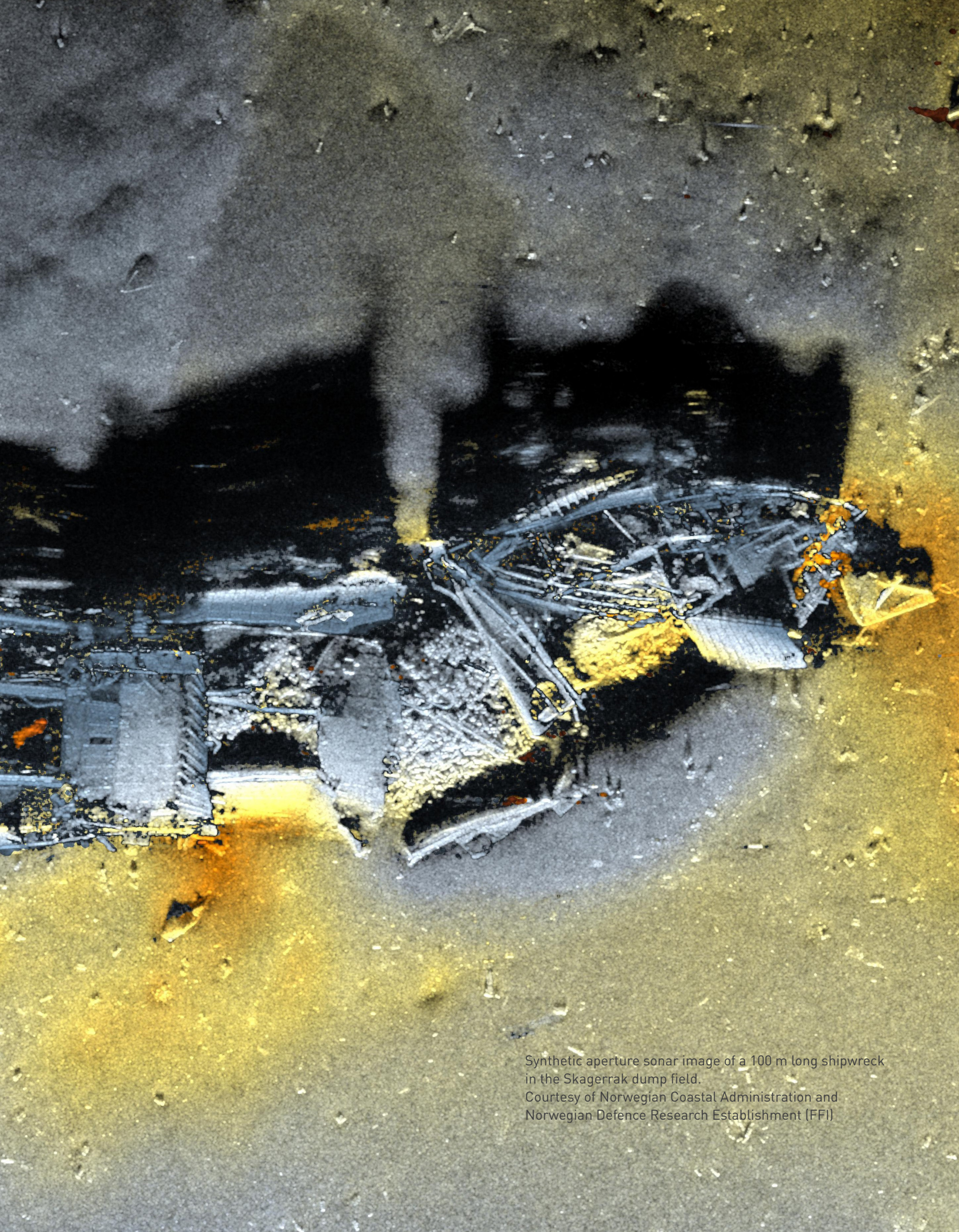
CIUS filed one patent application on machine learning for echocardiography in 2018.

New or improved methods/models/prototypes = 11 new apps for Vscan (handheld ultrasound).

In addition, several industry partners, such as Halfwave, analyze their data in new and improved ways due to the CIUS collaborations. CIUS has also supported 2 spin-off companies (ReLab, Cimon Medical) in 2018, where Cimon Medical will formally start up in 2019.

New products = 0

New services = Public partners in Northern Trøndelag started has implemented automatic algorithms for assessment of left ventricular function available for clinical evaluation.



Synthetic aperture sonar image of a 100 m long shipwreck in the Skagerrak dump field.
Courtesy of Norwegian Coastal Administration and Norwegian Defence Research Establishment (FFI)

International Collaboration

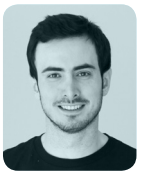

Kings College, London, UK
Århus University
Rigshospitalet, København, Denmark
University of Bath, UK
Interreg Norway-Sweden
M:V Lomonosov Moscow State University, Russia
Linköping University, Sverige
Technical University of Denmark, Lyngby, Denmark
Charité Hospital, Berlin, Tyskland
Medical University of Vienna, Austria
University of Lyon, France
GE Parallell Design, Nice, France
Hohai University, China
University of Rome, Italy
Genth University,Belgium
University of Rennes, France
KU Leuven, Belgium
Bichat Beaujon, Paris, France
Institute of Cancer Research, London
The Indigenous Cardiac Outreach Program, Queensland, Australia
University of Queensland, Australia

Kenneth K. Andersen (WP1)
Unconventional ultrasound transducer design
New ultrasound imaging and therapeutic modalities may require or benefit from ultrasound transducer that can operate at significantly different frequencies. To handle the complexity of these dual-frequency transducers, we have developed a numerical optimization method based on linearizing the phase spectrum. Using this method, a dual-frequency transducer has been designed and optimized for Phoenix Solutions AS. The transducer has been prototyped and tested, and is expected to be used in pre-clinical trials in 2018.

Erik Andreas Berg (WP5)
Multimodality and interventional imaging
We refine and validate a computerized algorithm for 3D transthoracic and transesophageal echocardiographic measures for reconstruction of aortic root morphology. We also work on a semi-automatic computerized algorithm for semi-quantification of aortic and mitral valve regurgitations based on ultrasound data, the clinical value of an algorithm for continuous ultrasound monitoring of LV function during major surgery, and an application for 3D echocardiography of coronary arteries.

Antoine Blachet (WP2)
SONAR seabed mapping
Together with Kongsberg Maritime, I am exploring new SONAR designs that could lead to improved performance in some particular applications. One possibility is to transmit advanced coded waveforms, inspired from modern techniques used in radar and wireless communication. We are trying to mitigate interferences between signals transmitted at the same time. This will make it possible to map multiple parts of the seabed at the same time. It may also increase the sounding density, and make the survey more efficient.

Per Kristian Bolstad (WP1)
Transducer design
Central topics of the PhD-project will be on developing and investigating new bonding methods for ultrasound transducers, using metal alloys to replace polymers. Single element and arrays will be designed, fabricated and characterized. The stability and robustness of the new structures will be investigated, such as long-time stability, aging, mechanical strength, and behavior under high temperatures and pressures.



Ali Fatemi (WP2)
Acoustics and beamforming
State-of-the-art echocardiography allows to correctly diagnose most of cardiovascular diseases. An unknown source of clutter, however, hinders the visualization of the heart in some cases. The aim of this project is to study the cause of this clutter noise in the current echocardiograms and to propose new processing methods to improve the image quality.

Cristiana Golfetto (WP3)
Doppler and deformation imaging
Doppler measurements in coronary arteries are difficult due to rapid motion of the myocardium and small vessel dimensions. High frame rate 3D Doppler imaging with retrospective spectral Doppler processing could potentially solve this. However, the combination of low blood flow velocities and excessive tissue motion in parts of the cardiac cycle makes clutter suppression challenging. I am working on finding an adaptive clutter filter able to reduce power Doppler artefacts such as flashing and dropouts. The project focuses on flow velocity measurements in non-stationary and noisy surroundings.

Marlene Halvorsrød (WP7)
Clinical feasibility and validation – ischemic heart disease
In our project, we want to find new ultrasound methods to predict who will benefit from revascularization in heart attacks. We will take advantage of ultrasound methods developed in CIUS for detection of fibrosis to decide whether the myocardium is viable. In addition, 1/3 of non-ST-elevation myocardial infarctions have a totally blocked artery and will need treatment immediately. Our aim is to better detect these patients and quantify the myocardial tissue at risk. We will use tissue Doppler, strain rate and 3D high frame rate imaging.

Aslak Lykre Holen (WP1)
Transmitters and receivers for ultrasound systems
This project is developing transmitter and receive hardware for low power and high integration targeting medical ultrasound. The aim of this project is to study low power adaptive solutions for integrated high voltage ultrasound pulse generators with harmonic suppression, and low power digital hardware beam formers for ultrasound receivers.

Thong Tuan Huyhn (WP1)
Non-ideal effects in transducers
Novel medical ultrasound imaging utilize the nonlinear properties of the tissue. This requires a good control of the nonlinear behaviour of the transmit system. The aim of this project is to develop methods to explore and model the non-ideal effects in this system, defined as any effect that can not be described by an impulse response. The ultimate goal is to develop methods to compensate for such effects by shaping the transmit pulses. The project uses our 3D scanning hydrophone measurement tank, connected to a GE Vingmed Ultrasound scanner.

Malgorzata Magelssen (WP 6)
Significant efforts are being made to improve the diagnostic accuracy of handheld ultrasound device (HUD). This can enhance the art of clinical examination by revealing disease at an earlier stage, and help to better identify patients in need for specialised care. The focus of our scientific work is to study the feasibility, accuracy and reliability of HUDs when used by less experienced health care professionals such as general practitioners and specialized nurses after a period of focused training. We want to evaluate the usefulness of using HUD as a supplement to clinical diagnostics in patients with suspected heart failure. Further, we want to evaluate the use of automatic analysis of heart function and telemedical support from cardiologist.

Wadi Mawad (WP7)
Cardiac blood flow and blood speckle tracking
The use of high-frame rate ultrasound and blood speckle tracking allows the visualization of cardiac blood flow patterns and quantification of flow characteristics such as vorticity and energy losses. Changes in flow characteristics are thought to precede overt cardiac remodeling which makes them potential early biomakers of adverse cardiac remodeling. This project focuses on the application of this imaging technology to multiple congenital cardiac conditions in children to assess its feasibility, reproducibility and to demonstrate differences in flow characteristics.

Andreas Sørbrøden Talberg (WP2)
Acoustics and beamforming
The focus is on using ultrasonic non-destructive testing methods in applications related to the oil & gas industry. Current work is being conducted with WP3 to combine the knowledge related to the propagation of waves in solids and the use of Doppler methods to inspect flow behind a solid layer through numerical and experimental work.

Morten Wigen (WP3)
3D Vector Flow Imaging
In my post.doc I will work on two projects. One will be a continuation of my PhD, where I worked with three-dimensional velocity estimation in the heart. In that project we overcome current limitations with angle dependencies when using conventional blood flow imaging methods. The next step in this project is to work with clinicians to investigate the clinical utility of the method. The second part of my work will be related to tissue characterisation for regional and global quantification of heart function, and hopefully be able to relate this to cardiac disease. We also want to investigate if we can combine these two project for investigation of flow-tissue interaction in the heart.

Marcus Wild (WP1)
Transdusers & Electronics
I investigate the heat generation and transfer within ultrasound transducers. Heating can cause performance and efficiency issues in modern transducers so it would therefore be of interest to be able to accurately model the temperature rise for a given design before prototyping. The initial part of my PhD consists of characterising the loss mechanisms in the piezoelectric component accurately for various external conditions such as driving voltage or temperature. I will then be using the determined losses to predict the temperature rise in a piezoelectric component.

Andreas Østvik (WP4)
Image processing, analyzis and visualization
The goal of my PhD project is to utilize and further develop machine learning methods to improve state-of-the-art solutions in the field of ultrasound image analysis and visualization. More specifically, research will be conducted on tasks such as classification of standard plane views in echocardiography, cardiac landmark detection and heart chamber segmentation in ultrasound images.

David Bouget (WP5)
Multimodiality and interventional imaging
In order to measure blood pressure and flow through a specific coronary artery, catheter insertion in the body is the current diagnosis approach. In order to perform the same measurement in a non-invasive manner, a solution is to use a US probe to image the flow inside the coronaries. One critical drawback is then the difficulty for the surgeon to properly target a specific coronary using only the US data. We are developing a system able to perform automatic registration between a pre-recorded CT with segmented coronaries and intra-diagnosis US data. In addition, the system is planned to be able to track the US probe motion in time in order to provide an accurate guidance map to the surgeon for reaching more easily regions of interest.

Yucel Karabiyik (WP2)
Researcher
I am working with cardiac ultrasound elastography. Primarily working with methods that utilize external actuators to generate shear waves. Tissue displacements generated by the actuators are estimated in the axial direction or in 2-D. These estimates are then used in methods used mainly in magnetic resonance elastography, such as direct inversion and phase gradient methods. The ultimate goal is to create 3-D stiffness maps of the myocardium and correlate these maps with myocardial dysfunction and relaxation abnormalities of the heart.

Hoai An Pham (WP5)
Interventional Ultrasound
The aim of the postdoc project is to solve some of the challenges in the development of the interventional cardiology ultrasound such as detecting probe movement from 3D TEE data, dynamic movement compensation, dynamic tracking of anatomic landmarks by using ultrasound to ultrasound global rigid motion registration. The developed tools will be implemented in a software plugin provided by GE and then in real-time on a GE scanner for the local clinical team to evaluate the developed tools.

Fabrice Prieur (WP2)
Acoustics and beamforming
My contributions to the CIUS project deals with three main areas: First, the use of nonlinear propagation in underwater acoustics and exploring how the nonlinear effects of sound propagation in water can contribute to improve image quality in SONARs. Secondly, acoustic waves are often used to inspect tank walls, pipe surface, or boreholes for weakness signs such as corrosion, cracks, or bonding faults. Acoustic waves travelling along this structure can be analyzed to discover and position these weaknesses. Finally, I will use my experience in simulations both using finite element modelling method and finite time difference methods to improve our understanding of the propagation of elastic waves.

Sebstien Salles (WP3)
Doppler and deformation imaging
I work with the development of acquisition strategies and processing algorithms for high frame rate 3D tissue deformation imaging, utilizing the increased data information available using parallel acquisition techniques. The overall aim is to evaluate regions with specific properties such as increased stiffness or reduced muscle contraction. Methods will be based on Doppler, speckle tracking, and acoustic radiation force principles.

Erik Smistad (WP4 and WP5)
Image processing, analyzis and visualization
I am primarily working on image segmentation, and exploring new developments in the field of machine learning and neural networks. The work has so far been on classification of images as well as identifying structures, such as blood vessels and the left ventricle. I have also developed software tools for easy annotation of ultrasound image data (Annotationweb), and tools for processing ultrasound images with a trained neural network in real-time.

Erlend Viggen (WP4)
Ultrasonic petroleum well logging
The integrity of a petroleum well can be evaluated with the help of measurements in the well, including ultrasonic ones. Equinor has released a large set of well measurement data to CIUS, and I am working on developing techniques to draw new information about the well status from this data. The aim is to provide more certainty about the status of the well, so that expensive operations such as plug and abandonment can be carried out in more cost-effective ways.

Researchers with External Financing in CIUS-projects

Postdoctoral Researchers

Jørgen Avdal, NTNU
Sofie Snipstad, NTNU
Hong Pan, UiO
Lucas Omar Muller, NTNU

PhD Candidates

Torvald Espeland, NTNU, St Olavs hospital
Stefano Fiorentini, NTNU
Harald Garvik, NTNU
Jahn Fredrik Grue, NTNU
Trine Husby, NTNU
Stine Hverven, UiO
Anna Karlberg, NTNU
Elisabeth Grønn Ramsdal, UiO
Ole Marius Rindal, UiO
Lars Saxhaug, NTNU
Silje Kjærnes Øen, NTNU
Vincent Perrot, Lyon
Sri Nivas Chandrasekaran, UiO
Tor Inge Birkenes Lønmo, UiO
Tollef Struksnes Jahren, UiO
Einar Sulheim, NTNU
Marieke Olsman, NTNU
Melina Mühlenpfordt, NTNU
Stein Martin Fagerland, NTNU
Petros Yemane, NTNU
Margrete Haram, NTNU, St Olavs hospital
Annichen Søyland Daae, NTNU
Anders Tjellaug Braathen, NTNU
Anna Hjort Hanssen, NTNU
Thomas Grønli, NTNU
Jun Fang, Hohai
Amirfereydoon Mansoori USN
Ellen Sagaas Røed, USN
Henrik Fon, NTNU

CIUS Faculty

Svend Aakhus, Professor, NTNU
Knut E Aasmundtveit, Professor, USN
Andreas Austeng, Professor, UiO
Håvard Dalen, Associate Professor, NTNU
Catharina Davies, Professor, NTNU
Live Eikenes, Associate Professor, NTNU
Roy Edgar Hanse, Professor II, FFI/UiO
Espen Holte, Assistant Professor, St.Olav/NTNU
Tung Mahn, Associate Professor, USN
Siri Ann Nyrnes, Reasearcher, NTNU
Annemieke van Wamel, Researcher, NTNU
Rune Wiseth, Professor, St Olav/NTNU
Andreas Åslund, Researcher, SINTEF
Ingvild Kinn Ekroll, NTNU
Solveig Fadnes, NTNU
Lars Eirik Bø, SINTEF
Lars Egil Kjenstad, Researcher, NTNU
Rune Hansen, Senior Research Scientist, SINTEF
Ingerid Reinertsen,Senior Research Scientist, SINTEF
Ole Vegard Solberg,Senior Research Scientist, SINTEF
Reidar Brekken,Senior Research Scientist, SINTEF
Lars Eirik Bø, Research Scientist, SINTEF
Thomas Langø, Chief Scientist, SINTEF
Sigrid Kaarstad Dahl, Research Scientist, SINTEF
Sebastien Muller, Senior Research Scientist, SINTEF
Torgrim Lie, Research Scientist, SINTEF
Janne Beate Bakeng, Research Scientist, SINTEF
Geir Arne Tangen, Research Scientist, SINTEF
Cecilie Våpnenstad, Research Scientist, SINTEF
Sigrid Berg, Research Scientist, SINTEF

Scientific Personnel

Tore Bjåstad
Scientific Programmer
The main purpose of Bjåstad's work is to accelerate the process of getting new methods and algorithms into aproduct. Primarily, the product will be a GE Vingmed ultrasound scanner intended for cardio vascular imaging. This work will typically involve further development of scanner code to make it capable of executing new methods in real time, or to collect data for offline processing, or in some cases just assistance in how to set up and use existing functionality of the scanner.

Jan D'hooge
Professor
Professor Jan D'hooge of the University of Leuven in Belgium visited NTNU as a guest researcher of CIUS in 2017. Although D'hooge has long-standing relations with some of the CUIS investigators, the main purpose of his stay was to optimize the collaboration between his lab in Leuven and CIUS' in Trondheim, in order to maximally exploit potential synergies and avoid redundancy where possible.

Martijn Frijlink
Associate Professor
The Department of Micro- and Nanosystem Technology (USN) are developing and investigating different aspects of ultrasound transducers for applications in both medical, maritime, and industrial fields. With Frijlink's background in different medical and nonmedical ultrasound applications, and having experience from the field of medical transducer design and manufacturing, his contribution mainly consists of supporting different ultrasound transducer related projects.

Bjørnar Grenne
Researcher
Grenne is a researcher at NTNU and a cardiologist at St. Olavs hospital. His main research areas are advanced echocardiography, valvular disease, coronary artery disease and echocardiography in valve interventions.

Bjørn Olav Haugen
Professor
Haugen is a professor at NTNU and consultant cardiologist at Trondheim Hjertesenter. He has been involved in ultrasound technology research since 1998, and is the leader of WP 6 and 7 in CIUS.

Alan Hunter
Associate professor
Dr. Alan Hunter is a researcher and engineering lecturer at the University of Bath, UK. His research interests are in underwater remote-sensing using acoustics and autonomous systems, and he is a specialist in high-resolution synthetic aperture SONAR imaging. Dr. Hunter has been an Adjunct Associate Professor in the Department of Informatics at the University of Oslo (UiO) since 2017.

Tonni Franke Johansen
Researcher
Tonni Franke Johansen is a researcher at SINTEF and NTNU. His research interests are simulation and instrumentation for ultrasonic measurements systems. He contributes in research and supervision at US with piezoelectric transducers, and at NTNU with wave propagation in layered media.

Gabriel Hanssen Kiss
Researcher
Hanssen Kiss works on fast registration and fusion tools for cardiac applications in order to identify and characterize the dynamics and function of cardiac structures based on multi-modal image data. In addiotion, he is also involved with augmented reality visualization techniques to be used in the echocardiographic lab under image acquisition.

Luc Mertens
Professor
Luc Mertens is Section Head, Echocardiography at the Labatt Family Heart Centre, Hospital for Sick Children in Toronto, Canada. Dr. Mertens' research interests focus on using new echocardiographic techniques to study the heart function in children. He was recently appointed as a guest scientist at CIUS, collaborating on applications of high-frame rate ultrasound in children with heart disease.

Alfonso Rodriguez Molares
Senior Engineer
Molares' fields of research are acoustics and ultrasonics. He is currently developing new beamforming techniques to improve the ultrasound imaging of acoustically hard surfaces, aiming to improve the visualization of bone tissue in ultrasound images to support intraoperative monitoring of spinal surgery.

Ole Christian Mjølstad
Researcher
Mjølstad has worked with the development of pocketsize ultrasound technology since 2009, trying to improve physical examination and to increase diagnostic precision. Mjølstad and his colleagues continuously work to establish the position of pocketsize ultrasound in daily clinical care. An important part is the development and clinical evaluation of applications that increase the usability among non-experts.

Anders Thorstensen
Researcher
Thorstensen and his colleagues aim to evaluate the diagnostic accuracy of post systolic foreshortening for direct echocardiographic quantification of myocardial infarct size, using LE-MRI as reference method. The areas of post systolic of foreshortening are likely to benefit from early revascularization in patients with acute myocardial infarction.

Svein Arne Aase
Svein Arne Aase and a small group of GE Vingmed employees are co-located with NTNU's ultrasound researchers. Aase is Vingmed's CIUS contact for research projects within Doppler and Deep Learning. Within Vingmed, he is leading a team who are integrating Deep Learning models into the ultrasound scanners. Their goal is to improve accuracy, reproducibility and efficiency by supporting human intelligence with automatic tools.

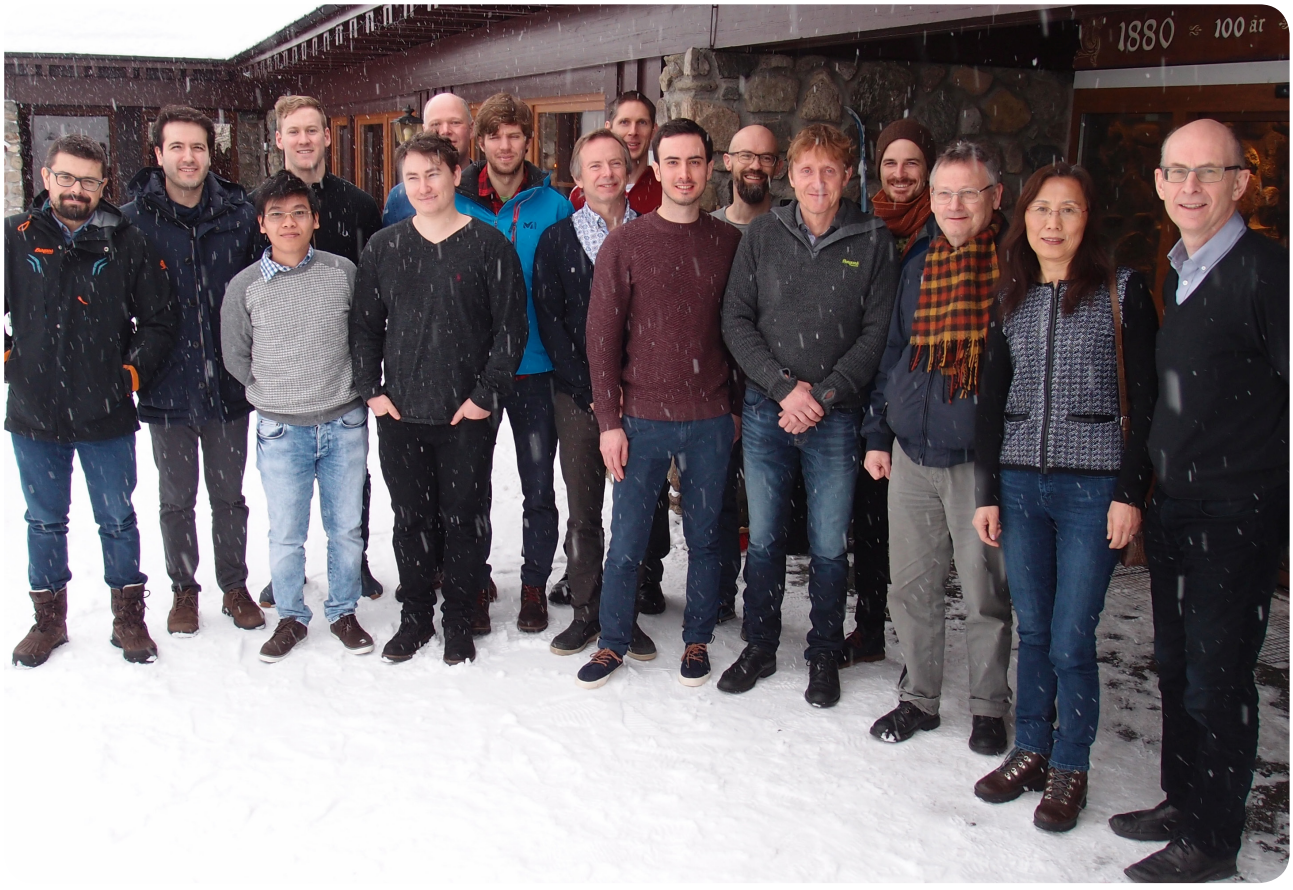
Dissemination, Media Coverage and Outreach

CIUS acknowledges the importance of communicating our research to the public, and in 2018, CIUS projects has been featured in local, national and international press.

Ranging from touching patient stories to new scientific findings and tools, we will continue to use different media platforms to spread our research as widely as possible.

Different platforms calls for different ways of communication, and one channel of information is the NTNU Medicine and Health blog. This is a well-visited site where CIUS-affiliated researchers published 16 posts in 2018. The post "DeepEcho: Machine learning for improved echocardiography" was read more than 2100 times and reached over 3100 people in social media.

We will continue to make our researchers aware of their responsibility to inform the public of important findings, and support them in taking time to do so.



CIUS team on 41st Scandinavian Symposium on Physical Acoustics in Geilo, 28 January – 31 January, 2018.

With CIUS at IUS	NTNUmedicine - blog
Mapping early signs of cardiac dysfunction in children using ultrasound	NTNUmedicine - blog
Samlet seg til to dagers hjernestorm om framtiden	Gjengangeren
Assessing aortic stenosis severity by ultrasound	NTNUmedicine - blog
Stort og smått om forskning	Steinkjer Avisa
Dette diagnoseverktøyet kan redde liv og hindre hjerneskader	Gemini.no
Det forskes for lite på barn - Kronikk	Adressa.no / Adressa
The health of petroleum wells	NTNU medicine - blog
Improving cardiac ultrasound in difficult-to-image patients	NTNU medicine - blog
Bare 0,01 prosent av cellegiften når fram til kreftsvulsten. Nanoteknologi og ultralyd skal gjøre noe med problemet	Teknisk Ukeblad
Vingmed Ultrasound ut av General Electric – Bra for oss	Gjengangeren
Nå kan vi fokusere på oss selv	Gjengangeren
Could your local doctor diagnose heart disease using a handheld ultrasound device?	NTNU medicine - blog
Ultralyd og nanokapsler gir bedre kreftbehandling	Teknisk Ukeblad (print)
Ultralyd og nanokapsler gir bedre kreftbehandling	Teknisk Ukeblad
Oppfinnelse fra Trondheim kan gi kreftpasienter et lenger liv	Adressa
Den er unik og kan bli helt avgjørende ved hjerteinfarkt	NRK Sørlandet
Improving ultrasound images of the heart's blood vessels	NTNU medicine - blog
CIUS promo video	YouTube, Twitter, LinkedIn, Facebook
Gravide bør passe vekta	Dagbladet
Fedme hos mor gir hjertesvake barn	Vårt Land
Studie: Fedme hos mor gir hjertesvake barn	Aftenbladet
Studie: Fedme hos mor gir hjartesvake barn	Firda Tidend
Fedme hos mor gir hjertesvake barn	Forskning.no
Fedme i svangerskapet påvirker barnets hjerte	Gemini.no
Studie: Fedme hos mor gir hjertesvake barn	Stavanger Aftenblad
Vil redde flere hjertebarn	NTNU medicine - blog
Using artificial intelligence to measure the heart	NTNU medicine - blog
Bruker bobler til å kurere kreft	DN.no
Video from Spring Seminar 2018	Twitter, LinkedIn
Making analog-to-digital converters for digital ultrasound probes	NTNU medicine - blog
DeepEcho: Machine learning for improved echocardiography	NTNU medicine - blog
Forskerprat om hjernen	God ettermiddag Trøndelag - NRK P1
TGen testing whether ultrasound can help fight pancreatic cancer	abc15 Arizona
Optimization of transmit ultrasound pulses in second harmonic imaging	NTNU Medicine - blog
Can hybrid PET/MRI improve the diagnostic accuracy of brain glioma?	NTNU Medicine - blog
Håndholdt ultralyd	NRK Midtnytt
Får bedre og raskere hjelp	Trønder-Avisa
Want to learn more about the Norwegian ultrasound research and business community?	NTNU Medicine - blog
Potential improvement in sonar seabed mapping	NTUN Medicine - blog
Measuring the heart's blood flow behaviour in 3D	NTNU Medicine - blog

ULTRALYD OG NANOKAPSLER GIR

BEDRE KREFT-BEHANDLING

Bare 0,01 prosent av cellegiften når fram til kreftsvulsten. Nanoteknologi og ultralyd er i ferd med å gjøre noe med problemet. ▸▸▸

In issue nr 6, the Norwegian Magazine Teknisk Ukeblad published an news article about the research on how ultrasound can make cancer treatment more targeted. Reprinted with permission from Teknisk Ukeblad.

Industry Partner R&D Staff

PHOENIX SOLUTIONS

EQUINOR

AUROTECH

INPHASE SOLUTIONS

ARCHER

GE VINGMED ULTRASOUND

HALFWAVE

SENSORLINK

X-FAB

MEDISTIM

KONGSBERG

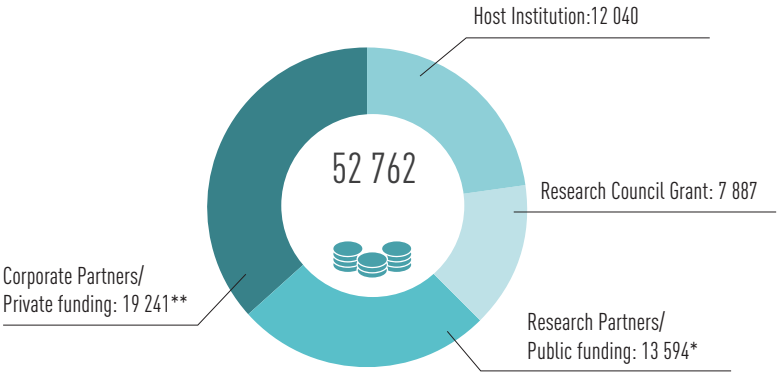
CIUS in Japan

Twenty-nine experts and researchers associated with CIUS participated at IUS, the IEEE International UltrasoundSymposium in Kobe, Japan, in October 2018. Not only the number of attendees, but also the number of presentations from CIUS was impressively high.
https://blog.medisin.ntnu.no/with-cius-at-ius/

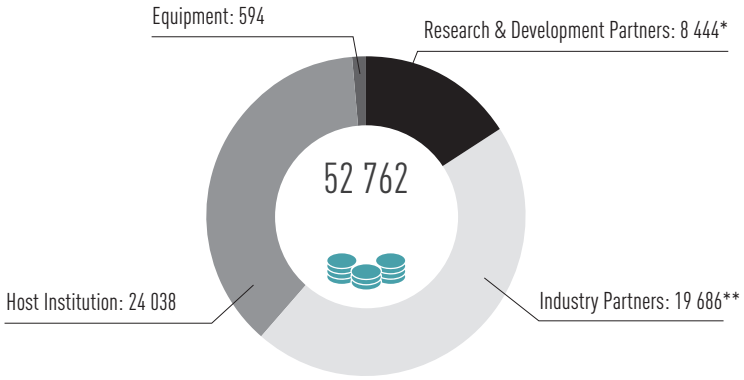
Photo: Lasse Løvstakken

Annual Accounts for 2018

FUNDING
(in 1000 NOK)



COSTS
(in 1000 NOK)



*SINTEF, University of Oslo, University College of Southeast Norway, Helse Midt Norge RHF, St. Olavs University Hospital HF, Nord-Trøndelag Hospital Trust.

**Equinor, GE Vingmed Ultrasound AS, Archer-Berfen Technology Center AS, Sensorlink AS, Phoenix Solutions AS, InPhase Solutions AS, Kongsberg Maritime as, Halfwave AS, Aurotech Ultrasound AS, X-Fab Semiconductor Foundries AS, Medistim ASA

Journal Articles

AUTHOR/AUTHORS	TITLE	JOURNAL
Wild M, Bring M, Halvorsen E, Hoff L, Hjelmervik K	The challenge of distinguishing mechanical, electrical and piezoeletric losses	Journal of the Acoustical Society of America
Andersen KK, Frijlink ME, Hoff L	A numerical Optimization Method for Tranducer Transfer Functions by the Linearity of the Phase Spectrum	IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control
Talberg AS, Dong H, Johansen TF, Måsøy SE, Brekke S, Rommetveit T	Ultrasonic focusing through a steel layer for acoustic imaging	Proceedings - IEEE Ultrasonics Symposium
Lu H, Paletti P, Li W, Fay P, Ytterdal T, Seabaugh A	Tunnel FET Analog Benchmarking and Circuit Design	IEE Journal of Exploratory Solid-State Computational Devices and Circuits
Låte E, Ytterdal T, Aunet S	A loadless 6T SRAM cell for sub- & near- threshold operation implementedin 28 nm FD-SOI CMOS technology	Integration
Vatanjou AA, Ytterdal T, Aunet S	An Ultra-Low Voltage and Low-Energy Level Shifter in 28 nm UTBB-FDSOI	IEEE Transactions on Circuits and Systems - II - Express Briefs
Evensen KB, O'Rourke M, Prieur F, Eide PK	Non-invasive Estimation of the Intracranial Pressure Waveform from the Central Arterial Blood Pressure Waveform in Idiopathic Normal Pressure Hydrocephalus Patients	Scientific Reports
Evensen KB, Paulat K, Prieur F, Holm S, Eide PK	Utility of the Tympanic Membrane Pressure Waveform for Non-invasive Estimation of The Intracranial Pressure Waveform	Scientific Reports
Holm S	Spring–damper equivalents of the fractional, poroelastic, and poroviscoelastic models for elastography	NMR in Biomedicine
Sinkus R, Lambert S, Abd-Elmoniem KZ, Morse C, Heller T, Guenthner C, Ghanem AM, Holm S, Gharib A	Rheological determinants for simultaneous staging of hepatic fibrosis and inflammation in patients with chronic liver disease	NMR in Biomedicine
Wei C, Chen W, Fang J, Holm S	A Survey on Fractional Derivative Modeling of Power-Law Frequency-Dependent Viscous Dissipative and Scattering Attenuation in Acoustic Wave Propagation	Applied Mechanics Review
Prieur FJG, Rindal OMH, Austeng A	Signal Coherence and Image Amplitude With the Filtered Delay Multiply and Sum Beamformer	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Karabiyik Y, Ekroll IK, Eik-Nes SH, Løvstakken L	Quantitative Doppler analysis using conventional color flow imaging acquisitions	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Zolich AP, Palma D, KansanenK, Fjørtoft KE, Sousa J, Johansen KH, Jiang Y, Dong H, Johansen TA	Survey on Communication and Networks for Autonomous Marine Systems	Journal of Intelligent and Robotic Systems
Perrot V, Avdal J, Løvstakken L, Salles S, Vray D, Liebgott H, Ekroll IK	Spatial and Temporal Adaptive FIR Clutter Filtering	Proceedings - IEEE Ultrasonics Symposium
Perrot V, Salles S, Vray D, Liebgott H	Video Magnification Applied in Ultrasound	IEEE Transactions on Biomedical Engineering
Arneberg HC, Andersen TA, Lorås L, Torp H, Scholbach T, Eggebø TM	Correlation Between Fetal Weight Gain and Birth Weight with Blood Flow in the Uterine Arteries Calculated with the PixelFlux Technique	Ultrasound International Open
Avdal J, Rodriguez-Molares A, Berg EAR, Torp H	Volume flow estimation in valvular jets using 3D high frame rate ultrasound	Proceedings - IEEE Ultrasonics Symposium
Fiorentini S, Saxhaug LM, Holte E, Bjåstad TG, Torp H, Avdal J	Maximum velocity estimation in coronary arteries using 3D tracking Doppler	IEEE Transactions on Ultrasonics, Ferroelectics and Frequency Control
Golfetto C, Ekroll IK, Torp H, Avdal J	3D Coronary Blood Flow Imaging: A Comparison of Automatic Adaptive Clutter Filters	Proceedings - IEEE Ultrasonics Symposium

AUTHOR/AUTHORS	TITLE	JOURNAL
Grue JF, Storve S, Dalen H, Salvesen Ø, Mjølstad OC, Samstad S, Torp H, Haugen BO	Automatic measurements of mitral annular plane systolic excursion and velocities to detect left ventricular dysfunction	Ultrasound in Medicine and Biology
Kozlowski P, Rodriguez-Molares A, Tangen TA, Kristoffersen K, Torp H, Gerard O, Samset E	Adaptive color gain for vena contracta quantification in valvular regurgitation	Ultrasound in Medicine and Biology
Ekroll IK, Wigen MS, Fadnes S, Avdal J	Quantitative vascular blood flow imaging: A comparison of vector velocity estimation schemes	Proceedings - IEEE Ultrasonics Symposium
Wigen MS, Fadnes S, Rodriguez-Molares a, Bjåstad T, Eriksen M, Stensæth KH, Støylen A, Løvstakken L	4D Intracardiac Ultrasound Vector Flow Imaging - Feasibility and Comparison to Phase-Contrast MRI	IEEE Transactions on Medical Imaging
Dietrichson FS, Smistad E, Østvik A, Løvstakken L	Ultrasound speckle reduction using generative adversial networks	Proceedings - IEEE Ultrasonics Symposium
Fiorito AM, Østvik A, Smistad E, Leclerc S, Bernard O, Løvstakken L	Detection of Cardiac Events in Echocardiography using 3D Convolutional Recurrent Neural Networks	Proceedings IEEE Ultrasonics Symposium
Leclerc S, Smistad E, Grenier T, Larizien C, Østvik A, Esponosa F, Jodoin P-M, Løvstakken L, Bernard O	Deep learning applied to multi-structure segmentation in 2D echocardiography: A preliminary investigation of the required database size	Proceedings - IEEE Ultrasonics Symposium
Smistad E, Østvik A, Salte IM, Leclerc S, Bernard O, Løvstakken L	Fully automatic real-time ejection fraction and MAPSE measurements in 2D echocardiography using deep neural networks	Proceedings - IEEE Ultrasonics Symposium
Østvik A, Smistad E, Aase SA, Haugen BO, Løvstakken L	Real-time Standard View Classification in Transthoracic Echocardiography using Convolutional Neural Networks	Ultrasound in Medicine and Biology
Østvik A, Smistad E, Espeland T, Berg EAR, Løvstakken L	Automatic Myocardial Strain Imaging in Echocardiography Using Deep Learning	Lecture Notes in Computer Science
Gelderblom FM, Tronstad TV, Viggen EM	Subjective evaluation of a noise-reduced training target for deep neural network-based speech enhancement	IEEE/ACM Transactions on Audio, Speech and Language Processing
Grønli T, Wigen MS, Segers P, Løvstakken L	A fast 4D B-spline framework for model-based reconstruction and regularization in vector flow imaging	Proceedings - IEEE Ultrasonics Symposium
Myhre PL, Omland T, Ukkonen H, Rademakers F, Engvall JE, Hagve T-A, Nagel E, Sicari R, Zamorano JL, D'Hooge JRM, Edvardsen T, Røsjø H	Cardiac troponin T concentrations, reversible myocardial ischemia, and indices of left ventricular remodeling in patients with suspected stable angina pectoris: A DOPPLER-CIP substudy	Clinical Chemestriy
D'hooge J, Fraser AG	Learning About Machine Learning to Create a Self-Driving Echocardiographic Laboratory	Circulation
Queiros S, Morais P, Barbosa D, Fonseca JC, Vilaca JL, D'hooge J	MITT: Medical Image Tracking Toolbox	IEEE Transactions on Medical Imaging
Smistad E, Johansen KF, Iversen DH, Reinertsen I	Highlighting nerves and blood vessels for ultrasound guided axillary nerve block procedures using neural networks	Journal of Medical Imaging
Iversen DH, Løvstakken L, Unsgård G, Reinertsen I	Automatic intraoperative estimation of blood flow direction during neurosurgical interventions	International Journal of Computer Assisted Radiology and Surgery
Espeland T, Lunde IG, Amundsen BH, Gullestad L, Aakhus S	Myokardifribrose	Tidsskrift for Den norske legeforening
Baghirov H, Snipstad S, Sulheim E, Berg S, Hansen R, Thorsen F, Mørch YA, de Lange Davies C, Åslund A	Ultrasound-mediated delivery and distribution of polymeric nanoparticles in the normal brain parenchyma of a metastatic brain tumour model	PLoS ONE
Sulheim E, Kim J, van Wamel A, Kim E, Snipstad S, Vidic I, Grimstad I, Widerøe M, Torp SH, Lundgren S, Waxman DJ, de Lange Davies C	Multi-modal characterization of vasculature and nanoparticle accumulation in five tumor xenograft models	Journal and Controlled Release
Snipstad S, Sulheim E, de Lange Davies C, Moonen C, Storm G, Kiessling F, Schmid R, Lammers T	Sonopermeation to improve drug delivery to tumors: from fundamental understanding to clinical translation	Expert Opinion on Drug Delivery
Govatsmark RES, Janszky I, Slørdahl SA, Ebbing M, Wiseth R, Grenne B, Vesterbekkmo EK, Bønaa KH	Completeness and correctness of acute myocardial infarction diagnoses in a medical quality register and an administrative health register	Scandinavian Journal of Public Health

AUTHOR/AUTHORS	TITLE	JOURNAL
Dahlslett T, Karlsen S, Grenne B, Sjøli B, Bendz B, Skulstad H, Smiseth OA, Edvardsen T, Brunvand H	Intra-Aortic Balloon Pump Optimizes Myocardial Function During Cardiogenic Shock	JACC Cardiovascular Imaging
Mawad W, Chaturvedi RK, Jaeggi E, Ryan G, Golding F	Percutaneous Fetal Atrial Balloon Septoplasty for Simple Transposition of the Great Arteries With an Intact Atrial Septum	Canadian Journal of Cardiology
Mawad W, Jaeggi E, Torigoe T, Seed M, Ryan G, Marini D, Golding F, Van Mieghem T	Treatment of fetal circular shunt with non-steroidal anti-inflammatory drugs	Ultrasound in Obstetrics and Gynecology
Mawad W, Mertens L	Recent Advances and Trends in Pediatric Cardiac Imaging	Current Treatment Options in Cardiovascular Medicine
Nyrnes SA, Garnæs KK, Salvesen Ø, Timilsina AS, Moholdt T, Ingul CB	Cardiac function in newborns of obese women and the effect of exercise during pregnancy. A randomized controlled trial	PLoS ONE
Cardim N, Dalen H, Voigt J-U, Ionescu A, Price S, Neskovic AN, Edvardsen T, Galderisi M, Sicari R, Donal E, Stefanidis A, Delgado V, Zamorano J, Popescu B	The use of handheld ultrasound devices: a position statement of the European Association of Cardiovascular Imaging (2018 update).	European Heart Journal-Cardiovascular Imaging
Gemes K, Janszky I, Strand LB, Laszlo KD, Ahnve S, Vatten LJ, Dalen H, Mukamal KJ	Light-moderate alcohol consumption and left ventricular function among healthy, middle-aged adults: The HUNT study	BMJ Open
Nielsen JB, Fritsche LG, Zhou W (et al)	Genome-wide Study of Atrial Fibrillation Identifies Seven Risk Loci and Highlights Biological Pathways and Regulatory Elements Involved in Cardiac Development	American Journal of Human Genetics
Rosner A, Khalapyan T, Dalen H, McElhinney DB, Friedberg MK, Lui GK	Classic-Pattern Dyssynchrony in Adolescents and Adults With a Fontan Circulation	Journal of the American Society of Echocardiography
Sigurdardottir JD, Lyngbakken MN, Holmen OL, Dalen H, Hveem K, Røsjø H, Omland T	Relative prognostic value of cardiac troponin I and C-reactive protein in the general population (from the Nord-Trøndelag Health [HUNT] Study)	American Journal of Cardiology
Støylen A, Hansen HEM, Dalen H	Relation between mitral annular plane systolic excursion and global longitudinal strain in normal subjects: The HUNT study	Echocardiography
Rosner A, Khalapyan T, Pedrosa J, Dalen H, McElhinney DB, Friedberg MK, Lui GK	Ventricular mechanics in adolescent and adult patients with a Fontan circulation: Relation to geometry and wall stress.	Echocardiography
Nielsen JB, Thorolfsdottir RB, Fritsche LG (et al)	Biobank-driven genomic discovery yields new insight into atrial fibrillation biology	Nature genetics
Selmeryd J, Henriksen E, Dalen H, Hedberg P	Derivation and Evaluation of Age-Specific Multivariate Reference Regions to Aid in Identification of Abnormal Filling Patterns: The HUNT and VaMIS Studies.	JACC: Cardiovascular Imaging
Kleveland O, Ueland T, Kunszt G, Bratlie M, Yndestad A, Broch K, Holte E, Ryan L, Amundsen BH, Bendz B, Aakhus S, Espevik T, Halvorsen B, Mollnes TE, Wiseth R, Gullestad L, Aukrust P, Damås JK	Interleukin-6 receptor inhibition with tocilizumab induces a selective and substantial increase in plasma IP-10 and MIP-1ß in non-ST-elevation myocardial infarction	International Journal of Cardiology
Sanches-Martinez S, Duchateau N, Erdei T, Kunszt G, Aakhus S, Degiovanni A, Mariono P, Caruccio E, Piella G, Fraser AG, Bijnens BH	Machine learning analysis of left ventricular function to characterize heart failure with preserved ejection fraction	Circulation Cardiovascular Imaging
Tennøe A, Murbræch K, Andreassen J, Fretheim HH, Garen TO, Gude E, Andreassen AK, Aakhus S, Molberg Ø, Hoffman-Vold A-M	Left ventricular diastolic dysfunction predicts mortality in patients with systemic sclerosis	Journal of the American College of Cardiology
Beela AS, Unlu S, Duchenne J, Ciarka A, Daraban AM, Kotrc M, Aarones M, Szulik M, Winter S, Penicka M, Neskovic AN, Kukulski T, Aakhus S, Willems R, Feshe W, Faber L, Stankovic I, Voigt JU	Assessment of mechanical dyssynchrony can improve the prognostic value of guideline-based patient selection for cardiac resynchronization therapy	European Heart Journal Cardiovascular Imaging
Støylen A, Hansen HEM, Dalen H	Strain and Strain Rate: Different Preload Dependence?	Journal of the American Society of Echocardiography
Hollund IMH, Olsen A, Skranes JS, Brubakk A-M, Håberg A, Eikenes L, Evensen KA	White matter alterations and their associations with motor function in young adults born preterm with very low birth weight	NeuroImage: Clinical
Husøy, AK, Pintzka CWS, Eikenes L, Håberg A, Hagen K, Linde M, Stovner LJ	Volume and shape of subcortical grey matter structures related to headache: A cross-sectional population-based imaging study in the Nord-Trøndelag Health Study.	Cephalalgia
Xiao Y, Eikenes L, Reinertsen I, Rivaz H	Correction to: Nonlinear deformation of tractography in ultrasound-guided low-grade gliomas resection	International Journal of Computer Assisted Radiology and Surgery

AUTHOR/AUTHORS	TITLE	JOURNAL
Xiao Y, Eikenes L, Reinertsen I, Rivaz H	Nonlinear deformation of tractography in ultrasound-guided low-grade gliomas resection	International Journal of Computer Assisted Radiology and Surgery
Olsen A, Dennis EL, Evensen KAI, Husby Hollund IM, Løhaugen GCC, Thompson PM, Brubakk AM, Eikenes L, Håberg AK	Preterm birth leads to hyper-reactive cognitive control processing and poor white matter organization in adulthood	NeuroImage
Rindal OMH, Seeberg TM, Tjønnås J, Haugnes P, Sandbakk Ø	Automatic Classification of Sub-Techniques in Classical Cross-Country Skiing Using a Machine Learning Algorithm on Micro-Sensor Data	Sensors
Solli GS, Kocbach J, Seeberg TM, Tjønnås J, Rindal OMH, Haugnes P, Torvik PØ, Sandbakk Ø	Sex-based differences in speed, sub-technique selection, and kinematic patterns during low- and high-intensity training for classical cross-country skiing.	PLOS ONE
Robinson JR, Frank EG, Hunter AJ, Jermin PJ, Gill HS	The Strength of Transosseous Medial Meniscal Root Repair Using a Simple Suture Technique Is Dependent on Suture Material and Position	The American Journal of Sports Medicine
Kumar R, Pierce DM, Isaksen V, Davies C de L, Drogset JO, Lilledahl MB	Comparison of compressive stress-relaxation behavior in osteoarthritic (ICRS graded) human articular cartilage	International Journal of Molecular Sciences
Einarsen CE, van der Naalt J, Jacobs B, Follestad T, Moen KG, Vik A, Håberg AK, Skandsen T	Moderate Traumatic Brain Injury: Clinical Characteristics and a Prognostic Model of 12-Month Outcome	World Neurosurgery
Fyllingen EH, Hansen TI, Jakola AS, Håberg AK, Salvesen Ø, Solheim O	Does risk of brain cancer increase with intracranial volume? A population-based case control study	Neuro-Oncology
Moe HK, Moen KG, Skandsen T, Kvistad KA, Laureys S, Håberg A, Vik A	The influence of traumatic axonal injury in thalamus and brainstem on level of consciousness at scene or admission: A clinical magnetic resonance imaging study	Journal of Neurotrauma
Skandsen T, Einarsen CE, Normann I, Bjøralt S, Karlsen RH, McDonagh D, Nilsen TL, Akslen AN, Håberg AK, Vik A	The epidemiology of mild traumatic brain injury: The Trondheim MTBI follow-up study	Scandinavian Journal of trauma, resuscitation & emergency medicine
Zotcheva E, Bergh S, Selbæk G, Krokstad S, Håberg AK, Strand AK, Strand BH, Ernstsen L	Midlife Physical Activity, Psychological Distress, and Dementia Risk: The HUNT Study	Journal of Alzheimer's disease

Presentations

AUTHOR/AUTHORS	PRESENTATION	LOCATION
Andersen KK, Healey AJ, Bush NL, Frijlink ME, Hoff L	Design, Fabrication, and Testing of a Dual-Frequency Transducer for Acoustic Cluster Therapy Activation	IEEE International Ultrasonics Symposium
Talberg AS, Dong H, Johansen TF, Måsøy SE	Target detection through a steel plate using beamforming	Scandinavian Symposium on Physical Acoustics
Talberg AS, Dong H, Johansen TF, Måsøy SE, Brekke S, Rommetveit T	Ultrasonic focusing through a steel layer for acoustics imaging	IEEE International Ultrasonics Symposium
Prieur FJG, Seynnes OR	Ultrasound elastography in muscle	Ultrasonic Imaging and Tissue Characterization
Prieur FJG, Seynnes OR	Ultrasound elastography in muscle	41st Scandinavian Symposium on Physical Acoustics
Blachet A	Advanced Pulse Transmission Techniques for Seabed Mapping with Sonar	Scandinavian Symposium on Physical Acoustics 2018
Blachet A	Doppler Correction with Multibeam Echosounders	Oslo Society of Exploration Geophysicist Annual UiO meeting
Fadnes S, Salles S, Tegnander E, Nyrnes SA, Løvstakken L	In vivo estimation of myocardial mechanical wave propagation in the fetus	IEEE International Ultrasonics Symposium
Nyrnes SA, Fadnes S, Salles S, Løvstakken L	High Frame Rate Imaging	29th Annual ASE Scientific Sessions
Perrot V, Avdal J, Løvstakken L, Salles S, Vray D, Liebgott H, Ekroll IK	Spatial and Temporal Adaptive FIR Clutter Filtering	IEEE International Ultrasonics symposium 2018

AUTHOR/AUTHORS	PRESENTATION	LOCATION
Salles S, Løvstakken L, Rodriguez-Molares A, Aase SA, Støylen A, Torp H	4D mechanical wave velocity mapping using clutter filter wave imaging. Healthy Subjects versus patients	IEEE International Ultrasonics symposium 2018
Wigen MS, Salles S, Støylen A, Løvstakken L	The continuous cardiac thick-slice acquisition - for simultaneous flow and tissue motion estimation	IEEE International Ultrasonics Symposium
Avdal J, Rodriguez-Molares A, Berg EAR, Torp H	Volume flow estimation in valvular jets using 3D high frame rate ultrasound	IEEE International Ultrasonic symposium 2018
Fiorentini S, Espeland T, Berg EAR, Aakhus S, Torp H, Avdal J	Combining automatic angle correction and 3-D tracking Doppler for aortic stenosis severity assessment	IEEE Ultrasonic Symposium
Rodriguez-Molares A, HoelRindal OM, D'Hooge JRM, Måsøy S-E, Austeng A, Torp H	The Generalized Contrast-to-Noise Ratio	International Ultrasonics Symposium 2018
Vik SD, Torp H, Støen R, Nyrnes SA	NeoDoppler- Ny ultralydteknologi for kontinuerlig måling av cerebral blodstrøm hos nyfødte	Pediatridagene 2018
FS, Smistad E, Østvik A, Løvstakken L	Ultrasound speckle reduction using generative adversial networks	IEEE International Ultrasonic Symposium 2018
Smistad E, Østvik A, Salte IM, Leclerc S, Bernard O, Løvstakken L	Fully automatic real-time ejection fraction and MAPSE measurements in 2D echocardiography using deep neural networks	IEEE International Ultrasonics Symposium 2018
Østvik A, Smistad E, Espeland T, Berg EAR, Løvstakken L	Automatic functional imaging in echocardiography using deep learning based segmentation and flow estimation	IEEE International Ultrasonics Symposium 2018
Østvik A, Smistad E, Løvstakken L	Deep learning for ultrasound image classification and segmentation	Myocardial velocity and deformation imaging
Grønli T, Wigen MS, Segers P, Løvstakken L	A fast 4D B-spline framework for model-based reconstruction and regularization in vector flow imaging	IEEE International Ultrasonics Symposium 2018
Mawad W, Nyrnes SA, Fadnes S, Grønli T, Løvstakken	Cardiac flow dynamics by echocardiography: current and future perspectives	American Society of Echocardiography
Løvstakken L	Next generation echocardiography - opportunities and challenges	IEEE International Ultrasonics Symposium
Olsman M, Sereti V, Snipstad S, van Wamel A, Andreassen K, Berg S, Urquhart A, Andreasen TL, Davies CL	Effect of focused ultrasound on biodistribution, tumour uptake and intratumoral microdistribution of enzyme sensitive liposomes in human prostate cancer xenografts	The 18th International Symposium for Therapeutic Ultrasound
Snipstad S	Nanomedicine and ultrasound for treatment of cancer and brain disease	International nanoscience student conference, INASCON
Snipstad S, Alsos OA	Visual scientific communication	The 2nd annual conference of Digital Life Norway Research School
Yemane PT, Åslund A, Sæterbø KG, Bjørkøy A, Snipstad S, van Wamel A, Berg S, Mørch YA, Hansen R, Angelsen BAJ, Davies CL	Extravasation and distribution of nanoparticles and 2MDa dextran in tumor imaged by multiphoton microscopy during ultrasound sonication.	CIUS spring conference 2018
Dalen H	Echocardiography and the left atrium	afib.no annual meeting 2018
Dalen H	Hjerteultralyd utenfor sykehus - Nye innovasjoner	Nordiska e-hälsodagarna
Dalen H	Ultralydteknologi for bedre sviktoppfølging i allmennpraksis	Hjertesviktakademi
Heitmann KA, Dalen A, Ingvaldsen RP, Welde B	Blood pressure responses during and after heavy resistance training in healthy males	23rd annual Congress of the European College of Sport Science, ECSS Dublin 2018
Kuttner S, Lassen ML, Kjærnes Øen S, Sundset R, Beyer T, Eikenes L	The impact of artefacts in MR-based attenuation correction maps on PET/MR images of lung cancer	MedFys 2018
Mawad W	Fontan: Imagerie du système lymphatique	8ème Rencontres Francophone Multidisciplinaire des Cardiopathies Congénitales
Healey AJ, Sontum PC, Kvåle S, van Wamel A, Bush N, Prentice P, Sulheim E, Muhlenpfordt M, Davies C de L	Acoustic cluster therapy for ultrasound mediated drug delivery: technology, proof of concept and clinical trial design	Leeds Microbubble Symposium

Book

AUTHOR/AUTHORS	BOOK CHAPTER	LOCATION
Kiss G, Palmer CL, Mjølstad OC, Dalen H, Haugen BO, Torp H	Augmented Reality-based Visualization for Echocardiographic Applications	Mixed and augumented reality in medicine

Posters

AUTHOR/AUTHORS	POSTER	LOCATION
Talbert AS, Dong H, Johansen TF, Måsøy SE, Brekke S, Rommetveit T	Ultrasonic focusing through a steel layer for acoustic imaging	IEEE International Ultrasonics Symposium 2018
Fatemi A, Torp H, Rodriguez-Molares A	A dynamic Generalized Coherence Factor based on Van Cittert-Zernike theorem	International Ultrasonics Symposium 2018
Golfetto C, Ekroll IK, Torp H, Avdal J	3D Coronary Blood Flow Imaging: A Comparison of Automatic Adaptive Clutter Filters	IEEE International Ultrasound Symposium 2018
Grue JF, Storve S, Torp H, Mjølstad OC, Støylen A, Haugen BO, Dalen H	Reference values for automatic measurements of tissue Doppler indices	Kardiologisk høstmøte
Grue JF, Storve S, Torp H, Mjølstad OC, Støylen A, Haugen BO, Dalen H	Reference values for automatic measurements of tissue Doppler indicies	ESC Congress 2018
Magelssen MI, Palmer CL, Hjorth-Hansen A, Nilsen G, Torp H, Mjølstad OC, Dalen H	The feasibility, accuracy and reliability of fully automatic analyses of left ventricular systolic longitudinal function by pocket-size imaging device	ESC Congress 2018
Ekroll IK, Wigen MS, Fadnes S, Avdal J	Quantitative vascular blood flow imaging: a comparison of vector velocity estimation schemes	IEEE International Ultrasound Symposium 2018
Perrot V, Avdal J, Løvstakken L, Salles S, Vray D, Liebgott H, Ekroll IK	Spatial and Temporal Adaptive FIR Clutter Filtering	IEEE International Ultrasonics Symposium 2018
Jiorito AM, Østvik A, Smistad E, Leclerc S, Bernand O, Løvstakken L	Detection of Cardiac Events in Echocardiography using 3D Convolutional Recurrent Neural Networks	IEEE International Ultrasonics Symposium 2018
Leclerc S, Smistad E, Grenier T, Laritzien C, Østvik A, Espinosa F, Jodoin P-M, Løvstakken L, Bernard O	Deep learning applied to multi-structure segmentation in 2D echocardiography: A preliminary investigation of the required database size	IEEE International Ultrasonics Symposium 2018
Østvik A, Smistad E, Espeland T, Berg EAR, Løvstakken L	Automatic Myocardial Strain Imaging in Echocardiography Using Deep Learning	MICCAI 2018, 4th Workshop in DEEo Learning in Medical Image Analysis (DLMIA)
Grønli T, Wigen MS, Segers P, Løvstakken L	A fast 4D B-spline framework for model-based reconstruction and regularization in vector flow imaging	IEEE International Ultrasonics Symposium 2018
Sælensminde M, Grønli T, Nyrnes SA, Løvstakken L	Intraventricular blood velocity measurements - a comparison between iVFM and blood speckle tracking	IEEE International Ultrasonics Symposium 2018
Snipstad S, Yemane PT, Åslund A, Grendstad K, Berg S, Mørch YA, Bjørkøy A, Sulheim E, Hansen R, van Wamel A, Torp SH, Davies CL	Sonoporation enhances delivery of nanomedicine for improved cancer treatment	11th European and Global Summit for Clinical Nanomedicine, Targeted Delivery and Precision Medicine (CLINAM)
Mawad W, Grosse-Wortmann L, Pagano J, Riesmkampff E, Natan P, Mertens L, Kantor P, Greenberg M, Liu P, Mital S	Pediatric cancer survivors have no MRI evidence of diffuse myocardial fibrosis and demonstrate preserved systolic and diastolic function	CMR 2018
Hauge SW, Dalen H, Nega B, Yadeta D, Guteta S, Mekonnen D, Vikenes K, Bogale N, Ellensen VS, Solholm A, Hovstad T, Farstad M, Hammersborg SM, Estensen M-L, Haaverstad R	Pre- and post-operative echocardiography in end-stage rheumatic heart disease during Development of Cardiac surgery in sub-Saharan Africa.	Kardiologisk høstmøte
Letnes JM, Nes B, Vaardal-Lunde K, Bratt Slette M, Mølmen HE, Aspenes ST, Støylen A, Wisløff U, Dalen H	Associations of Left Atrial Volume with Cardiorespiratory Fitness and Indices of Left Ventricular Diastolic Function in a Fit Population Sample	ESC Congress 2018
Rindal OMH, Rodriguez-Molares A, Austeng A	A simple, artifact-free, virtual source model	International Ultrasonics Symposium 2018
Rodriguez-Molares A	The Ultrasound File Format (UFF)-First draft	International Ultrasonics Symposium 2018
Blachet A	Multibeam echosounder survey simulation	FEMME 2018

Degrees 2018

MASTER THESES

PHD THESES

MASTER STUDENTS OBTAINING THEIR DEGREE IN 2018 ON A CIUS TOPIC		
Alex Khiem Dinh Tran	Modelling and monitoring blood flow in premature infants with open ductus arteriosus using ultrasound Doppler technique	H Torp
Anna Karoline Wisløff	Modeling of Peripheral Resis-tance in the Micro-vasculature for Diabetic Patients with Ultrasound Doppler Technique	H Torp
Fabian Dietricshon	Deep learning applications in medical imaging: Deep Convolutional Generative adversarial networks	L Løvstakken
Mikhail Vasilyev	Implementation and optimization of ultrasound image classification and segmentation on a portable device based on deep learning	L Løvstakken
Magnus Sælesminde	Intraventricular Vector Flow Mapping – An In Silico and In Vivo Evaluation	L Løvstakken
Kristine Andreassen	Addressing the barriers for delivery of liposomal nanoparticles to tumors	C Davies
Ingunn Hanson	Solid Stress and nanoparticle microdistribution in xenografts: Effects of ultrasound and microbubble cavitation	C Davies
Ruth Gong Li	Engineering a vascular model based on microfluidics for studying microbubbles in an acoustic field	C Davies
May Lise Salomonsen	Study of the chicken chorioalloantoic membrane (CSM) as an in vivo-moel for ultrasound-mediated delivery of drugs using nanoparticle-stabilized and standard ultrasound microbubbles	C Davies
Ellen Nymark	Acoustic cluster therapy and the chicken chorioalloantoic membrane model	C Davies
Amirfereydoon Mansoori	Piezoelectric Material Characterization for Ultrasonic Transducers	L Hoff
Martin Henrik Hassel	Perioperative Monitoring of Cardiac Function Based on Transesophageal Echocardiographic Data.	G Kiss/EA Berg
Gerard Clarke	Trondheim Mild TBI Study: an investigation into blood biomarkers & the etiology of post-concussion Syndrome	A Håberg
Henrik Fon	SAR ADC block in 22 nm FDSOI	T Ytterdal
Marjeris Romero	Compiled analog and digital building	T Ytterdal
Sindre Langen Bjørvik	Using Delay Line Ultrasonic Transducer to Measure Temperature and Compensate	TF Johansen

PHD CANDIDATES 2018	
Jarle Ladstein	Data acquisition for high resolution blood oxygen level dependent fMRI, Supervisor: P.E.Goa
Lars Erik Bø	Ultrasound in image-guided spine surgery Enabling technologies and first steps, Supervisor: T. Hernes

https://blog.medisin.ntnu.no/tag/cius-en/
https://twitter.com/CIUS_NTNU
https://www.linkedin.com/company/cius/
https://www.facebook.com/NTNUhelse/

www.ntnu.edu/cius

Location
NTNU MTFS and ISB, located at Øya, St. Olavs hospital in Trondheim

CIUS NTNU, Faculty of Medicine and Health Sciences,
Department of Medical Imaging and Circulation,
PO Box 8905, 7491 Trondheim, Norway

Contact
Asta Håberg (Centre Director)
+47 902 59 147 / asta.haberg@ntnu.no
Svein-Erik Måsøy (Industry Liaison)
+47 926 25 082 / svein-erik.masoy@ntnu.no
Christina Kildal (Project Coordinator/Administrator)
+47 938 03 615 / christina.kildal@ntnu.no
Kari Williamson (Web & Communication)
+47 986 66 928 / kari.williamson@ntnu
Sigrid Berg (CIUS Intranet/Web)
+47 905 71 587 / sigrid.berg@ntnu.no
Karl Jørgen Marthinsen
+47 994 20 017 / karl.j.martinsen@ntnu.no

Thanks to Hege Hovd at NTNU Grafisk senter for design and production of this report and Freelancer Janne Tellefsen.