2019 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

SØRLANDET SYKEHUS

Levanger kommune

VERDAL KOMMUNE

Associated Partner

FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

Host

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

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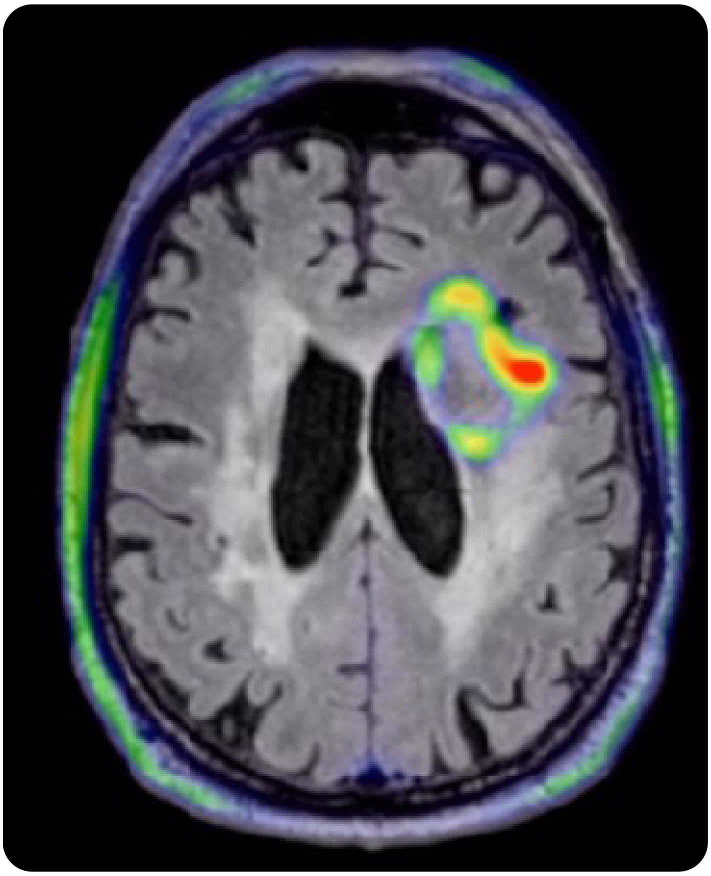
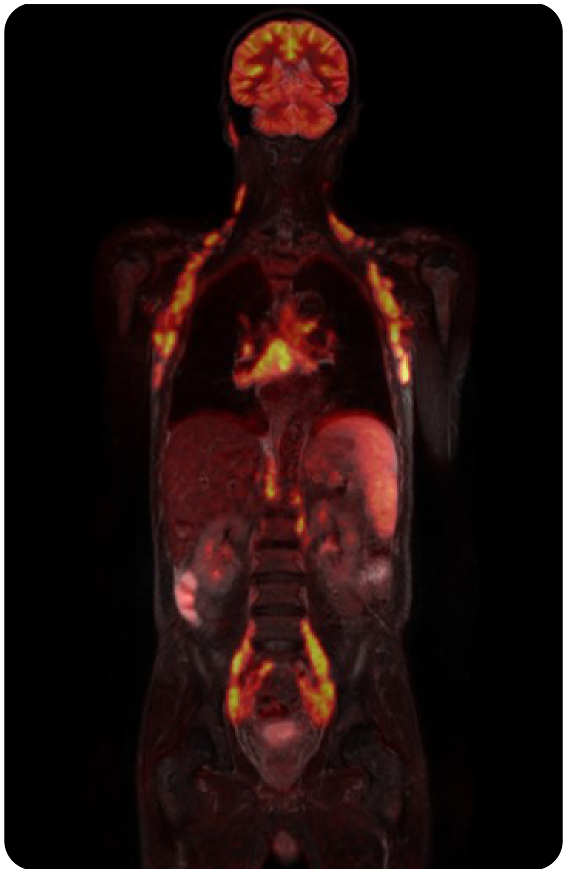
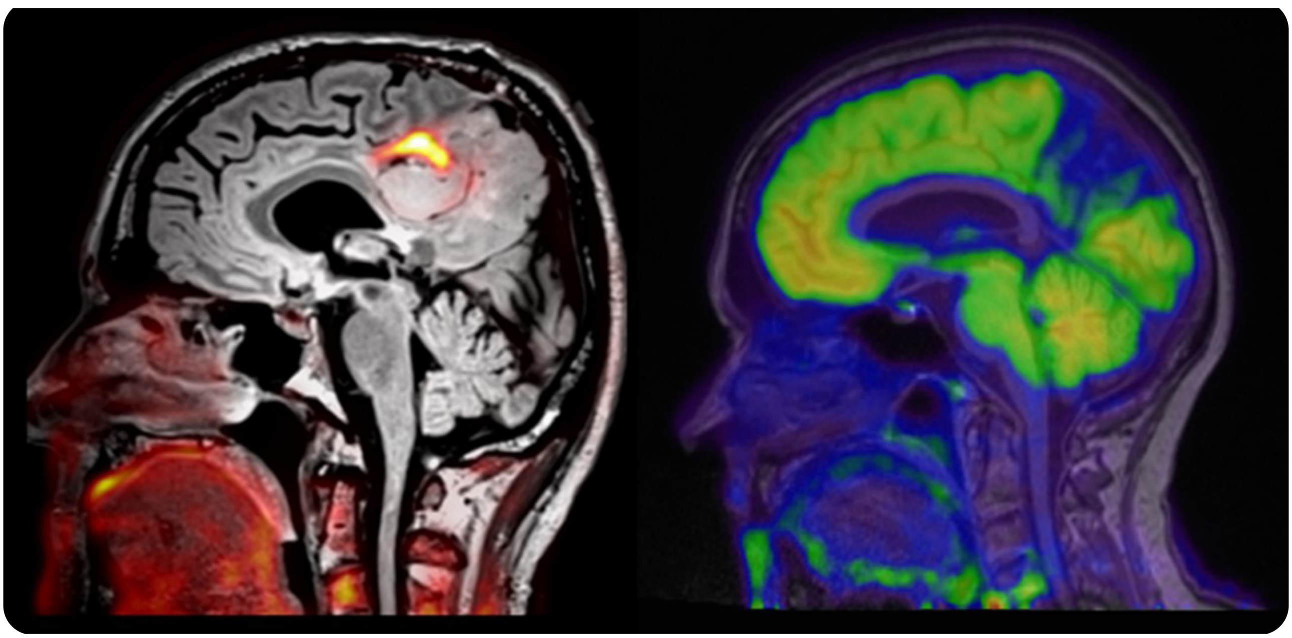






Asta Håberg
Centre Director

Dear CIUS family and friends

I am exited to present the CIUS 2019 annual report. You can get a good overview of the activities and results from last year, as deeper insights into some of the CIUS projects within for instance electronics and handheld ultrasound for non-expert users in this year's report.

SFI CIUS is now midway in the 8- year funding period and was evaluated by The Research Council of Norway and their team of international experts in 2019. CIUS got approved for the last 4 years of the SFI period, but had to present a more detailed plan of the research to be completed in work packages 8 and 9. For more information on the updated plans, please see the revised WP8-9 descriptions on p 36.

Academically, CIUS is progressing well with the first fully CIUS-financed PhD students starting to complete their PhD projects and submitting their PhD theses for evaluation and defense in 2019. You can find links to the defended PhD theses on p 78. Likewise, all scientific publications coming out of CIUS can be accessed by using the links on p 70.

CIUS partners are utilizing the research coming out of the SFI in their workflow and products. Kongsberg Maritime has for example implemented a new modeling tool for multibeam simulation, as well as launched a new product where the use of multiple frequencies is included. In the health care sector several new methods are established, like non-expert ultrasound combined with telemedicine and novel methods for realtime realignment of intraoperative ultrasound and pre-surgery CT scans of the heart. Several AI-applications for automated image interpretation, quantification and guidance of user for the three different CIUS sectors, health, maritime and oil and gas, are emerging. The success of this work is reflected in sveral CIUS DOFIs submitted within AI applications in 2019. Two new patent applications have also been filed.

I would like to use this opportunity to thank all academic staff, industry and health care partners for their dedication and hard work, collaborative spirit and creative input in 2019.

◀ *PET MRI images*
Top left, axial view of the brain with a glioma enhanced by the amino acid tracer 18F-FACBC, the center of the tumor is necrotic and is therefore not enhanced.
Top right, coronal view of the head and torso where yellow-red regions are those loaded with 18F-FDG (i.e. radioactive glucose) such as the brain, hearth, muscles,, kidneys, liver and, in this person, the spleen (the enlarged, long structure on the right side on the image, left for the patient) due to lymphoma.
Lower right, saggital view of the brain of patient with glioma in the precuneus enhanced by the amino acid tracer 18F-FACBC.
Lower left, saggital view of the brain of a patient with dementia with classical loss of 18F-FDG uptake in the precuneus, a region affected early in Alzheimer's disease.

Brita Pukstad
Vice Dean

Greetings from the Vice Dean

The Faculty of Medicine and Health Sciences (MH) at NTNU its proud to be host for CIUS and follows with great excitement their excellent scientific and innovative achievements.

2019 was a good and productive year for the faculty, and our study programs are popular with a high number of applicants and good evaluations. In Norway, there is currently a major restructuring of the National Curriculum Regulations in health and welfare education in order to make our students more future-oriented (RETHOS). The faculty is specifically following up the learning outcomes where more innovative knowledge is in demand, and sees great value in collaborating with other faculties at NTNU in this regard. In 2019 we have had special focus on the different processes in our PhD-education, increasing quality in admission, on-boarding and supervision. Paralleling the increase in academic performance, the MH faculty has been highly successful in acquiring external funding, acquiring resources from local, regional, national and international sources in 2019.

With NTNU's strategy "Knowledge for a better world", the MH faculty is continuing to strive with the ambitious "Health for a better world" as its strategic vision. Our aim is to develop knowledge, skills and solutions that contribute to good health from a regional, national and global perspective. The vision also expresses our aim to enable a fairer distribution of knowledge and resources, and a large focus in 2019 has been on the UN sustainable development goals. We have strengthened our commitment to research, innovation and education for better global health. To realize our vision an increased focus on innovation and collaboration between academia, industry and public sectors has also been central. MH is pursuing these goals at every level in the organization, and our student led health innovation lab, DRIV, has successfully been active with workshops and hackathons. DRIV is open for all students interested in health innovation in order to facilitate innovative activity 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 for PhD students and postdoctoral fellows.

NTNU's central administration created 15 new innovation manager positions to help transform more research into benefits in practice in 2018. Two of these positions went to research groups at MH where one was allocated to the ultrasound group, which constitutes the core of CIUS. These innovation managers have contributed to increasing awareness of the innovative culture also at the rest of the faculty.

The centers for research-based innovation, such as CIUS, embody the culture NTNU aspires to in its strategy, and MH is proud to be CIUS' host.

We look forward to a further fruitful and engaging collaboration with CIUS in 2020!

Eva Nilssen
Board Leader

Greetings from the CIUS Board

In order to continue CIUS, we were, as all other SFIs, required to do a midway performance evaluation to meet the requirements set by the granting authorities. The evaluation is done by an external committee of experts and NRC representatives. The evaluation result is gating for continued funding from the RCN. Although somewhat painful, it is also a great opportunity for us to review and present our activity and to get feedback and adjust accordingly for the remainder of the funding period. By looking at the activity with fresh eyes, the midway evaluation board identified several areas for improvement. These recommendations were analyzed by the the CIUS board together with the CIUS Director and leadership group, and we put together a plan to address the concerns. The revised plan for the PhD candidates and the updated O&G and Maritime strategy for implementation of new innovations were especially valuable.

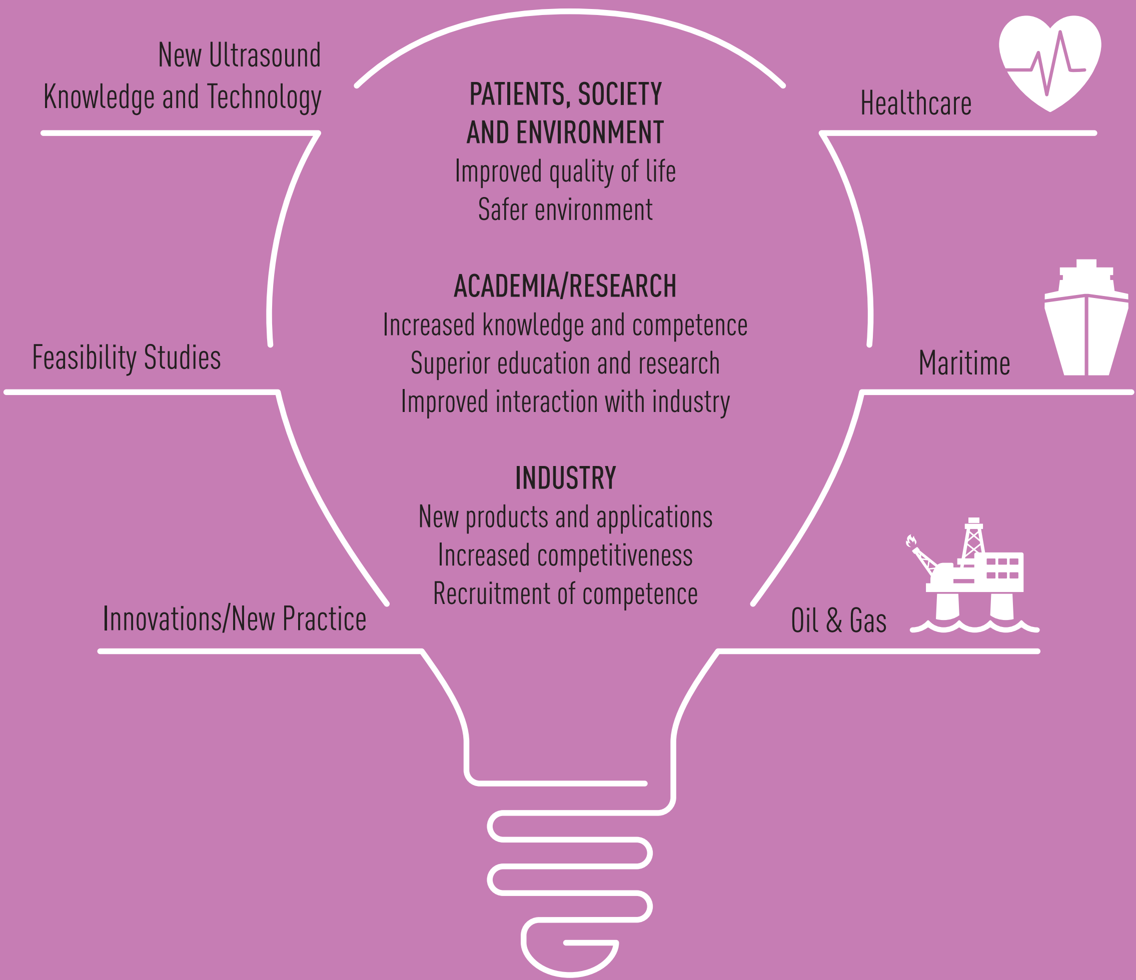
The recommendation to focus more on industrial and international research placements for CIUS PhD students is addressed by making sure that the candidates visit the industry partner in the first semester, and continue with regular visits throughout the PhD period. In addition, the CIUS industry partners will make funding available for hiring the candidates (8-12 weeks) to work in the firm where applicable. These types of assignments have proven to be quite successful, for the research results and for potential employment later, either as a post doctorate researcher or in the industry. Also, the supervisors in CIUS are required to facilitate and help the candidate to apply for international lab visits (2 weeks to 6 months). This in order to take advantage of the national PhD funding infrastructure, teach the candidates to start writing their own applications with the benefit of improving their CVs with received reward/grants, and gain international experience.

CIUS Industry Liaison Svein-Erik Måsøy led the work for a revised and clarified O&G and Maritime strategy, and corresponding plan for pilot testing and implementation of new innovations. Svein-Erik worked closely with the industry partners to ensure that the academic activities are aligned with the partners' activities and interests. The outcome was a very comprehensive document with concrete projects, timing and resources for all parties involved. Another benefit of this work is setting the right level of expectation. While pilot testing of medical technology is more readily available within the CIUS health care partners, piloting of technologies in O&G and Maritime industries means demonstrating the technology and its capabilities on partner or 3rd party equipment, which is both expensive and challenging to operate. Therefore, piloting of WP8-9 must be decided and planned only when clear project results exist. I.e. for most projects, this means in the next 2-4 years.

In summary, the CIUS leadership team welcomed the review and the opportunity to improve the CIUS project even further. CIUS and has a portfolio of excellent research projects across all the industry sectors, and the next 3-4 years are crucial for successful innovation results. We are now moving into the phase of piloting of the research results for all industries. The strengthening of the leadership team with Ultrasound Innovation Manager Tormod Njølstad last year is a welcomed additional resource to ensure this focus moving forward. The midway evaluation was successful - CIUS is approved for the next 4 years!

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 used to investigate more than 200 000 people on a daily basis.

- Maritime: More than 90% of the global fleet mapping the world's fishing resources, and therefore determining quotas for fishing, use SONARs from Kongsberg Maritime Subsea. Also, 99 % of the ocean floor is still unexplored and KM is a world leader in SONARs and AUVs for seabed mapping.

- Oil & gas: Equinor is going to plug & abandon (P&A) thousands of wells on the Norwegian Continental Shelf in the next 20 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 enable cost-efficient abandonment methods and ensure that the plugged wells are environmentally safe for 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 its 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 6 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 initiated projects are based on 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 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 six user partners within the medical health provision sector: St. Olavs hospital, Mid-Norway Regional Health Authorities, Nord-Trøndelag Hospital Trust, Levanger and Verdalen Community Health Services, and Sørlandet Hospital.

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 Officers 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.

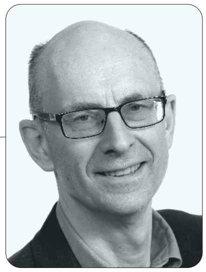
Each WP has a primary investigator (PI) who oversees the respective WP's research activity. All CIUS activities are supervised and directed by a working Board of Representatives consisting of nine members with a majority from the corporate partners. The Board Chair is Eva Nilssen, Director of R&D, GE 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
Petter Norli, Halfwave
BOARD
CIUS
APPOINTED BOARD REPRESENTATIVES
Pål Hemmingsen, Equinor
Dag Økland, Equinor
Frank Tichy, Kongsberg Maritime
Gunnar Morken, St. Olavs hospital
Olav Haraldseth, NTNU
Berit L. Strand, NTNU
Pål Hemmingsen replaced Dag Økland during 2019
SCIENTIFIC ADVISORY BOARD
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

WORK PACKAGE LEADERS

Professor Lars Hoff (USN)

Professor Sverre Holm (UiO)



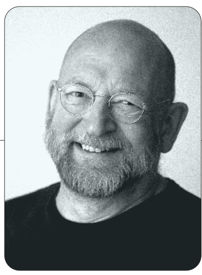
Professor Hans Torp (NTNU)

Professor Lasse Løvstakken (NTNU)

Professor Asta Håberg (NTNU)

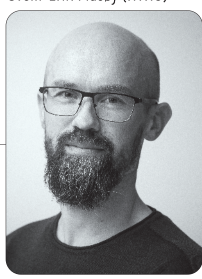
Professor Bjørn Olav Hauge (NTNU)

Professor Asbjørn Støylen (NTNU)



INNOVATION TEAM

Industry Liason
Svein-Erik Måsøy (NTNU)



Innovation Manager
Tormod Njølstad

WORK PACKAGE SUPERVISORS

Hefeng Dong (NTNU)

Trond Ytterdal, NTNU

Tonni Franke Johansen (NTNU/Sintef)

Catharina de Lange Davies (NTNU)

ADMINISTRATION

Christina Kildal

Marthe Charlotte Solbu

Vegard Nyhus

Karl Jørgen Marthinsen

Sigrid Berg

Partners and Collaborations

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

Academic Partners

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

Industry Partners

Aurotech ultrasound AS
Archer – Bergen Technology Center
Equinor ASA
GE Vingmed Ultrasound AS
Halfwave
InPhase Solutions AS
Kongsberg Maritime Subsea AS
Medistim ASA
Phoenix Solutions
Sensorlink AS
X-Fab Semiconductor Foundries GmbH

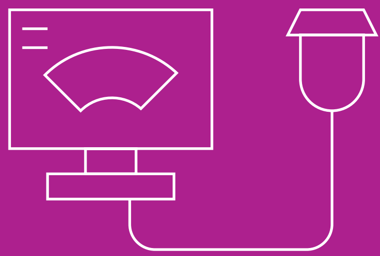
Health Sector Partners

Helse Midt-Norge (Central Norway Regional Health Authority)
Helse Nord-Trøndelag (Nord-Trøndelag Health Trust, Levanger Hospital)
St. Olavs hospital (Trondheim university hospital)
Innherred-samkommune (Innherred joint council primary health care)
Sørlandet sykehus HF (Sørlandet Hospital health authority)

Associated Partner

Forsvarets forskningsinstitutt (Norwegian Defence Research Establishment)

Centre for Innovative Ultrasound Solutions



CIUS 2019

INNOVATION STATISTICS

- 1 NEW PRODUCT
- 4 NEW METHODS/PROSESSES
- 5 NEW SERVICES
- 2 PATENT APPLICATIONS
- 7 DISCLOSURE OF INVENTIONS
- 68 JOURNAL AND PROCEEDINGS ATRICLES

CONFERENCE CONTRIBUTIONS: 65

CIUS researchers have delivered Declarations of Inventions covering a wide range of topics from 3D volume imaging in medical ultrasound, machine learning methods for the oil & gas industry and new transducer technology.

New methods developed in CIUS include new modeling tools for multibeam echosounder simulations, designs for new broadband Sonar transducers, and new method for ultrasound assisted targeted drug delivery treatment in metastatic cancer.

CIUS also started licensing negotiations for transfer of technology in 2019 to the CIUS partners.

1

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

Transducer and Electronics

WP1 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 CIUS partners.

WP1-1: Acoustic source characterization and optimization

Good theoretical models are essential for designing optimal ultrasound transducers. We base our work on analytical 1D equivalent circuit models and FEM simulation models. Building on existing software, we have developed an extensive software library for a variety of transducer designs, and integrated these into other software, such as optimization algorithms. Likewise, good experimental characterization methods are essential to investigate the designs and determine unknown parameters. The facilities of USN MST-lab provide equipment for classic material characterization. Through CIUS, we continue to develop dedicated system to characterize ultrasound transducers, such as acoustic material parameters, electro-acoustic transfer function, beam pattern, and pulse shape.

WP1-2: Integrated high-performance transducer array electronics

New high-density ultrasound arrays require electronics to be moved closer to the transducer. In maritime acoustics, this means moving electronics to the sonar head, while in medical ultrasound, from the scanner to the probe. A purely digital interface between the system and the transducer is preferred. In WP1, we are developing integrated circuits for low-noise receiving amplifiers, analog-to-digital converters, and high-voltage transmitters to be integrated with the transducer inside the probe head.

WP1-3: Embedded ultrasonic sensors

The main emphasis in this sub-WP is on transducers that can withstand the harsh environments found in oil wells, i.e. high pressures and temperatures. We explore new materials and fabrication methods to ensure reliable operation under these conditions. The resulting improved robustness and reliability will also be beneficial for other application areas.

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

Combined therapeutic and diagnostic ultrasound applications require transducers covering a wider frequency range than conventional ultrasound imaging applications. The same applies to novel imaging methods based on nonlinear acoustics. We have developed new design and modeling methods for multi-band transducers, and use these to develop piezoelectric transducer structures covering several frequency bands. Micromachining is another approach to achieve this performance, i.e. CMUT and PMUT technology. This can be combined with a conventional piezoelectric stack to cover several frequency bands. The resulting transducers can open new opportunities for combined ultrasound imaging and drug-delivery systems.

Activities in 2019

USN

Main focus has been on finishing the three PhD-projects started in 2016 and consolidate the three projects started in 2018. Marcus Wild successfully defended his PhD in 2019, one submitted his thesis, and the last is in the finishing phase. The USN PhD students worked with the industry partners Kongsberg Maritime, Phoenix Solutions, GE Vingmed Ultrasound and BTC Archer in 2019. Two new master students started in 2019.

Four journal articles were published in 2019, and two submitted. The group was represented at the IEEE International Ultrasonics Sympiosium, with two contributions published in the IEEE IUS proceedings. Regarding internationalization, one PhD-student had an internship with TDK Invensense in Milan, Italy, to gain experience on PMUT technology. The lab also received an international exchange student from Ho Chi Minh City University of Technology (HCMUT) in Vietnam.

The main challenge for the transducer lab is maintenance and upgrading of the lab.

NTNU

Three PhD students at IES NTNU are working together with GE Vingmed Ultrasound on integrated circuit design for in-probe electronics. The work involves both transmitters and receivers. Circuits from a tape-out in January came back in September 2019 and characterization activities were performed in September.

Going forward in 2020

Ramp up the activity on receive chain for hybrid (dual frequency) transducers with novel design, prototype and tape-out of integrated circuit of in-probe LNA and HV transmitters.

Start two new PhD-projects, one on hybrid piezoelectric-CMUT transducers, and one on transducers for very high temperatures.

2

Sverre Holm, Professor,
University of Oslo (UiO)
WP leader

Acoustics and Beamforming

This work package covers fundamental research on acoustic wave propagation and image formation (beamforming) common to applications in oil & gas, maritime and medicine. Knowledge and simulation tools are developed for improved algorithms in all applications to achieve improved image resolution and contrast, higher frame rates, and improved measurement accuracy (e.g. in Doppler imaging). Research systems at academic laboratories as well as computer simulations will be used to investigate next-generation imaging based on channel data processing that will provide a strong basis for innovation for the user partners.

New book

The book "Waves with Power-Law Attenuation" (Acoustical Society of America Press and Springer Continuum Physics) was published in 2019 after a 3 year writing effort by Professor Sverre Holm, covering models for wave propagation as well as wave equations for complex media like those encountered in medical ultrasound, elastography, and sediments in underwater acoustics.

WP2-1: UltraSound Toolbox

This work package covers joint development of the UltraSound Toolbox (USTB), an open source software toolbox for processing ultrasonic signals for medical, oil & gas, and maritime applications. It aims to facilitate the comparison of imaging techniques and thereby generalizability and dissemination of research results. USTB covers processing techniques for tissue and flow visualization, as well as other image reconstruction techniques. We are continuously developing our joint software toolbox for research scanners with the addition of new functions. Please visit USTB (https://www.ustb.no/) to check out the functionalities in UST v2.1. In 2019, we have implemented processing of the IQ (Image Quality)-database in USTB. The IQ-database consists of channel data from more than 100 anonymized patients, recorded with the 4Vc probe on an E95 scanner by cardiologists at St. Olavs hospital, Trondheim, Norway. These data can now be processed by USTB. We have spent quite some time moving the processing of the IQ-data base into the servers at UiO to speed up the processing by parallelization. This work is particularly valuable for continued work in WP2-4 and WP2-6.

WP2-2: Ultrasound Non-destructive testing (NDT) methods

Here we use ultrasonic NDT methods to solve various problems relevant to the partners of CIUS. These problems will be to detect and give information about a flowing fluid with solid particles outside a pipe or a plate, to find the properties of cement on the outside of a pipe, to detect cracks in a solid pipe, and to get general information about the state of a pipe in terms of e.g. cracks and corrosion. The work on transmitting and receiving ultrasonic waves through a solid layer has been steered towards how to get the proper acoustic signal through the steel layer for doing Doppler measurements. A numerical simulation study using the FDTD-tool SimSonic has been followed by experimental measurements at the Ultrasonics lab at ISB, NTNU. The experimental results analysed by our colleagues in WP3 indicate improvement in terms of flow detection and SNR.

WP2-3: Multibeam Sonar Imaging with Nonlinear Acoustics

As stated in our 2012 IEEE Oceanic Eng. paper: "We investigate the feasibility of utilizing the part of the signal generated around the second harmonic frequency band by nonlinear propagation of sound in water. The combined use of the signal components in the second harmonic and fundamental frequency bands provides a high-resolution image at short range and a long-range imaging capability at a lower resolution as well as a multifrequency characterization of targets." This project takes this research further. There has been low activity in this work package this year.

WP2-4: Adaptive Image Formation for Improved Image Quality

This work focuses on developing methods for adaptively improving image quality in echocardiography. This means 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. Advances in the project have been made this year and new methods are under evaluation on the GE Vingmed E95 system for echocardiography.

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

Recent development of sonar technology allows for more flexible sonar array design, and for greater frequency agility. The development of high-performance computing in small form-factors also allows for using substantially more complex signal processing. Taking these factors into account, a re-visit of the fundamentals in signal processing in certain advanced sonar applications is studied.

Orthogonal coded MBES: This study reviews the possibility to use frequency and phase coded waveforms for multi-sector MBES mapping. Results show the possibility to increase the individual sector bandwidth beyond the limit of today's systems. The technique has been tested on simulated data.

Improved amplitude detection for wide-band LFM MBES signals: Suggested a technique for reducing the variance of amplitude bottom detection through multiple parallel depth estimations at different frequency bands. The technique has been validated on simulated data. MBES data simulation: assessment by direct comparison with a high-resolution multi-settings wreck survey. Collaboration with the Irish marine institute (Infomar) and Ulster University. Paper was presented at UACE 2019.

WP2-6: Suppression of Reverberation Artifacts in Ultrasound Imaging

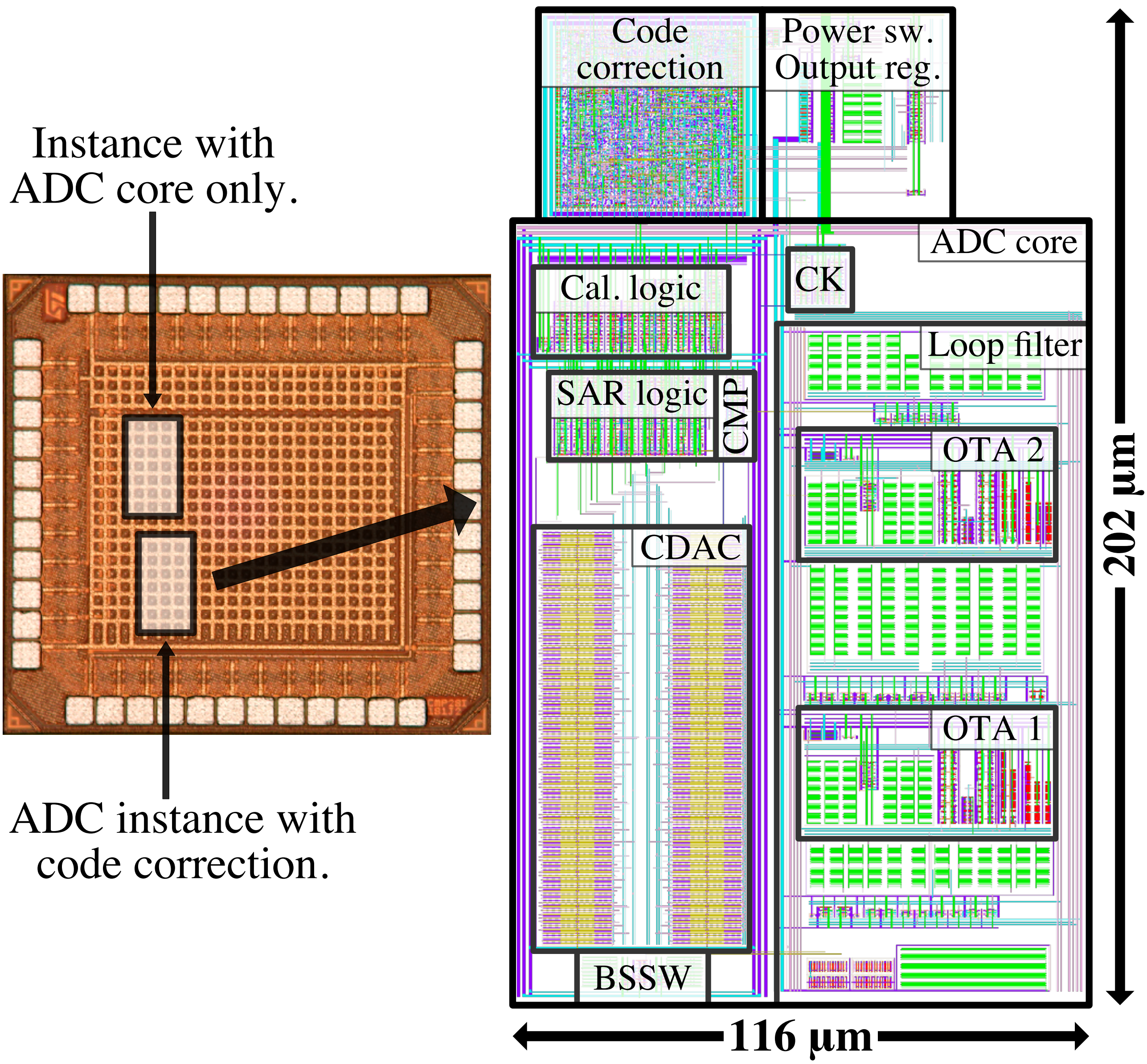
The image quality of echocardiograms has increased greatly in the last 20 years, making it possible to correctly diagnose the occurrence of cardiovascular disease in about 80% of patients. In the remaining 20% a number of physical factors hinder good visualization of the heart and assessment of its function. Patients with a high body mass index often have an impaired acoustic window that is translated into aberration and reverberation artifacts. This project aims at understanding and correcting the factors that lead to reverberation artifacts, such as secondary out-of-plane reflections from ribs/lungs. An article entitled "Studying the origin of reverberation clutter in echocardiography: in vitro experiments and in vivo demonstrations" was published in Ultrasound in Med. Biol. journal in July 2019. This is mainly based on lab experiments that were carried out in 2017 and 2018. This year efforts have been steered towards new beamforming techniques based on coherence factors for echocardiography. A new proposed technique promising results when applied to in vitro data. This technique was also tested in vivo on data gathered at the St. Olavs hospital in Trondheim. The results are still under evaluation.

WP2-7: Ultrasound Elastography with Harmonic Source for Cardiology

Commercial ultrasound elastography is either based on static elastography or acoustic radiation force elastography. MR elastography is however based on an external vibration source. Here we explore the potential of the MR approach for ultrasound elastography, as it has the potential for e.g. deeper penetration and more accurate reconstruction. Since elastography of the heart is a tough challenge due to the motion, the project will progress from imaging of static phantoms, to stationary organs (e.g. thyroid gland), to the heart. 3D ultrasound elastography: Implementation of ultrasound elastography using time harmonic imaging in 3D. The 4V probe has been used for 3D recording and an ECG simulator has been used for synchronization of sub-volumes. It has been implemented and evaluated using an elasticity phantom. Transverse oscillations have been tested for 3D vector velocity estimation to use more advanced methods for elasticity estimations.

Going forward in 2020

The PhD thesis on Improved mapping rate in seabed mapping with sonar will be submitted. Several papers from research in WP2-2,4,6 and 7 will be submitted. Contribute to feasibility/piloting studies together with BTC Archer on ultrasound imaging through steel. One PhD will be hired to work on machine learning methods for seabed classification in Sonar, and one Post Doc will be hired to work on Adaptive image formation (WP2-5) and the USTB toolbox (WP2-1.)



On the left is a photo of a new highly energy efficient chip designed by Harald Garvik and colleagues with original size of 1 x 1 mm and on the right the layout of the integrated circuit is shown.

*Associate Professor at University og Southern Norway is presenting the scientific work during the CIUS Conferece in Horten.
Photo: Karl Jørgen Marthinsen*

*The autonomous submarine Hugin is presented dusing a guided tour at Kongsberg Maritime Subsea in Horten.
Photo: Karl Jørgen Marthinsen*

3

Doppler and Deformation Imaging

Hans Torp, Professor, NTNU
WP leader

Technology to improve methods for detecting and measuring flow and displacements in ultrasound 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 are developing and utilize next-generation multi-dimensional imaging of blood velocities, enabled by utilizing the increased data information available using parallel acquisition techniques.

The clinical potential of novel technologies for visualization of intracardiac vector flow developed in WP3 is currently being tested in pediatric patients at Sick Kids Hospital, Toronto, Canada, and at Ålesund Hospital. In 2019 we have further improved robustness of intracardiac vector flow and performed an in vitro validation study of this method.

These results were presentet at IEEE International Ultrasonic symposium in October 2019. Also, a new 3D vector flow method for improved assessment of aortic stenosis has been published in IEEE TUFFC. Data collection from 100 patient with aortic stenosis has been performed, and analysis on the new methods clinical applicability and added value are ongoing. The flow quantification of mitral and aortic valve insufficiency by 3D Doppler ultrasound which started in 2018, uses the latest within 3D ultrasound technology: Volume flow measurement in insufficient heart valves.

Extensive in vitro experiments as well as piloting in patients have been performed in 2019. A DOFI has been submitted and preliminary results presented at EuroEcho in December 2019.

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.

The 3D coronary flow method has now been tested in a clinical feasibility study, including 24 patients with coronary artery heart decease.

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.

The method "Clutter wave imaging" developed by Sebastien Salles and collaborators in CIUS to quantify myocardial stiffness has been further developed and refined in 2019. The latest results include a 3D vector map of deformation wave direction and propagation speed that was presented at the IEEE International Ultrasonic symposium in October 2019. A patent application of the new method has been submitted. Data collection in 100 patients with myocardial fibrosis has been performed, and analysis of the data is in progress.

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.

Extensive lab experiments with Doppler acquisitions, based on wave propagation simulations has been performed in 2019, and a paper is in preparation.

Going forward in 2020

All 4 subprojects will continue in 2020, with focus on WP3-1 and WP3-3, where we are developing methods which are coming close to clinical implementation. A new project under WP3-4 "Doppler while drilling" starts in 2020.

4

Image Analysis and Visualization

Lasse Løvstakken, Professor, NTNU
WP leader

This work package covers the development of image processing and analysis methods to extract relevant contextual information from ultrasound image data, to improve measurement quality, and to provide a more efficient workflow to reduce the time to decision. These tasks are also coupled to enhanced data visualization to improve data exploration and interaction. Challenges in medical, maritime and industrial applications are addressed using modern approaches in signal and image processing, with emphasis on recent machine learning algorithms (e.g. deep learning) for classification and extraction of data and image features.

WP4-1: Real-time 3D Image Segmentation of all Heart Chambers

Our long-term aim is to achieve a fully automatic real-time 2D/3D segmentation of the heart chambers. This information is highly useful for automatic calculation of relevant clinical measures (e.g. ejection fraction, MAPSE), and for providing a priori information of anatomy that can be used to provide automatic views in 3D imaging, as initialization for other clinical measurement tools (e.g. strain imaging), and to provide an optimized acquisition protocol for higher image quality and frame rate.

We have developed a deep learning approach to image segmentation which runs in real-time and is highly robust. This component is included in a pipeline for fully automatic anatomical measurements of several structures in the heart. We have shown that we are able to provide an accuracy in ejection fraction and mitral annular plane systolic excursion (MAPSE) measurements that is comparable or better than the expected inter-observer variability provided by cardiologists. This methodology is carried forward to AI -based guiding of novice ultrasound users, for optimal scanning by non-expert users, and in cardiological practice to reduce manual analysis time. The expertise and tools developed in this project will be of benefit to other projects, such as for achieving improved data quality and measurements for non-expert users, as well for translation to ongoing and upcoming projects in oil well logging and SONAR (see below).

WP4-2: Automated Measurements and Improved Workflow in Echocardiography

In this project we develop and integrate the use of several components to facilitate automatic clinical measurements, and to develop improved workflow in the echo-lab for obtaining quantitative measurements. This includes anatomical measurements such as ejection fraction and MAPSE, but also automated deformation imaging based on current deep learning approaches for mapping motion in image data. We focus on real-time implementation and testing based on streaming data from high-end GE scanner to separate computers for processing and display.

WP4-3: Improved Processing of Corrosion Pittings in External Pipe Inspection

This project will develop and investigate new acoustic pulsing and signal processing schemes for determination of pitting onset in external pipe inspection. Determining the very onset of pitting using an external single element transducer is of high value for the industry, and is challenging using single element transducers with finite resolution.

WP4-4: Automatic Interpretation of Well Status in Downhole Logging

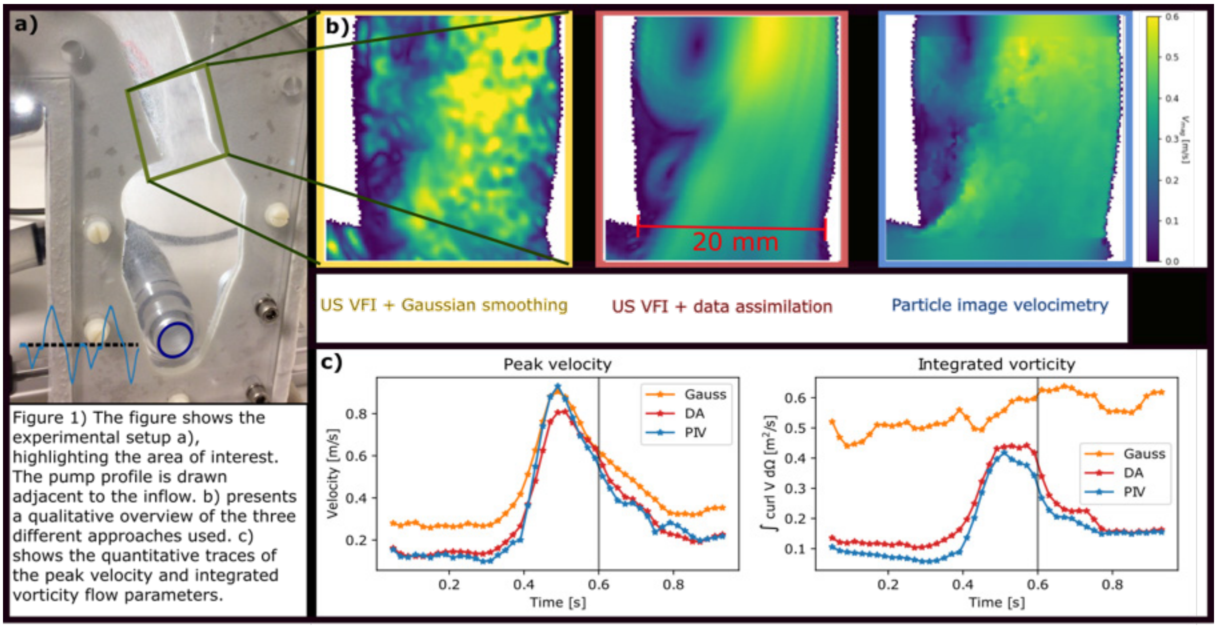
This project aim is to provide an automated analysis and interpretation of sonic/ultrasonic well logs using state-of-the-art machine learning. The machine learning tool can be integrated into the everyday workflow by providing an initial interpretation for further approval by the human operator. If successful the method can save time and cost, and potentially also provide a more consistent interpretation. We have shown that we are able to train a deep neural net to interpret well logs using both sonic and ultrasonic information with promising accuracy. We are now planning a further and more in-depth collaboration with Equinor on this topic.

WP4-5: Echocardiography for the Non-expert User

In collaboration with work package 6 in CIUS, we develop the technical solution to aid the non-expert user obtain cardiac images with sufficient quality for clinical measurements and interpretation. This includes the development of an image guiding system, the inclusion of automated measurements, and a computer-aided system for interpretation of image findings.

Going forward in 2020

Our 2020 activities will focus on further completing and extending our automatic analysis tools in echocardiography and oil&gas well logging operations. We will further hire new personnel to start several new activities for the final years in CIUS. This includes sea-bed classification together with Kongsberg Maritime, corrosion detection / classification together with Sensorlink, and salmon classification together with In-Phase Solutions. We expect to deliver several peer-reviewed academic publications in the medical and oil&gas domain, and to lay the academic groundwork for the new projects.



The figure shows models predicting how fluids will flow in a tube. This can make ultrasound flow measurements more accurate. Illustration: Thomas Grønli

CIUS researchers present at the conference IEEE IUS 2019 in Glasgow, UK. Photo:

Phd candidate Annichen Søyland Daae presenting at EuroEcho2019 in Vienna, Austria. Photo: Marlene Halvorsrød

5

Asta Håberg, Professor, NTNU
WP leader

Multimodality and Interventional Imaging

This work package covers the development and application of multimodal and interventional imaging. 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.

WP5-1 & WP5-2: Multimodal Imaging and 3D Volume Registration in Cardiology and Image Guided Surgery

In this project we are developing and investigating novel methods for multimodal imaging in cardiology and for image guided surgery.

A novel method for ultrasound-based non-invasive assessment and quantification of myocardial fibrosis and stiffness has been developed (see WP3). This method involves acquisitions of ultrasound images with very high time resolution to look at mechanical waves propagating through the myocardium. The velocity of these waves is linked to the stiffness of the myocardium. Preliminary results show that the method is promising, and further clinical validation is ongoing. Additionally, a new 3D Doppler method for more precise evaluation of aortic stenosis has been investigated.

For cardiac interventions, a new registration tool to fuse preoperative CT data of the heart with ultrasound images recoded during surgery in real time is under development. Furthermore, registration of longitudinal ultrasound volumes taken during surgery is investigated. This allows for detection and compensation of ultrasound probe movement during surgery and thereby provide more consistent fusion with the pre-operative imaging data.

The prototype for cardiac acquisitions was extended for treatment of liver metastasis in combination with targeted drug delivery (see WP5-4). Moreover, PET-MRI neuroimaging data (See WP5-3) are now included in the ultrasound guided neuronavigational system for improved delineation of hotspots within brain tumors to help guide resection of cancerous tissues.

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

The unique combination of US and the PET-MR hybrid system is currently explored for applications in brain- and other diseases. The first PhD in PET MRI investigating novel PET tracers for brain tumors and the feasibility of using such data in US based navigated surgery was defended in May at NTNU by Anna Karlberg. She is continuing her work as a postdoc financed by Kystsamarbeidet (Mohn foundation). Through Kystsamarbeidet, a national multicenter clinical PET-MRI research project has been initiated, headed by NTNU, covering brain cancer, cognitive decline, prostate, head and neck cancers.

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

This project aims to use US in combination with microbubbles for targeted drug delivery (TDD) in cancer treatment. A prerequisite for successful cancer therapy is that the therapeutic agents reach all tumor cells and kill them. Focused US (FUS) combined with microbubbles improve the delivery of nanoparticles loaded with drug as well as free drugs in tumor tissue thereby increasing the therapeutic efficacy. Treating patients with non-resectable pancreatic cancer with TDD is of special interest due to these patients' poor prognosis. Preclinical studies in mice with pancreatic tumors are currently preformed to test drug dosage, timing of drug delivery and application of acoustic intensity.

A clinical study has commenced in 2019 in patients with liver metastasis from colorectal cancer. In addition to the standard chemotherapy, the patients receive microbubbles, one liver metastasis is treated with FUS, and another metastasis serves as control.There is considerable work on understanding the fundamental mechanisms for US-mediated drug delivery. Performing intravital microscopy of tumors growing in window chambers of the back of mice, revealed that extravasation of nanoparticles mainly occurred in vessel branching points. Furthermore, studying tumor growing subcutaneously in mice, we found that immediately after US, perfusion was reduced and US reduced solid stress in tumors.

Going forward in 2020

Publish novel methods for US guided invasive cardiological procedures and evaluate their clinical feasibility. The methods will be integrated as applications on the ultrasound scanner so that they can be easily made available in the operating room. Additionally, tracking of various anatomic landmarks of the heart in the ultrasound images in a real-time setup is highly desirable and planned for implementation.

Publish clinical results on the new ultrasound method described above, for non-invasive evaluation of myocardial fibrosis in patients with aortic stenosis. Start Norwegian multicenter PET MRI studies for evaluation of the method's clinical applicability and added value for cancer and dementia diagnostics and follow up.

Based on the promising preclinical TDD studies showing that cancer is cured in mice, a clinical study will start, investigating whether inoperable pancreatic adenocarcinomas can be more efficiently treated with conventional chemotherapy when combined with microbubles and FUS (NCT04146441). A novel dual-frequency transducer has been developed to be able to image the pancreatic tumour at a high frequency and using a lower frequency for treatment. The first patient is to be enrolled in spring 2020. We will continue studying the mechanism for US-mediated drug delivery especially the transport through the extracellular matrix.

6

Ubiquitous Ultrasound

Bjørn Olav Haugen, Professor, NTNU
WP leader

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 in the Western world. 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, clinical measurments). Methods will be adapted for non-expert personnel, but will also find use in high-end systems when successful. "Computer-aided acquisition, workflow and measurements in echocardiography" is a collaborative project between WP4, WP6 and GEVU which aims to provide non-expert users with aid during scanning to achieve images with sufficient quality for measurements and diagnosis. In 2019 work development of technology for quality assurance of echo images, and automated measurements, suitable for real-time performance on the Android or iOS platform started.

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 a number of conditions such as dehydration, fluid retention and urine bladder volume and heart failure by pocket-sized ultrasound in nursing homes and general practitioner (GP) offices. These are common conditions, but difficult to assess clinically and can be treated at point of care instead of hospitalization. This project has also relevance to low-to-middle income countries were dehydration and hemorrhage is a leading cause of mortality among children and women.

Several studies are ongoing to ascertain the added value of pocket-sized ultrasound for increased diagnostic accuracy and point of care treatment. GPs that provide services in nursing homes have been trained in simplified use of ultrasound to detect heart failure and fluid overload. In another study, general practitioners are scanning patients with the pocket-sized ultrasound Vscan for detection and follow up of heart failure in outpatients and transfer the recordings to a cardiologist with a telemedicine system. This study includes cardiological measures obtained by GPs, automatic software for analyses of cardiological measures integrated in real time in the pocket-sized ultrasound device, and support of inexperienced users by cardiologist using telemedicine.

In 2019 a large normal reference database of automatic measurements was completed by PhD student Grue using data from high-end scanners (GE Vingmed Ultrasound AS Vivid 7 and E9) acquired by cardiologists. The study was published in *Echocardiography*. 2019; 36: 1646–1655. https://doi.org/10.1111/echo.14476 where the results featured on the cover page.

In another on-going study, pocket-sized ultrasound of the carotid arteries is being performed by residents at the Levanger hospital for a quicker and more accurate diagnoses in stroke/TIA.

WP6-3 Automatic Detection of Signs of Rheumatic Heart Disease

Approximately 8-15 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 the screening of children in Nepal, Australia or other countries with high incidence of infectious valvular disease.

Preliminarily results from the work performed in Australia on MAPSE were presented in a poster on the 67th Annual Scientific Meeting of the Cardiac Society of Australia and New Zealand. Patient enrollment is still engoing in Australia.

Going forward in 2020

We will finalize patient inclusion in several of the above-mentioned studies, analyze results and publish.

Additional activity by will start in WP6 funded through the Clinical Academic Group status bestowed onto the cardiological research group by the Regional health authorities (HMN).

7

Asbjørn Støylen, Professor, NTNU
WP leader

Clinical Feasibility

This work package focuses on clinical assessment of new technical ultrasound modalities for evaluation of coronary disease and congenital heart disease. Coronary heart disease is still the largest single cause of death, as well as being highly 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 to develop more effective diagnostic modalities to assess cardiac infarction, for both the acute and late phases, to select patients to appropriate treatment in the acute phase to minimise organ damage and at the same time reduce the number of unnecessary procedures. The emphasis is on quantitative ultrasound methods, using new technology, especially 3/4D ultrasound methods for deformation and flow assessment. This has significant development potential and can be a paradigm for quicker pre- and early in-hospital assessment and 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.

Additionally, this work package includes work on evaluating new ultrasound technologies for qualitative assessment of flow abnormalities in congenital heart disease both in utero, in the neonatal period and childhood, and in adults. Congenital heart disease (CHD) is the most common birth defect affecting children, and advances in surgery and interventions have revolutionized the survival of children born with heart disease.

WP 7-1 Ultrasound Coronary Angiography and Cardiac Flow – Feasibility and Validation

The main aim of this project is to assess the feasibility of new 3D methods for visualizing coronary arteries and quantification of coronary stenosis with Doppler. Traditional coronary imaging is based on invasive heart catheterisation, but is increasingly done non-invasively by CT. This still uses ionising radiation and X-ray contrast agent, which represents a potential health risks. Functional assessment of the coronary arteries has been done by fractional flow reserve (FFR), based on invasive pressure measurement, but is now possible to do by CT based on mathematical modelling. Ultrasound, on the other hand is non-invasive and ultrasound contrast is near risk free. Functional assessment can therefore be done by Doppler flow reserve based on pulsed wave and colour 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. In a collaborative project with CT based anatomical and functional assessment of coronary arteries, stress echo has been implemented utilising new high-end scanners with increased resolution and frame rate to evaluate speckle tracking stress echocardiography as a functional test for coronary perfusion. This approach only just became feasible due to new technologies implemented in recent scanners. The inclusion into this study was finished in 2019 and data analysis is ongoing.

An additional project based on 2D and 3D vector flow imaging to map cardiac flow patterns in children is ongoing in collaboration with Sick Kids Hospital in Toronto, Canada, and Ålesund Hospital. In addition, the technique is being tested for feasibility in adults at St. Olavs hospital We aim to map flow patterns in congenital heart disease in fetal life, during childhood and into adulthood compared to healthy matched controls, to evaluate the diagnostic accuracy of 2D flow quantification in congenital heart disease, and to characterize changes in intracavitary flow in heart disease with and without preserved ejection fraction in adults, and its consequences for energy loss.

WP 7-2 and 7-3 Ultrasound Imaging and Quantification of Tissue at Risk and Myocardial Viability – Feasibility and Validation

Approximately 1/3 of patients with non-ST elevation myocardial infarction (NSTEMI) have an occluded artery. In this project the aim is to assess the feasibility of new US methods to detect and quantify tissue at risk, i.e. ischemic myocardial tissue that with high probability can be normalized with urgent revascularization. The non-invasive detection and possible quantification of cardiac fibrosis using ultrasound methods developed in CIUS is another aim.

Due to the lack of specific ECG changes to myocardial infarction in about 1/3 of the patients, these will miss early invasive treatment, which leads to larger infarcts and worse prognosis. Using newer physiological markers of ischemia, in combination with 3D deformation imaging using ultrasound, we aim to quantitate "myocardial area at risk" to select NSTEMI patients for early treatment. The same parameters will be used to evaluate the extent of myocardial scarring in patients with chronical infarcts, as presence of extensive scarring indicates that invasive treatment has no beneficial effect.

Going forward in 2020

Take the methods developed in *WP 7-2 and 7-3* into real time 3D deformation imaging of acute coronary ischemia. We have already developed a method for high frame rate 3D ultrasound, which can be used for area measurement. This will be tested in the early infarct setting, to quantitate both area of ischemia (area at risk) and area of potential myocardial damage.

Develop method for assessment of diastolic function in children which is currently not available, and tools to extract quantitative flow measures. Lastly, we aim to develop and test 3D flow techniques in pediatric patients in 2020.

Minister of Finance Siv Jensen visited NTNU Department of Circulation and Medical Imaging to learn more about CIUS and innovations in ultrasound. Photo: Johanne Færevaag Nome

The handheld ultrasound device GE Vingmed V-scan. Photo: Karl Jørgen Marthinsen

8|9

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

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

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.

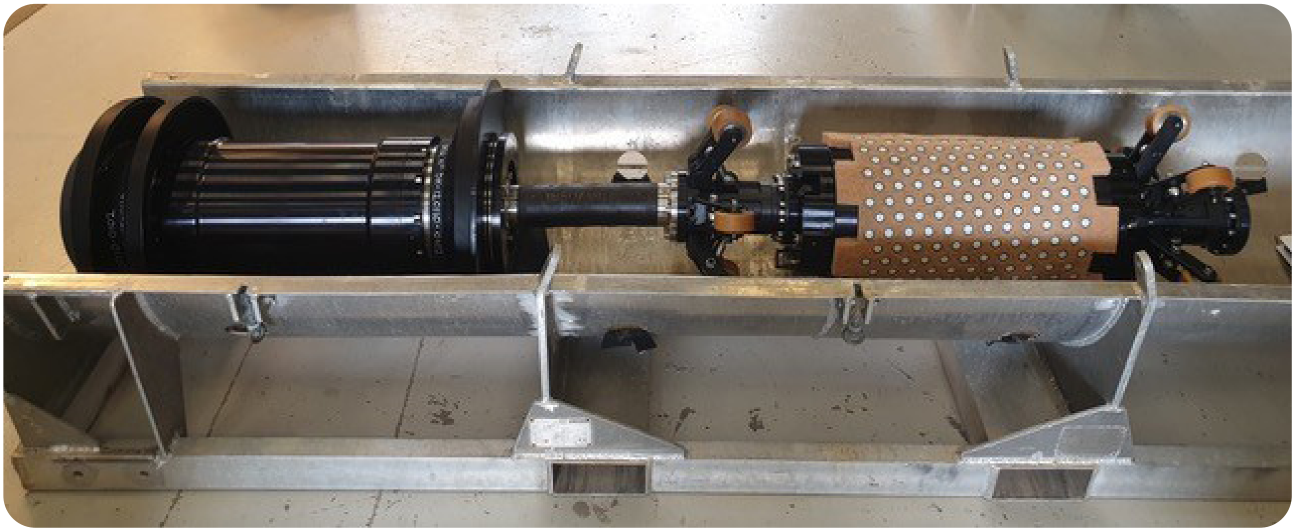
2019

CIUS partner Halfwave is developing a new tool for crack detection in gas pipelines, which is related to a pilot project in CIUS on improving algorithms for crack detection. The main objective of Halfwave's 2019 R&D activity was to assemble and factory acceptance test (FAT) the prototype crack detection tool for gas pipelines. In the late summer, the tool was assembled and tested at the Norwegian Underwater Institute (NUI), essentially on schedule. The initial test was fairly successful, but some hardware modifications were required. Later in the fall, the tool passed all the aspects of the FAT, upon which it was shipped to the field for the pilot run in North America. This is a very important milestone for both Halfwave and CIUS in order to ensure progress on the crack detection algorithm development.

Kongsberg Maritime have in 2019 developed a new transducer design with single crystal optimized for large bandwidth based on the PhD work of Ellen Sagaas Røed. This is now ready for prototyping in 2020.

2020

In response to a request by The Research Council of Norway (RCN), based on the mid-term evaluation of SFI CIUS conducted in the spring of 2019, a detailed plan for work packages 8 and 9 in CIUS was developed during the autumn of 2019. Work package (WP) 8 concerns piloting of projects in the oil & gas sector, and WP9 piloting within the maritime sector.



Prototype crack detection tool by Halfwave. Photo: Petter Norli

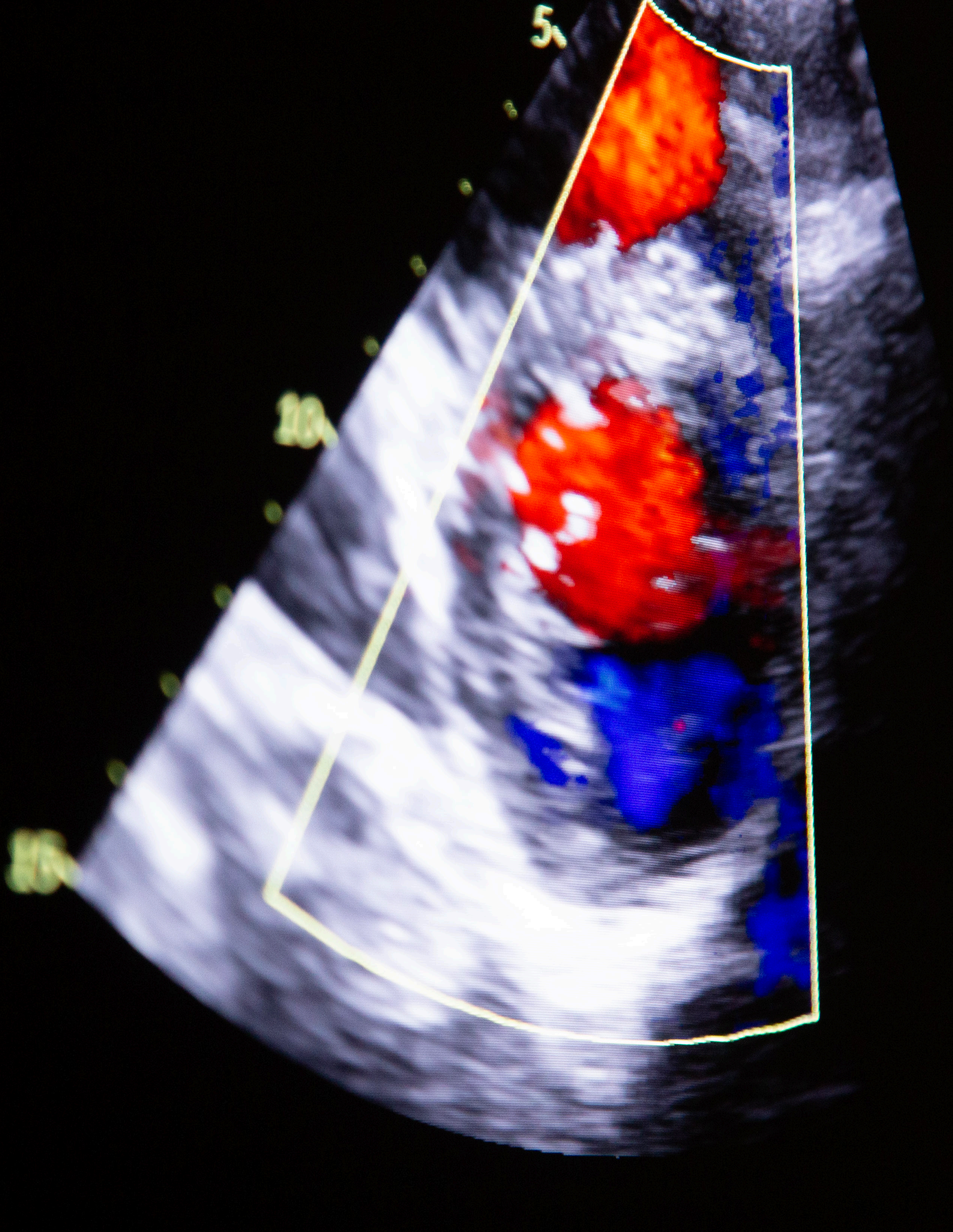
The plans were detailed in close collaboration with our partners, and have been approved by team leaders, R&D managers etc., depending on the various titles and positions in our partner organizations. This means that all plans have management backing. More than 36 people from 10 partners were involved in the planning process over several months.

In order to define detailed pilot projects and connect them to finished, ongoing, and not yet started research projects in CIUS, a detailed plan on all research projects for the oil & gas and maritime sector was also finalized during this process.

In total, 17 research projects on PhD and Post Doc level have been defined (9 oil & gas totaling 31 man-years, 8 maritime totaling 22 man-years) with work and funding in WP1-4.

These research projects are connected to 15 planned pilot projects (10 oil & gas, 5 maritime) with an estimated budget of 43 MNOK in in-kind from CIUS industrial partners organized in WP8 and 9.

In 2020, an expected 6 pilot projects will start within oil & gas on topics ranging from new transducer manufacturing techniques to automatic interpretation of well integrity logs using neural networks. Four pilot projects are expected to start in maritime with projects such as automatic seabed classification using machine learning and field testing of new echosounder techniques. We look forward to a productive year in CIUS.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Profiles and 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 builds on the efforts of CIUS` talented researchers.

A new generation of researchers

Generation of ultrasound researchers is supervised by internationally recognized, leading academics in collaboration with the CIUS partners' R&D staff. Meet three CIUS PhD candidates:

Malgorzata Magelssen is finding out how doctors and nurses use handheld ultrasound to improve speed and accuracy.

Olivia Mirea is researching how to improve the analog electronic design. Her aim is to make the transducers more compact and thereby smaller, more user friendly and efficient.

Simen Midtbø is working together with industry to use seismological models for detecting cracks in oil and gas pipelines to ensure safe transport.

The impact of handheld ultrasound

What would the health care system look like, if all nurses and doctors had an ultrasound machine in their pocket? Read about the research on how the new handheld ultrasound devices can change hospitals.

Downsizing the electronics

What is happening in the development of electronics? In our story, you can read about the ongoing research that enables the ultrasound devices of tomorrow.

PhD Candidate, CIUS

Malgorzata Isabela Magelssen

Support for Improved Diagnostics by the use of Hand-held Ultrasound Device

Photo: Karl Jørgen Marthinsen

Ultrasound can be hard to use for people without training, and today it has been an imaging technology reserved for dedicated sonologist and cardiologists. However, new technological progress can make ultrasound imaging more accessible for other medical personel. This can make the health care system much more efficient.

Malgorzata Isabela Magelssen is both a cardiologist at St. Olavs hospital in Trondheim and a PhD candidate at CIUS: "Our group has a clinical focus. We are evaluating new functions implemented in hand-held ultrasound devices in order to improve diagnostics in heart diseases," she says. **Read more about the research on handheld ultrasound on page 48.**

Evaluating Hand-held Ultrasound

"We are researching new possibilities for general practitioners to diagnose heart failure using hand-held ultrasound devices. In addition to a clinical examination, other diagnostic tools may be helpful in order to make a correct diagnosis."

170 patients with suspicion of heart failure have been included into the study. They are being examined by five general practitioners in addition to specialized nurses and specialists in cardiology. Their task is to determine whether the patients have heart failure. Magelssen explains that they are examined by the medical staff in three steps:

"First, the doctors and nurses examine the patient with a regular ultrasound image, using a handheld device.

"The next step is to enable the automatic measuring functions on the devices. This can guide inexperienced users to make a better decision whether the patient has heart failure."

The images taken by general practitioners are also sent to specialists in cardiology for evaluation. They give written feedback with a possible diagnosis.

"The general practitioners must consider the diagnosis after each step. Ultrasound by cardiologist has been used as a reference."

Research is important

Malgorzata went to medical school in Warsaw, Poland and graduated in 2006. After an internship, she first worked in Gothenburg, Sweden for a couple of years before permanently moving to Trondheim in 2010. Since then, she has worked in internal medicine at St.Olavs hospital.

"I've always had an interest in Cardiology and have worked as a MD at the clinic of Cardiology since 2015," she says.

"Research is a big part of the Clinic of Cardiology at St. Olavs hospital and we are always encouraged to get involved in research programs. I was interested in a clinical project with clear goals. This project suited med perfectly since it potentially can lead to an improvement in the diagnostic process of heart failure."

Utilization of Handheld Ultrasound can have Large Benefits

Patients with suspicion of heart disease are referred to a specialist for further diagnosis. Waiting lists are usually long and sometimes patients have a long way to travel to get to a specialist. However, Malgorzata is optimistic about the future of handheld ultrasound.

"The devices can potentially aid in the evaluation of patients suspected of having heart disease. The patients who need urgent care can be correctly prioritized and others might not need a referral. Also, hand-held ultrasound devices are a great asset in specialist health care, especially in the acute cases when you need a quick overview of the patient's clinical status.

The use of technology must be validated

"I think I'm a tech optimist, but I feel that it is very important that new technology is properly validated before it's used by the "masses". I'm convinced that in the future, medical imaging used by more inexperienced users. It is therefore important that the tools available are reliable and that specialists are used for consultation when needed. I think that telemedicine will be used in a larger scale to assist in the diagnosis of heart diseases.

"I hope that our research will lead the way for further research in the area and possibly increased use of handheld ultrasound devices by general practitioners. Also, I hope it will lead to more research in more rural areas where the access to healthcare is scarce."

PhD Candidate, CIUS

Olivia Mirea

In-probe Receivers for Medical Ultrasound Systems

Photo: Karl Jørgen Marthinsen

According to WHO, Cardiovascular Diseases (CVDs) are the leading cause of death globally. The number of deaths caused by CVDs is 17.9 million. Thinking of this major problem, several questions arise in my head: What is the root-cause of those diseases? How can we prevent them in a timely manner - to reduce the mortality rate? Being passionate about electronics, I focus on the last question. The purpose of my research is to improve the quality of ultrasound heart imaging by developing new integrated in-probe electronics using dual frequency hybrid CMUT technology. The aim of the project is to improve the current state-of-the-art of the circuits.

Olivia is part of a research group at NTNU working on the design of integrated circuits for various applications where in-probe electronics for medical ultrasound is one of the main activities.

"I finished my Engineering Bachelor degree in Microelectronics in 2015 and, after that, I finished a Master in Advanced Microelectronics in 2017, both at the Faculty of Electronics, Telecommunications and Information Technology of the Polytechnic University of Bucharest. In my 3rd year of engineering studies, I started working in the industry, at Microchip (1 year) and then at Infineon (4 years) in Bucharest."

Insipired by nature

""The journey of a thousand miles begins with one step", right? I love mountains. It's such a beautiful view from the top of a mountain! But more important to me is the joy of walking there than of being there. Pursuing this PhD, I've already made the first step. The decision was based on the combination of the PhD subject, which motivates me a lot, and the amazing Norwegian nature.

"Having had contact with both the industrial and academic environment, I found that I am very interested in an academic career, in which I can dedicate a significant part of my time to research. The magical words in the CIUS position advertisement were "Analog integrated circuit design available at CIUS", which instantly caught my attention. Afterwards, I started to find out more and more information about this research, about CIUS, and the nature and culture of Norway.

"Working with professor Trond Ytterdal, my supervisor, makes the research more and more interesting day by day!

"There are also other team-mates: Carsten Wulff (my co-supervisor), and Aslak Lykre Holen (who's working on the transmitter part of the probe). Together, we complete each other in a great team.

"Friends and mountain trips also give me a lot of joy. Overall, I am happy to do my research in this pleasant environment, in the cosy and lovely Trondheim!

"I am confident my research will move the existing ideas ideas forward by at least one step."

> *I love mountains. It's such a beautiful view from the top of a mountain! But more important to me is the joy of walking there than of being there.*

PhD candidate, CIUS

Simen Midtbø

Crack Detection

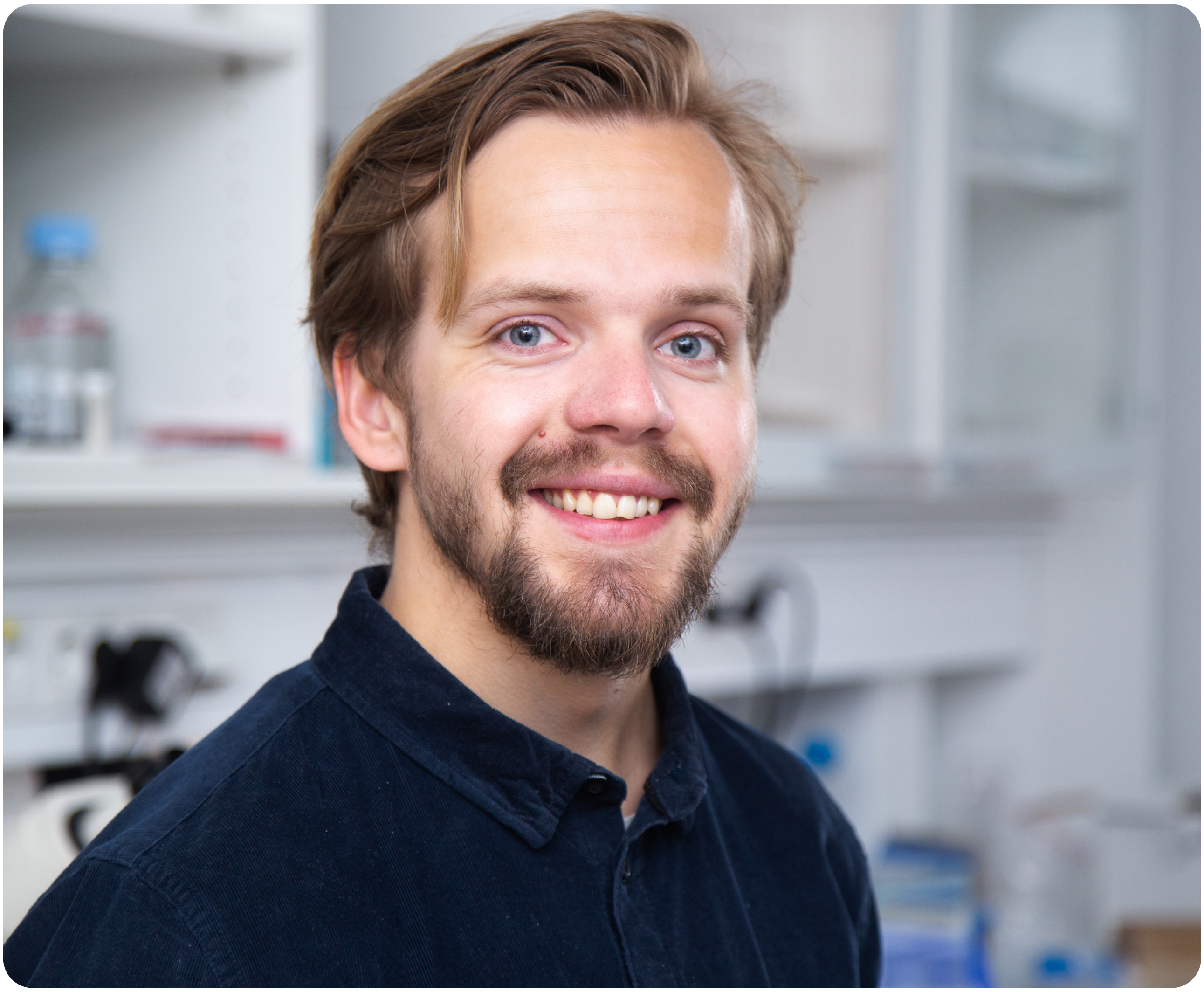


Photo: Karl Jørgen Marthinsen

Simen Midtbø is a PhD Candidate at CIUS, and is studying guided waves in pipe walls and their interaction with cracks and defects for the development of a crack detection tool in pipes. The project is in cooperation with Halfwave, a company that wants to develop such a tool based on their already established technology.

"Halfwave is a rather young company, which are developing and employing ultrasound technology for use in NDT (non-destructive testing). Their technology is primarily used for wall thickness monitoring of pipe walls, and now they want to expand into the crack detection field as well.

"The main challenges that all crack detection tools face is the quantification of cracks versus general irregularities within the pipe, and sizing of the cracks. I'm working on an inverse tomography method used in seismology, where they're combining simplified scattering models with measurements in order to reconstruct a wave path where the wave has encountered some discontinuity or disruption.

"This is analogous to our case, so we want to apply the same methods, but for a pipe wall. We know that the concept works, but we want to improve the underlying mathematical and physical principles."

Leakages are bad for both the economy and the environment

Recently, The Economist had an article on the discovery of a gas leak of methane in Turkmenistan last year. The leakage was not due to a crack, but supposedly due to an unlit flare, and it was discovered by chance via satellite imaging. Later analysis showed that the leak had been going on for some time, and they estimated that about 140 000 tons of methane had been released into the atmosphere.

"With methane being one of the greenhouse gases, this is very unfortunate. Every year there are incidents of gas leaks due to cracks, which may not be of the same magnitude as in Turkmenistan," he says.

"However, the many incidents could have the same potential. These pipes can often cover big distances in uninhabited areas where sufficient pipe monitoring is challenging. As we just saw in Turkmenistan, the leak can go undisturbed for a long time.

"There is a need for good pipe monitoring tools, and a crack detection tool will be a very good supplement for this."

A rewarding collaboration

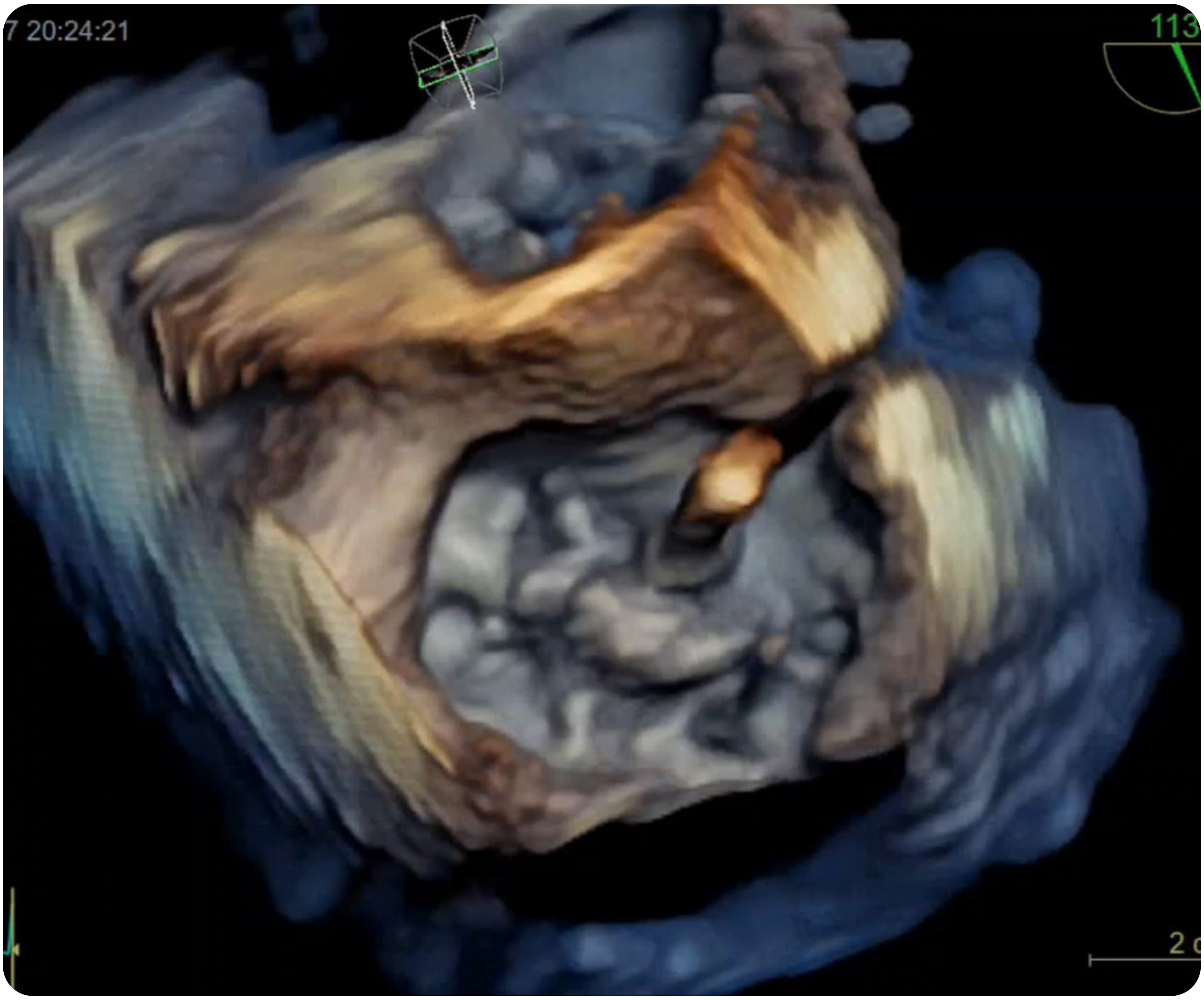
Simen Midtbø is living and working in Bergen where the company has its main office.

"Halfwave has been very welcoming and cooperative since I started my PhD. I also feel fortunate as I can get an inside glimpse of how it is to work with research and development in the industry."

> *There is a need for good pipe monitoring tools, and a crack detection tool will be a very good supplement for this.*

The Importance of Microelectronics for Ultrasound

In the early 2000s, 3D medical ultrasound imaging was introduced with the use of so called 2D matrix arrays, ultrasound probes containing thousands of elements stacked in rows and columns like a matrix. Prior to this, every single element in an ultrasound probe, usually between 92-256, was connected to the ultrasound scanner through a cable.



3D image of the heart taken from the oesophagus during cardiac intervention. Courtesy of GE Vingmed Ultrasound AS.

With thousands of elements, this became practically impossible as the cable be enormous, probably weighing several kilograms, and simply being too expensive. This challenge was solved only because the electronics had become so small and power-efficient that they could be placed inside the handle of the probe, performing parts of the signal processing there, prior to transmission through the cable.

The development of this kind of micro-electronics also led to the introduction of hand-held ultrasound systems, such as the GE Vscan, again placing electronics inside the probe handle and allowing the systems to shrink. The compromise is reduced image quality due to an order of magnitude lower element count in hand-held devices in order to keep prices for such systems low.

Today, the development of micro-electronics continues, becoming ever more power frugal and miniaturized. This has led to element counts of between 6000-10 000 in 3D medical imaging probes with superior image quality.

In CIUS, research into micro-electronics is important for improved performance of medical imaging probes, but also for the reduction of size and power consumption of sonar arrays.

Ongoing Research

The research on improving the design of electronic circuits, is done by a research group led by Professor Trond Ytterdal at NTNU. Their goal is to downsize the circuits and improve the ultrasound image quality.

PhD candidate Olivia Mirea is one of the researchers in this group.

"First we need to convert the analog signal received from echoes into a digital signal. For this, we use an analog-to-digital converter (ACD)," she says.

Because the signal is attenuated while propagating inside the body, it requires amplification prior to digitalization in the ADC, or else the information would be lost. Therefore, the use of a so-called time-gain amplifier (TGA) is also required and constitutes a very important component in the receiver analog circuit. Making the TGAs and ADCs ever smaller and more power frugal is an important part of PhD candidate Olivia Mirea's research.

Read more about PhD candidate Olivia Mirea on page 42.

Another researcher at Ytterdals group, is PhD candidate Aslak Lykre Holen. He is working with transmitters, the component that send out the sound waves.

"Transducers usually need a lot of power to generate proper sound waves. The transmitters I'm usually working with is under a high voltage."

He is designing integrated transmitters.

"Designing the transmitter into a integrated circuit makes it possible to place the transmitter into the probe, and that is very important for the overall size of the ultrasound device."

The purpose of all the micro-electronic circuits inside the ultrasound probe, besides making it small and compact, is to improve the quality of ultrasound imaging in general. For high end systems, this means the use of 2D matrix arrays with ever more elements. For portable systems, this means improving image quality but maintaining low costs. In the end, this will benefit the clinicians and patients. Although SONAR systems lag behind the medical field in micro-electronics development, they will also benefit from this research as the maritime industry is getting more and more engaged in this development.

Designing the transmitter into a integrated circuit makes it possible to place the transmitter into the probe, and that is very important for the overall size of the ultrasound device.

Can Handheld Devices Change Health Care Systems?

Handheld ultrasound scanners have already been on the market for some years. They can make ultrasound diagnostic tools more available for the medical staff. However, correct interpretation of ultrasound images demands a lot of experience. What happens when general practitioners diagnose patients with handheld ultrasound?

Professor Håvard Dalen is leading a group of scientists, investigating how general practitioners use handheld ultrasound. He is positive that this technology has a lot of potential. **Read more about researcher Malgorzata Magelssen, working on handheld ultrasound on page 40.**

"In today's Norwegian health care system, there is a long wait for patients to be examined by a cardiologist. We believe it is possible to improve the situation by equipping doctors and nurses with handheld ultrasound diagnostic tools that are easy to use."

Dalen says handheld ultrasound can make it easier to diagnose symptoms with many possible causes.

"For instance, a patient might see a doctor because he or she is short of breath. This symptom can have many causes. Instead of having to wait several months for a cardiologist examination, the doctor can instead use a handheld ultrasound device, and check if the heart of the patient has any signs of weakness. If not, non-cardiac causes may be more probable. If we can provide a system that ensures patients the best diagnostics at an early stage, we could save the patient and the health care system for a lot of time and effort."

Dalen's project has invited nurses and general practitioners to test handheld ultrasound on volunteer patients. The evaluation is done in three steps. First, they look at a normal ultrasound image, to see if they can spot any problems. In the next step, they get additional aid from automatic measurements of cardiac function. The machine will guide them to see if the left ventricle (main system chamber) is enlarged or dysfunctional. The last supportive step is that the live images recorded by the doctors and nurses are interpreted by a telemedicine cardiologist, who helps them to interpret the images and how to make the proper decision of the patient's medical need.

At Levanger Hospital the inclusion of patients is in progress. PhD Candidate Anna Hjorth-Hansen is supervising the process.

"The patients are being examined. The patients that may or may not have a weakness in the heart. They are going to be examined by our doctors and nurses, and we are monitoring the process.

"Working with new technology is very exciting. However, it is very important to learn how it is being utilized by unexperienced users. I think this is what's so unique at CIUS. Technical developers and clinicians can work together to create useful technology."

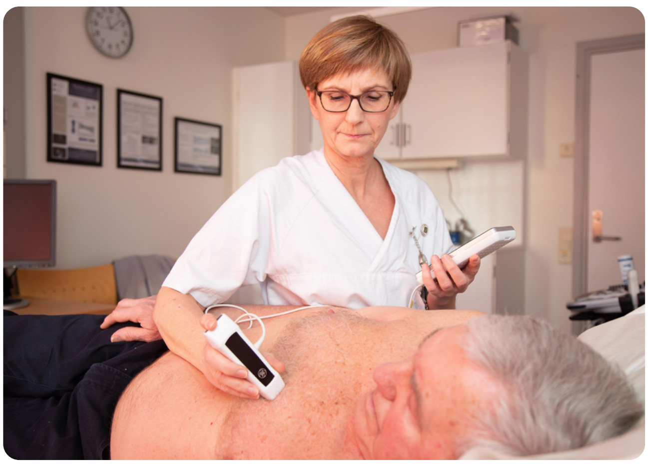
Håvard Dybdahl is one of the general practitioners that is trying out handheld ultrasound technology.

Correct interpretation of ultrasound images requires a lot of experience. When examining a patient, it is very easy to discover false positives. Therefore, it is very important to determine what you're looking after and stay focused.

Anna Hjorth-Hansen is optimistic about the future of handheld ultrasound:

"I think more accessible ultrasound diagnostic tools can change how the health care system is run. In the future, we need to treat more patients with the same resources we have today."

PhD candidate Anna Hjorth-Hansen



Hilde Haugberg Haug (nurse) is using handheld ultrasound to examine a patient.

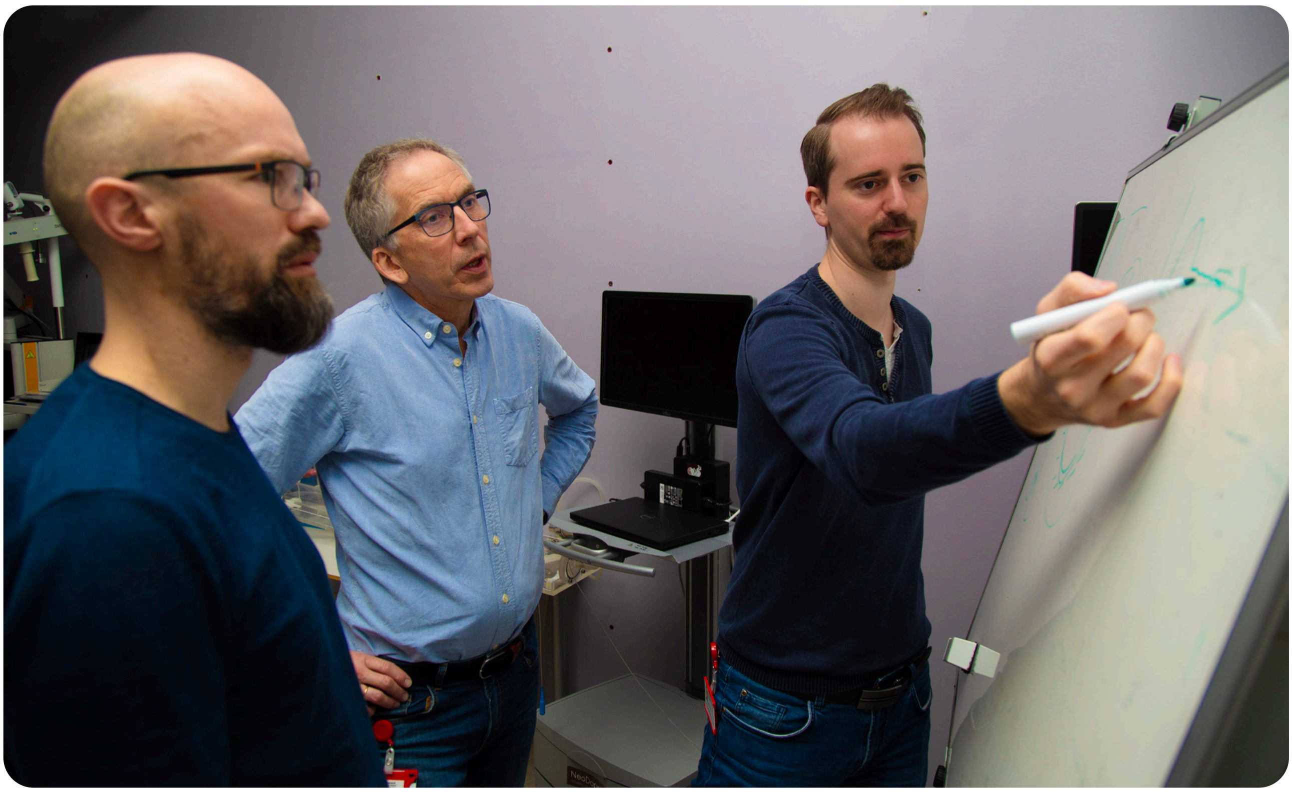
Håvard Dybdal is a general practitioner, participating in the study.

All photos: Karl Jørgen Marthinsen

Developing an Innovation into Product – the CIUS Innovation Pathway and the Pilot

Svein-Erik Måsøy, Industry Liaison and Tormod Njølstad, Innovation Manager

CIUS is all about developing research-based innovations that our industry partners can use in their products, services, or processes. Whenever our researchers come up with something smart, they report it to our partners using a Declaration of Invention form or DOFI. Then, a formal process of recognition of the DOFI by our partners starts, where all partners have to state their interest in the reported innovation. Usually, at least one of our partners is interested, and sometimes several.



From left: Svein-Erik Måsøy, Tormod Njølstand, and Post Doc Erlend Wiggen. Photo: Karl Jørgen Marthinsen. Photo: Karl Jørgen Marthinsen

This marks the start of a journey, where the innovation reported has to be tested and validated more properly in collaboration with the interested partner. The purpose of this process is to assure relevance of the innovation and push the innovation as close as possible to a potential product, process, or service, with the ultimate goal of creating just that.

This is not necessarily a process which evolves similarly for each reported innovation. Every case is unique and depends on what is invented, within what field, which partner who shows an interest, and what state the innovation is in when being reported. In CIUS, we use the EU Horizon 2020 definition of Technology Readiness Levels, or TRL level, to describe the state of an innovation.

The CIUS innovation pathway

The CIUS innovation pathway consists of a three-step process:

1.Research based innovation projects in CIUS – Academic center driven based on partner input

- Carried out at PhD, Post Doc, and researcher level. The projects are motivated from CIUS partners' input with the goal of leading to innovations of relevance for our partners. Innovation ideas are reported to the CIUS consortium using DOFIs.
- These projects are led by the academic partners but carried out in close collaboration with the partners.

2. Piloting in CIUS – Partner driven with academic center support

- From developed innovation ideas, CIUS partners carry out piloting and validate the potential of the innovations in collaboration with CIUS researchers, with the goal of deciding full commercialization or not.
- The pilots are led and funded by the industrial partners, but also supported by the academic partners.

3. Commercialization in CIUS – Partner driven with or without support from academic centers

- If a pilot is deemed successful, CIUS partners commercialize the innovation ideas or utilize CIUS created knowledge in their daily operations, production processes or services.
- The commercialization process is fully driven by the industry partners. Support from the academic partners can still be required, but not necessarily.

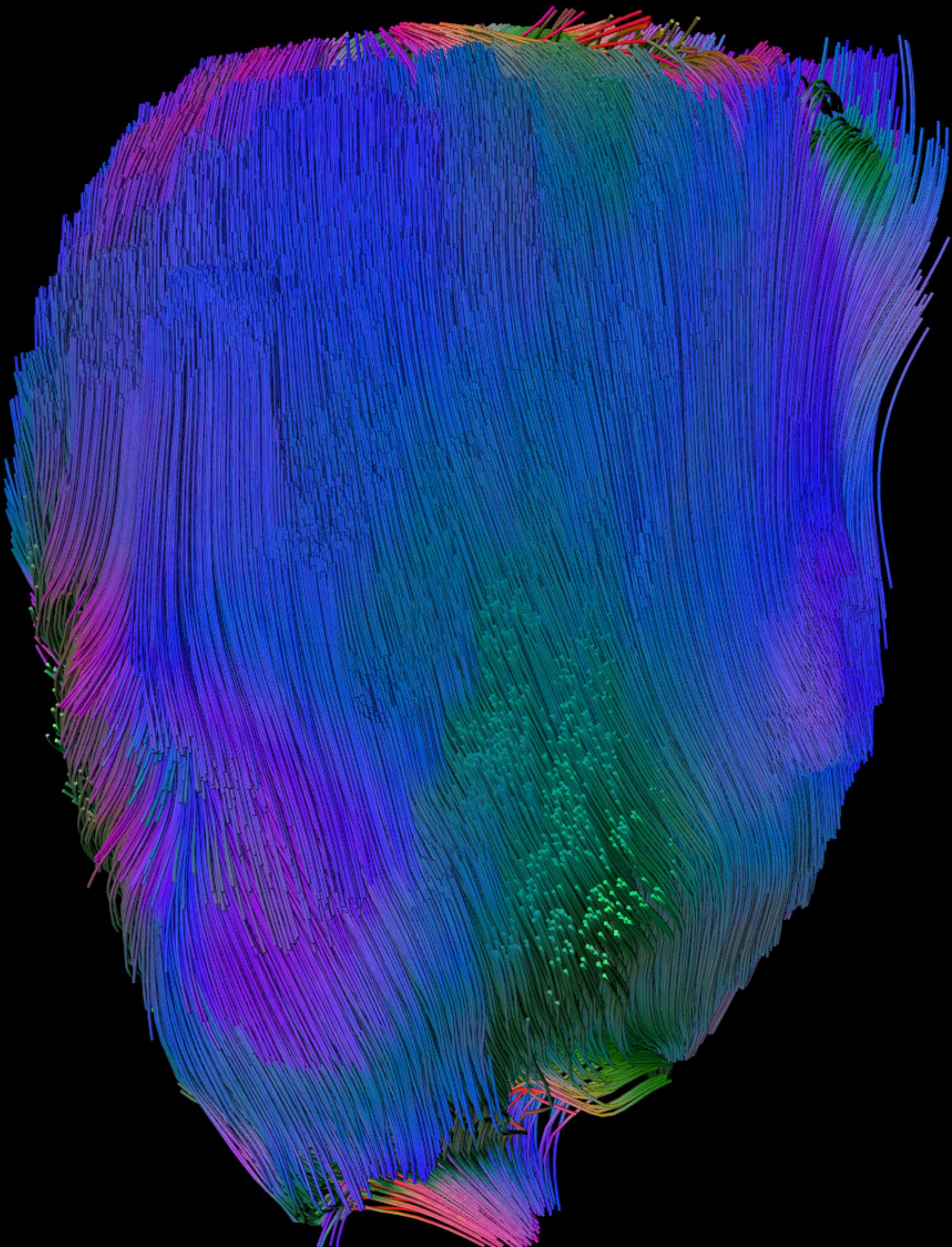
The pilot

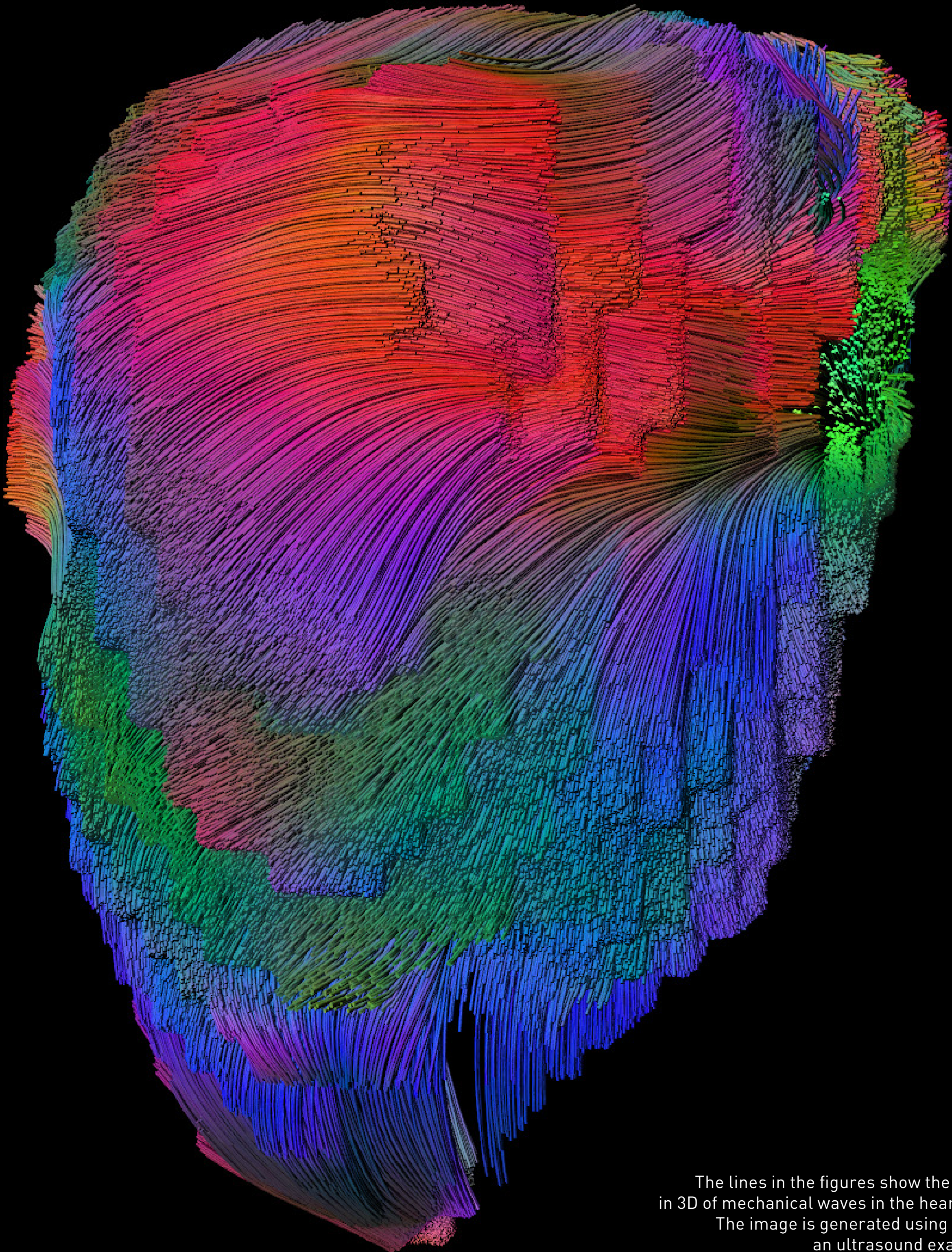
All the researchers in CIUS start their work in step 1 of the innovation pathway, trying to come up with something new and useful. When a DOFI is reported, it is usually in a TRL state between 1-4. The next important step is the pilot. Some simple guidelines for pilots in CIUS are that a pilot should only start when TRL level 4 has been achieved, and that the pilot should increase the TRL level to at least 5 or 6.

The goal of the pilot is to create enough information in order to decide upon full commercialization of an innovation. This is very important for our partners since they usually are very busy and have many projects they are developing in parallel. Prioritizing is always challenging and a decision on commercialization involves large investments, both in time allocated to personnel and potentially in new equipment or processes.

CIUS has now passed its halfway mark, and the number of pilots is starting to increase as results from the research are ticking in via DOFIs. CIUS now has 13 ongoing pilots, related to reported DOFIs in collaboration with our partners, and has plans for many more in the last 4 years of the project.

On behalf of CIUS we are convinced that the outcome of each of these partner driven pilots will have a great value and be applicable to the partners in their future operations, to the benefit of us all.

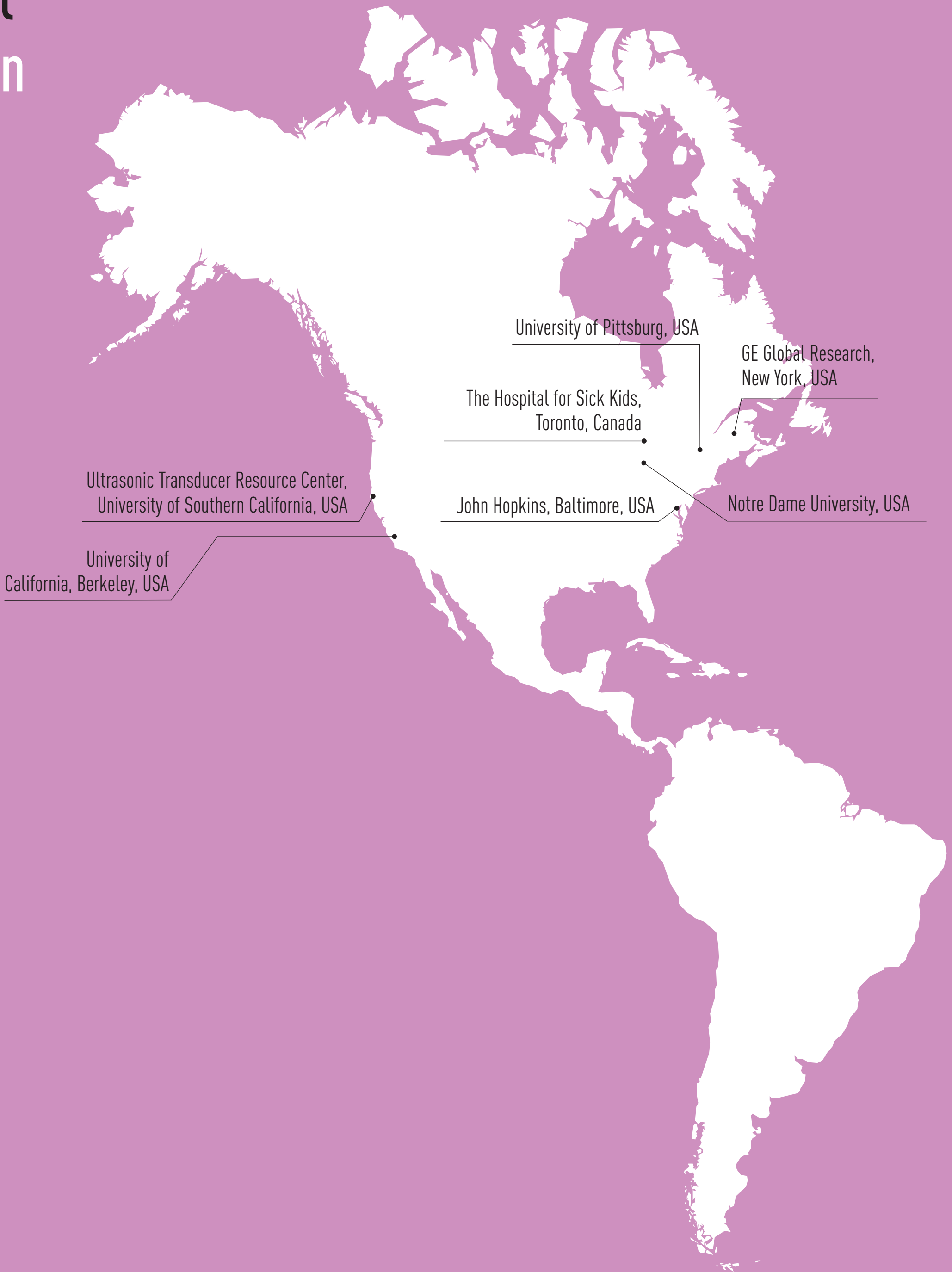


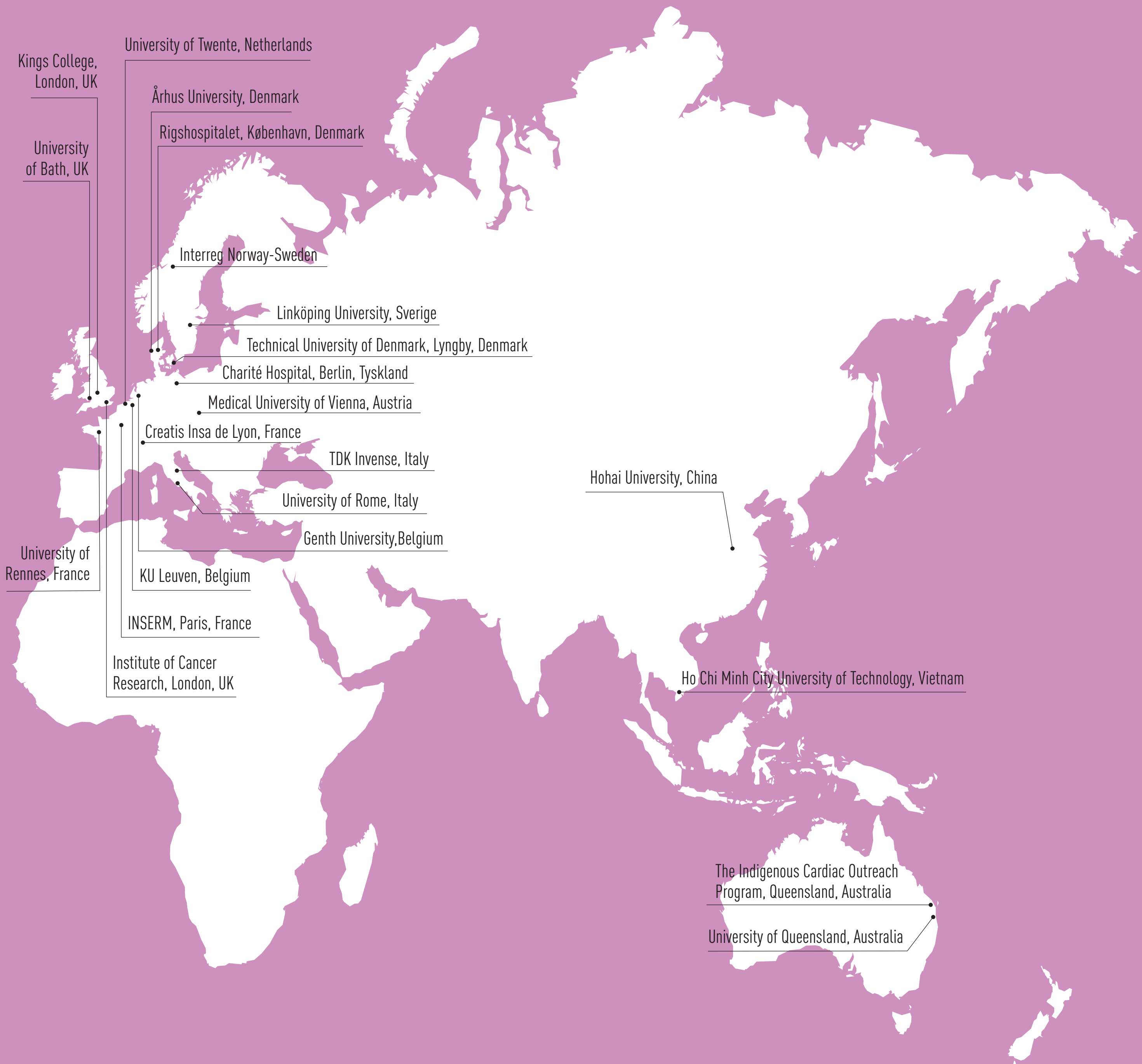


The lines in the figures show the pathways
in 3D of mechanical waves in the heart muscle.
The image is generated using data from
an ultrasound examination.
The heart to the left is healthy and
the heart to the right is sick.

Illustration: Sebastien Salles

International
Collaboration





University of Twente, Netherlands
Kings College, London, UK
Århus University, Denmark
Rigshospitalet, København, Denmark
University of Bath, UK
Interreg Norway-Sweden
Linköping University, Sverige
Technical University of Denmark, Lyngby, Denmark
Charité Hospital, Berlin, Tyskland
Medical University of Vienna, Austria
Creatis Insa de Lyon, France
TDK Invense, Italy
Hohai University, China
University of Rome, Italy
Genth University,Belgium
University of Rennes, France
KU Leuven, Belgium
INSERM, Paris, France
Institute of Cancer Research, London, UK
Ho Chi Minh City University of Technology, Vietnam
The Indigenous Cardiac Outreach Program, Queensland, Australia
University of Queensland, Australia

PhD Candidates

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.

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.

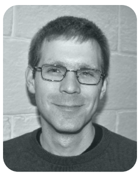
Antoine Blachet (WP2)
SONAR seabed mapping
Together with Kongsberg Maritime, I am exploring new SONAR designs that could lead to improved performance in some particular applications. One possibility is to transmit advanced coded waveforms, inspired from modern techniques used in radar and wireless communication. 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.

Jessica Lage (WP5)
Targeted drug delivery
Acoustic Cluster Therapy (ACT) is found to improve the delivery of drugs and nanoparticles (NPs) to tumors and across the blood-brain barrier. The overall aim of the project is to bring light to the underlying mechanisms ACT, a method that is based on the use of ultrasound in combination with large microbubbles, in order to improve the delivery of NPs to tumor tissue. Of special interest is clarifying the cause and mechanism of the enhanced tissue extravasation and flow through the Extracellular Matrix (ECM), specially on Infiltrating ductal adenocarcinoma of the pancreas (PDAC). The project will also aim to evaluate the application of ACT mediated delivery in brain diseases, especially on a glioma model. Moreover, we will evaluate the response of the immune system.

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.

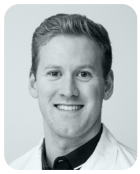
Amirfereydoon Mansoori (WP1)
Wideband solutions for Piezoelectric MEMS Ultrasonic Transducers (pMUTs)
Piezoelectric MEMS Ultrasonic Transducers (pMUTs) are promising alternatives to conventional bulk piezoelectric transducers, particularly in applications where miniaturization, cost, ease of fabrication and integration to the front-end circuitry are of critical importance. Unlike its capacitive counterpart (cMUT), pMUT does not require a DC bias voltage and operates linearly however the performance of conventional pMUTs have been limited by their narrow bandwidth. The aim of this project is to first identify the theoretical as well as practical limits of pMUTs and then propose novel solutions to enhance the bandwidth of such devices enabling new ultrasonic imaging applications.

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 quantifi-cation 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.

Simen Hammervold Midtbø (WP4)
Crack detection
Cracks and defects in oil- and gas pipelines are a major concern to operators across the globe today. Halfwave AS is a company that are developing a tool that can detect and quantify the severity of the cracks, using ultrasound and tomography methods. By exciting and recording the resonances in the pipewalls using an array of ultrasound transmitters and receivers, tomography methods can be used to detect irregularities within the pipewall. The challenge, however, lies in differentiating actual cracks from more general irregularities, such as corrosion, within the pipe. It is our objective to contribute to this task by optimizing an inverse tomography technique that combines theory and measurement, while simultaneously increasing knowledge on how waves interact with cracks in order to improve analysis results.

Olivia Mirea (WP1)
In-probe receivers for medical ultrasound systems
The purpose of this research is to improve the quality of the ultrasound heart imaging by developing new integrated in-probe electronics using dual frequency hybrid CMUT technology. Different topologies of LNA (Low Noise Amplifier), TGC (Time Gain Compensation amplifier) and ADC (Analog to Digital Converter) will be studied/compared, the aim of the project being to find new ideas of improving current state-of-the-art of the Circuits.

David Pasdeloup (WP4)
Image analyses
With the availability of portable ultrasound devices, the number of examinations carried out by non-expert users will increase. The aim of the project is to use state-of-the-art machine learning to develop tools that aid the non-expert user when acquiring images, performing image measurements, and for proposing an initial diagnosis. All steps in the echocardiography workflow can benefit from these tools. Challenges in image acquisition will initially be approached by developing a probe guidance system. Further focus will be placed on automatic interpretation of ultrasound images.



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.

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.

Postdocs

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.

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.

Morten Wigen (WP3)
2D and 3D echocardiography
My postdoc project topics are related to measurements of both tissue and flow properties in the heart, using 2D and 3D echocardiography. The enabling technology for both projects is high frame rate imaging, which is sensitive to rapid changes needed to capture mechanical waves traveling in the heart walls and the blood speckle movement in the ventricles. The methods used for the projects have underwent technical validation, and are currently in a phase of clinical validation. For this I'm working together with clinicians who are using software where the methods are implemented. I am also working on technological novelties related to processing of ultrasound signals to further improve our measurements, and new parameters that can be extracted from them.


Multi D
TVI
CW
4D
Color
MM
2D
Update Menu
Caliper
Image Store
Cursor
Track Ball
Angle

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
Ellen Sagaas Røed, USN
Henrik Fon, NTNU
Sindre Hellum Olaisen, NTNU

CIUS Faculty

Svend Aakhus, Professor, NTNU
Knut E Aasmundtveit, Professor, USN
Andreas Austeng, Professor, UiO
Håvard Dalen, Associate 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
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
Janne Beate Bakeng, Research Scientist, SINTEF
Geir Arne Tangen, Research Scientist, SINTEF
Sigrid Berg, Research Scientist, SINTEF
Paal Skjetne, Senior Research Scientist, SINTEF
Paul Roger Leinan, Research Scientist, SINTEF
Erik Smistad, Research Scientist, SINTEF
Jørgen Avdal, Research Scientist, SINTEF

Scientific Personnel

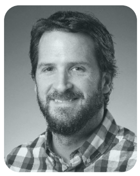
Tore Bjåstad
Scientific Programmer
The main purpose of Bjåstad's work is to accelerate the process of getting new methods and algorithms into aproduct. Primarily, the product will be a GE Vingmed ultrasound scanner intended for cardio vascular imaging. This work will typically involve further development 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.

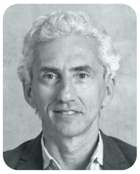
Bjørn Olav Haugen
Professor
Haugen is a professor at NTNU and consultant cardiologist at Trondheim Hjertesenter. He has been involved in ultrasound technology research since 1998, and is the leader of WP 6 and 7 in CIUS.



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.

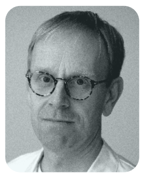


Luc Mertens
Professor
Luc Mertens is Section Head, Echocardiography at the Labatt Family Heart Centre, Hospital for Sick Children in Toronto, Canada. Dr. Mertens' research interests focus on using new echocardiographic techniques to study the heart function in children. He was recently appointed as a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

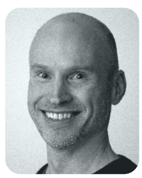
Alfonso Rodriguez Molares
Senior Engineer
Molares' fields of research are acoustics and ultrasonics. He is currently developing new beamforming techniques to improve the ultrasound imaging of acoustically hard surfaces, aiming to improve the visualization of bone tissue in ultrasound images to support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

Ole Marius Rindal
Researcher
Rindal works on beamforming for medical ultrasound imaging, more specifically on advanced beamforming techniques and metrics for evaluation of image quality improvements. Most of his work is centered around the development and maintenance of the UltraSound ToolBox (http://www.USTB.no).



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
Lead Engineer
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 2019, CIUS projects have 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.

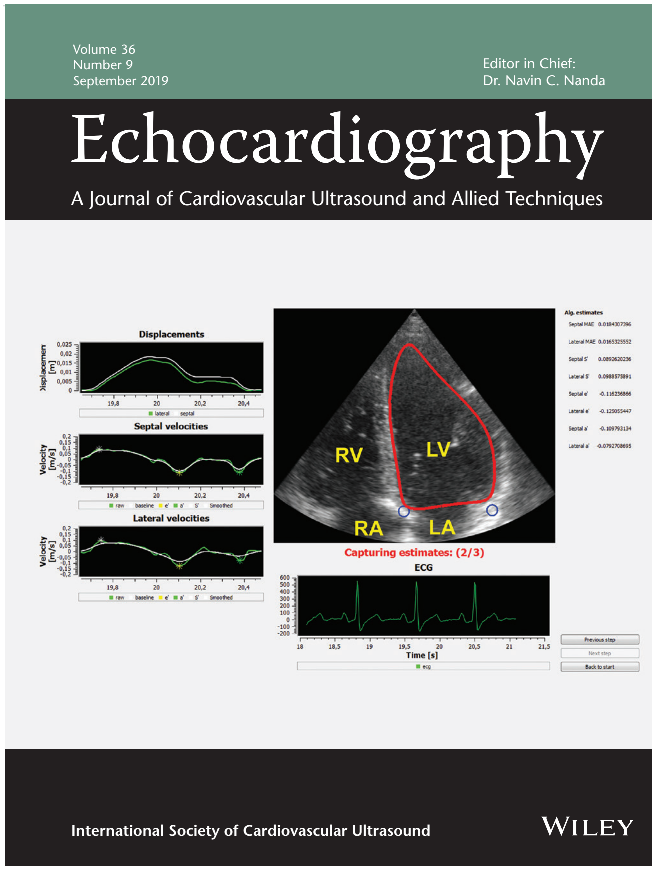
Different platforms call for different ways of communication, and one channel of information is the NTNU Medicine and Health blog. This is a well-visited site where CIUS-affiliated researchers published 16 posts in 2019. The post "DeepEcho: Machine learning for improved echocardiography" was read more than 1 500 times.

In 2019, CIUS started a new collaboration with the Norwegian research news website Forskning.no. Together, we have established the blog "Alt om Ultralyd" ("Everything about Ultrasound"), and we can publish blog post to their 1.9 million monthly readers.

In October, CIUS and the NTNU Department of Circulation and Medical Imaging challenged NRK radio host consisting of Ronny Brede Aase to present his "Soon-Weekend"-theory to a panel of our researchers. The challenge raised NOK150 000 for charity, and reached over 200 000 viewers online in addition to the live viewers and listeners.

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.

Reducing SONAR overheating	NTNU Helse
Hvordan virker hjernen	Skolebesøk
Eplefasong kan krympe hjernen	NRK
Ultralyd viser finansministeren hvorfor NTNU vil ha ny campus	Adressa
Viser ministeren hvorfor NTNU vil ha ny campus	Adressa
Ny teknologi kan hindre hjerneskade hos for tidlig fødte barn	NRK
Ultrasound can be more than you think	NTNU Helse
Meet the researcher: Ellen Katrine Sagaas Røed	NTNU Helse
God kondisjon er spesielt viktig for kvinners hjerter	Forskning.no
The road to disputation	NTNU Helse
Gjør som dronning Elisabeth – bruk hodet	Gemini.no
Her får du tipsene som holder hjernen din frisk	Dagens Næringsliv TV
Brain health for all ages	Big Challenge Science Festival
Tissue Stiffness Estimation using Ultrasound	NTNU Helse
Lydbølger som er viktig for helsa	Gemini
How can we improve cardiac diagnostics at the GP's office?	NTNU Helse
Svangerskapsforgiftning er et faresignal	Gemini
Det står bra til med trønderes hjerner	Forskning.no
The importance of treating ischemic heart disease fast!	NTNU Helse
Hvor god stendsans har du?.	NRK P1
Her er seks ulike næringer NHO har troen på for fremtidens Norge	Aftenposten
Kenneths artikkel ble «Editor's pick»	USN
Hva er normal puls?	ABC Nyheter
Verdens eneste hjerteinfarktambulanse	Agderposten
To sentre for forskningsdrevet innovasjon må legge bedre planer	Khrono
Ultralyd kan gjøre at flere overlever hjerteinfarkt	Forskning.no
Hjernens romvesen	Researchers Night
Generasjon100: Metale ferdigheter og hjernen	Folkemøte
Nyhetene vi aldri glemmer	Rbnett.no
P3-aksjonen: Ronny holder foredrag	NRK1, NRK P3, NRK.no, YouTube, Facebook
Røyking kan føre til hvite arr i hjernen	Gemini
Røyking kan føre til hvite arr i hjernen	ABC Nyheter
Får 20 millioner til hjerteforskning	Trønder-Avisa
Markering av Midt-Norges første Clinical Academic Groups	Helse Midt-Norge
Mer medisin til kreftsvulsten ved hjelp av ultralyd og mikrobobler	Forskning.no
Fører ekspertene sammen for en bedre helsetjeneste	Helse Midt-Norge
Henter 20 millioner til nyfødthjelp - Prises til rundt 40 millioner kroner	Finansavisen
Denne gjengen ligger helt i norgestoppen	Innherred
Styrker helsetjenesten med nysatsingen CAG	Helse Nord-Trøndelag



The journal Echocardiography published an article written by CIUS PhD candidate Jahn Fredrik Grue, et.al.


NRK
Logg inn
Viten

Ny teknologi kan hindre hjerneskade hos for tidlig fødte barn

Et for tidlig møte med verden kan bety stor risiko for hjerneskade. Nå håper norske forskere at et nyutviklet apparat vil kunne forebygge og hindre skadene hos de små barna.

Frida Krüger
Journalist

Publisert 14. mars 2019 kl. 10:
Oppdatert 14. mars 2019 kl. 20:19

Artikkelen er mer enn ett år gammel.

TI UKER FOR TIDLIG: Thea og tvillingsøsteren følges opp tett ved St. Olavs hospital i Trondheim.
FOTO: FRIDA J. KRÜGER / NRK

Faksimile: NRK.no 14.03.2019

Photo: Tom Øverlie/NRK P3

Industry Partner R&D Staff

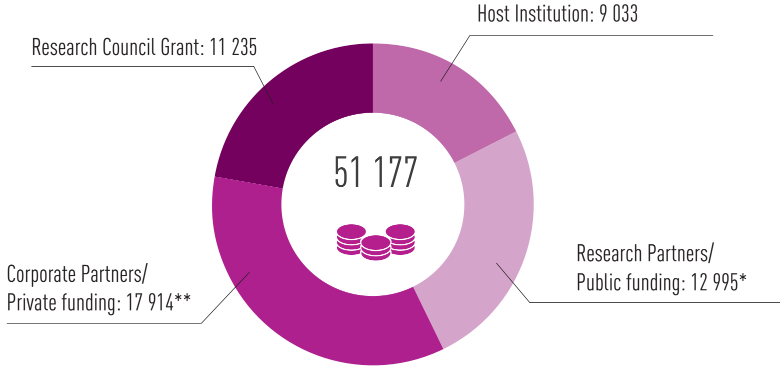
Innovation Diploma

PhD candidate Kenneth Kirkeng Andersen and collaborators working in WP1 at USN were awarded the CIUS Declaration of Innovation (DOFI) Prize for 2019 of 25 000 NOK. The prize was for the DOFI "A dual-frequency transducer utilizing the 1st and 5th harmonics of a single element transducer for the Acoustic Cluster Therapy".

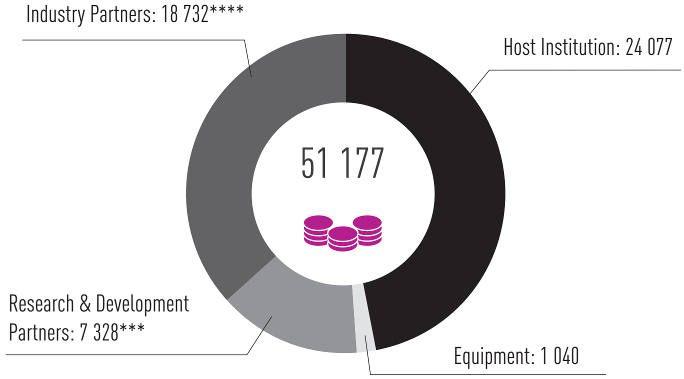
Photo: Karl Jørgen Marthinsen

Annual Accounts for 2019

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

*** SINTEF, Universitetet i Oslo, University College of South-Eastern Norway

**** 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, St. Olavs University Hospital, Helse Midt-Norge og Nord-Trøndelag Hospital

Journal Articles and Conference Proceedings - CIUS

AUTHOR/AUTHORS	TITLE	JOURNAL
Cardim N, Dalen H, Voigt JU, 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
Letnes JM, Dalen H, Vesterbekkmo EK, Wisløff U, Nes B	Peak oxygen uptake and incident coronary heart disease in a healthy population: the HUNT Fitness Study	European Heart Journal
Andersen KK, Frijlink ME, Hoff L	A Numerical Optimization Method for Transducer Transfer Functions by the Linearity of the Phase Spectrum	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Wild MS, Martin B, Hoff L, Hjelmervik KB	Comparison of Two Models for Power Dissipation and Temperature in Piezoelectric Transducers	Proceedings - IEEE Ultrasonics Symposium
Mansoori A, Hoff L, Wild MS	A FEM-based Method for Complete Parameter Identification of Thin Piezoceramic Bars	Proceedings - IEEE Ultrasonics Symposium
Huynh T, Hoff L, Eggen TH	Sources of 2nd harmonic generation in a medical ultrasound probe	Proceedings - IEEE Ultrasonics Symposium
Andersen KK, Healey AJ, Bush N, Frijlink ME, Hoff L	Design, Fabrication, and Testing of a Dual-Frequency Transducer for Acoustic Cluster Therapy Activation	Proceedings - IEEE Ultrasonics Symposium
Savioa AS, Barbara M, Manh T, Hoff L, Lanteri F, Gelly JF, Eggen TH	Design, Fabrication and Characterization of a Hybrid Piezoelectric-CMUT Dual-Frequency Ultrasonic Transducer	Proceedings - IEEE Ultrasonics Symposium
Bolstad PK, Hoff L, Torp H, Johansen TF	Design, Fabrication and Testing Highly Sensitive Single Element Doppler Transducers	Proceedings - IEEE Ultrasonics Symposium
Wild MS, Bring M, Hoff L, Hjelmervik KB	Characterization of Piezoelectric Material Parameters Through a Global Optimization Algorithm	IEEE Journal of Oceanic Engineering
Leclerc S, Smistad E, Pedrosa J, Østvik A, Cervenansky F, Espinosa F, Espeland T, Berg EAR, Jodoin PM, Grenier T, Lartizien C, D'Hooge JRM, Løvstakken L, Bernard O	Deep Learning for Segmentation using an Open Large-Scale Dataset in 2D Echocardiography	IEEE Transactions on Medical Imaging
Palmer CL, Rindal OMH	Wireless, Real-Time Plane-Wave Coherent Compounding on an iPhone: A Feasibility Study	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Holen AL, Ytterdal T	A high-voltage cascode-connected three-level pulse-generator for bio-medical ultrasound applications	IEEE International Symposium on Circuits and Systems proceedings
Andersen KK, Healey A, Bush N, Frijlink ME, Hoff L	A Harmonic Dual-Frequency Transducer for Acoustic Cluster Therapy	Ultrasound in Medicine and Biology
Rindal OMH, Austeng A, Fatemi A, Rodriguez-Molares A	The Effect of Dynamic Range Alterations in the Estimation of Contrast	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Liu X, Ytterdal T, Kachorovskii V, Shur MS	Compact Terahertz SPICE/ADS Model	IEEE Transactions on Electron Devices
Smistad E, Østvik A Pedersen A	High Performance Neural Network Inference, Streaming, and Visualization of Medical Images Using FAST	IEEE Access
Grue JF, Storve S, Støylen A, Torp H, Haugen BO, Mølmen HE, Dalen H	Normal ranges for automatic measurements of tissue Doppler indices of mitral annular motion by echocardiography. Data from the HUNT3 Study	Echocardiography
Nguyen TT, Espinoza AW, Hyler S, Remme EW, D'Hooge J, Hoff L	Estimating Regional Myocardial Contraction Using Miniature Transducers on the Epicardium	Ultrasound in Medicine and Biology
Støylen A, Hansen HEM, Dalen H	Left ventricular global strains by linear measurements in three dimensions: interrelations and relations to age, gender and body size in the HUNT Study	Open heart

AUTHOR/AUTHORS	TITLE	JOURNAL
Gopinath A, Ytterdal T, Miled ZB, Meagher R, Rizkalla M	Leakage Current and Static Power analysis of TFET 8T-SRAM Cell	Materials Today: Proceedings
Patnala M, Yadav A, Williams J, Gopinath A, Nutter B, Ytterdal T, Rizkalla M	Low power-high speed performance of 8T static RAM cell within GaN TFET, FinFET, and GNRFET technologies – A review	Solid-State Electronics
Song R, Dong H, Bao X	Numerical study of the effect of cement defects on flexural-wave logging	Geophysics
Bolstad PK, Le AD, Manh T, Hoff L	Intermetallic Bonding As an Alternative to Polymeric Adhesives in Ultrasound Transducers	Proceedings - IEEE Ultrasonics Symposium
Røed EKS, Andersen KK, Bring M, Tichy F, Aasjord EM, Hoff L	Acoustic Impedance Matching of PMN-PT/epoxy 1-3 Composites for Underwater Transducers with Usable Bandwidth Restricted by Electrical Power Factor	Proceedings - IEEE Ultrasonics Symposium
Karlsen T, Videm V, Halle M, Ellingsen Ø, Støylen A, Dalen H, Delagardelle C, Larsen AI, Hole T, Mezzani A, Craenenbrock EM, Beckers P, Pressler A, Christle JW, Winzer E, Mangner N, Woitek F, Höllriegel R, Snoer M, Feiereisen P, Valborgland T, Linke A, Prescott EIB	Baseline and Exercise Predictors of VO2peak in Systolic Heart Failure Patients: Results from SMARTEX-HF	Medicine & Science in Sports & Exercise
Rindal OMH, Rodriguez-Molares A, Måsøy SE, Bjåstad TG	Improved Lesion Detection Using Nonlocal Means Post-Processing	Proceedings - IEEE Ultrasonics Symposium
Garvik H, Wulff C, Ytterdal T	A 68 dB SNDR Compiled Noise-Shaping SAR ADC With On-Chip CDAC Calibration	Proceedings 2018 IEEE Asian Solid-State Circuits Conference
Fatemi A, Berg EAR, Rodriguez-Molares A	Studying the Origin of Reverberation Clutter in Echocardiography: In Vitro Experiments and In Vivo Demonstrations	Ultrasound in Medicine and Biology
Salles S, Løvstakken L, Aase SA, Bjåstad TG, Torp H	Clutter Filter Wave Imaging	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Karabiyik Y, Avdal J, Ekroll IK, Fiorentini S, Torp H, Løvstakken L	Data Adaptive 2-D Tracking Doppler for High-Resolution Spectral Estimation	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Fiorentini S, Espeland T, Berg EAR, Aakhus S, Torp H, Avdal J	Combining Automatic Angle Correction and 3-D Tracking Doppler for the Assessment of Aortic Stenosis Severity	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Espeland T, Berg EAR, Eriksen M, Stensæth KH	Moving ferromagnetic objects distorting cardiac magnetic resonance imaging	European Heart Journal-Cardiovascular Imaging

Journal articles and Conference Proceedings - CIUS related

AUTHOR/AUTHORS	TITLE	JOURNAL
Avdal J, Ekroll JK, Torp H	Fast Flowline Based Analysis of Ultrasound Spectral and Vector Velocity Estimators	IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
Bjørnsen LP, Naess-Pleym LE, Dale J, Grenne B, Wiseth R	Description of chest pain patients in a Norwegian emergency department	Scandinavian Cardiovascular Journal
Shigdel R, Dalen H, Sui X, Lavie CJ, Wisløff U, Ernstsen L	Cardiorespiratory Fitness and the Risk of First Acute Myocardial Infarction: The HUNT Study	Journal of the American Heart Association
Perrot V, Salles S, Vray D, Liebgott H	Video Magnification Applied in Ultrasound	IEEE Transactions on Biomedical Engineering
Karlsen RH, Einarsen CE, Moe HK, Håberg A, Vik A, Skandsen T, Eikenes L	Diffusion kurtosis imaging in mild traumatic brain injury and postconcussional syndrome	Journal of Neuroscience Research
Siddiqui SI, Dong H	Blind deconvolution based equalizer for underwater acoustic communications	Applied Acoustics
Bouget DNJM, Jørgensen A, Kiss G, Leira HO, Langø T	Semantic segmentation and detection of mediastinal lymph nodes and anatomical structures in CT data for lung cancer staging	International Journal of Computer Assisted Radiology and Surgery
Tjønnås J, Seeberg TM, Rindal OMH, Haugnes P, Sandbakk Ø	Assessment of Basic Motions and Technique Identification in Classical Cross-Country Skiing	Frontiers in Psychology
Kvam J, Holm S, Angelsen BAJ	Exploiting Ballou's rule for better tissue classification	Journal of the Acoustical Society of America
Kuttner S, Lassen ML, Øen SK, Sundset R, Beyer T, Eikenes L	Quantitative PET/MR imaging of lung cancer in the presence of artifacts in the MR-based attenuation correction maps	Acta Radiologica
Haug EB, Horn J, Markovitz AR, Fraser A, Klykken BE, Dalen H, Vatten LJ, Romundstad PR, Rich-Edwards JW, Åsvold BO	Association of Conventional Cardiovascular Risk Factors with Cardiovascular Disease after Hypertensive Disorders of Pregnancy: Analysis of the Nord-Tr?ndelag Health Study	JAMA cardiology
Karlberg AM, Berntsen EM, Johansen H, Skjulsvik AJ, Reinertsen I, Hong YD, Xiao Y, Rivaz H, Borghammer P, Solheim O, Eikenes L	18F-FACBC PET/MRI in diagnostic assessment and neurosurgery of gliomas	Clinical Nuclear Medicine
Hovem JM, Dong H	Understanding ocean acoustics by eigenray analysis	Journal of Marine Science and Engineering
Øen SK, Eikenes L, Karlberg AM	Image Quality and Detectability in Siemens Biograph PET/MRI and PET/CT Systems - A Phantom study	EJNMMI Physics
Lyngbakken M, Røsjø H, Holmen OL, Dalen H, Hveem K, Omland T	Temporal changes in cardiac troponin i are associated with risk of cardiovascular events in the general population: The Nord-Trøndelag health study	Clinical Chemistry
Vik SD, Torp H, Follestad T, Støen R, Nyrnes SA	NeoDoppler: New ultrasound technology for continous cerebral circulation monitoring in neonates	Pediatric Research
Øen SK, Kail TM, Berntsen EM, Aanerud JF, Schwarzlmüller T, Ladefoged CN, Karlberg AM, Eikenes L	Quantitative and clinical impact of MRI-based attenuation correction methods in[18F]FDG evaluation of dementia	EJNMMI Research
Chandrasekaran SN, Holm S	A multiple relaxation interpretation of the extended Biot model	Journal of the Acoustical Society of America
Cepelis A, Brumpton BM, Laugsand LE, Dalen H, Langhammer A, Janszky I, Strand LB	Asthma, asthma control and risk of acute myocardial infarction: HUNT study	European Journal of Epidemiology (EJE)
Karlsen S, Dahlsett T, Grenne B, Sjøli B, Smiseth OA, Edvardsen T, Brunvand H	Global longitudinal strain is a more reproducible measure of left ventricular function than ejection fraction regardless of echocardiographic training	Cardiovascular Ultrasound

AUTHOR/AUTHORS	TITLE	JOURNAL
Vangberg TR, Eikenes L, Håberg A	The effect of white matter hyperintensities on regional brain volumes and white matter microstructure, a population-based study in HUNT	NeuroImage
Shahini N, Ueland T, Auensen A, Michelsen A, Ludviksen JK, Hussain AI, Pettersen K, Aakhus S, Espland T, Lunde IG, Kirschfink M, Nilsson P, Mollnes TE, Gullestad L, Aukrust P, Yndestad A, Louwe MC	Increased complement factor B and BB levels are associated with mortality in patients with severe aortic stenosis	Journal of Immunology
Madan A, Joshi M, Rahmani M, Ytterdal T, Rizkalla M	High Speed High Sensitive Temperature Sensing Integrated Devices for a Wide Temperature Range Operation Using TFET Devices	International Journal of Advances in Electronics and Computer Science
Parker K, Szabo T, Holm S	Towards a consensus on rheological models for elastography in soft tissues	Physics in Medicine and Biology
Moe HK, Myhr JL, Moen KG, Håberg A, Skandsen T, Vik A	Association of cause of injury and traumatic axonal injury: a clinical MRI study of moderate and severe traumatic brain injury	Journal of Neurosurgery
Tannvik TD, Rimehaug AE, Wigen MS, Løvstakken L, Kirkeby-Garstad I	Ventriculo-arterial interaction may be assessed by Oscillatory Power Fraction	Clinical Physiology and Functional Imaging
Einarsen CE, Moen KG, Håberg A, Eikenes L, Kvistad KA, XU J, Moe HK, Tollefsen MH, Vik A, Skandsen T	Patients with Mild Traumatic Brain Injury Recruited from Both Hospital and Primary Care Settings: A Controlled Longitudinal Magnetic Resonance Imaging Study	Journal of Neurotrauma
Yemane PT, Åslund A, Snipstad S, Bjørkøy A, Grendstad K, Berg S, Mørch YA, Torp SH, Hansen R, Davies CL	Effect of ultrasound on the vasculature and extravasation of nanoscale particles imaged in real time	Ultrasound in Medicine and Biology
Sulheim E, Mørch Y, Snipstad S, Borgos SE, Miletic H, Bjerkvig R, Davies CL, Åslund AKO	Therapeutic Effect of Cabazitaxel and Blood-Brain Barrier opening in a Patient-Derived Glioblastoma Model	Nanotheranostics
Zadeh SH, Ytterdal T, Aunet S	Ultra Low Voltage Subthreshold Binary Adder Architectures for IoT Applications: Ripple Carry Adder or Kogge Stone Adder	2019 IEEE Nordic Circuits and Systems Conference (NORCAS): NORCHIP and International Symposium of System-on-Chip (SoC)
Zadeh SH, Ytterdal T, Aunet S	Exploring optimal back bias voltages for ultra low voltage CMOS digital Circuits in 22 nm FDSOI Technology	2019 IEEE Nordic Circuits and Systems Conference (NORCAS): NORCHIP and International Symposium of System-on-Chip (SoC)
Skandsen T, Nilsen TIL, Einarsen CE, Normann I, McDonagh D, Håberg A, Vik A	Incidence of mild traumatic brain injury: A prospective hospital, emergency room and general practitioner-based study	Frontiers in Neurology
Tennøe AH, Murbræch K, Andreassen JC, Fretheim H, Midtvedt Ø, Garen T, Dalen H, Gude E, Andreassen A, Aakhus S, Molberg Ø, Hoffmann- Vold A	Systolic Dysfunction in Systemic Sclerosis: Prevalence and Prognostic Implications	ACR Open Rheumatology
Smenes B, Flade HM, Kudra S, Heigert M, Winnerkvist A, Grenne B	En tungpustet mann i 50-årene med sirkulatorisk kollaps ved narkose	Tidsskriftet Den norske legeforening
Espeland T	Peroral eller intravenøs antibiotika ved endokarditt?	Tidsskriftet Den norske legeforening

Presentations - CIUS

AUTHOR/AUTHORS	TITLE	LOCATION
Pham HA, Berg EAR, Veronesi F, Fiorentino S, Fatemi A, Grenne B, Gerard O, Kiss G	Fast Ultrasound to Ultrasound Auto-Registration for Interventional Cardiology	The 2019 IEEE International Ultrasonics Symposium
Talberg AS, Dong H, Johansen TF, Måsøy SE	Ultrasonic focusing through a steel layer	Scandinavian Symposium on Physical Acoustics 2019
Dalen H	Håndholdt ultralyd i allmennpraksis	Fagmøte for allmennlege
Dalen H	Flow patterns in different mitral lesions	Cardiac Imaging Day
Dalen H	Kontrastforsterket ultralyd	NFUD 2019
Mjølstad OC	Ultralyd på fastlegelegekontoret	Oppdalsuka
Garvik H, Wulff C, Ytterdal T	A 68 dB SNDR Compiled Noise-Shaping SAR ADC With On-Chip CDAC Calibration	2019 IEEE Asian Solid-State Circuits Conference
Fadnes S	Vector flow imaging in the neonatal heart	Artimino 2019 - Ultrasound conference on tissue motion and blood velocity imaging
Hjort-Hansen A, Magelssen MI, Andersen GN, Graven T, Kleinau O, Skjetne K, Mjølstad OC, Dalen H	Feasibility and accuracy of real-time automatic quantification of left ventricular ejection fraction by hand-held ultrasound device	Norsk Cardiologisk Selskaps Høstmøte 2019
Salles S, Løvstakken L, Espeland T, Wigen MS, Fadnes S, Støylen A, Torp H	3D mechanical wave trajectory mapping in the left ventricle using Clutter Filter Wave Imaging	2019 IEEE International Ultrasonics Symposium
Grønli T, Lainan PR, Wigen MS, Skjetne P, Dahl SK, Løvstakken L	In vitro validation of ultrasound VFI regularization through rapid data assimilation	2019 IEEE International Ultrasonics Symposium
Wigen MS, Daae AS, Grønli T, Støylen A, Løvstakken L	A single recording for quantitative echocardiography - Simultaneous tissue and flow measurements	Myocardial function imaging
Dalen H	Left-ventricular non-compaction - Cryptic cardiomyopathy	European Association of Cardiovascular Imaging
Magelssen MI, Palmer CL, Hjort-Hansen A, Nilsen HO, Kiss G, Torp H, Mjølstad OC, Dalen H	The feasibility and reliability of automatic quantitative analyses of mitral annular plane systolic excursion by hand-held ultrasound devices	Norsk Cardiologisk Selskaps Høstmøte 2019
Leclerc S, Smistad E, Grenier T, Laritzien C, Østvik A, Cervenansky F, Espinosa F, Espeland T, Berg EAR, Jodion PM, Løvstakken L, Bernard O	RU-Net: A Refining Segmentation Network for 2D Echocardiography	IEEE International Ultrasonics Symposium (IUS)
Torp H, Løvstakken L	Super- resolution power-Doppler imaging	IEEE International Ultrasonic Symposium
Løvstakken L, Østvik A, Smistad E	Deep learning for automated anatomical and deformation measurements in echocardiography	Leuven Meeting on Myocardial Function Imaging
Løvstakken L, Østvik A, Smistad E	Deep learning for automated anatomical and deformation measurements in echocardiography	Annual congress of the Belgian working group on non-invasive cardiac imaging
Løvstakken L, Østvik A, Smistad E	Machine learning for improved echocardiography	The Artimino Conference on Medical Ultrasound Technology
Lecrec S, Smistad E, Østvik A, Cervenansky F, Espinosa F, Espeland T, Berg EAR, Jodoin PM, Grenier T, Lartizien C, Løvstakken L, Bernard O	Deep Learning Segmentation in 2D echocardiography using the CAMUS dataset : Automatic Assessment of the Anatomical Shape Validity	International Conference on Medical Imaging with Deep Learning
Haukom T, Berg EAR, Aakhus S, Kiss G	Basal Strain Estimation in Transesophageal Echocardiography (TEE) using Deep Learning based Unsupervised Deformable Image Registration	IEEE IUS Ultrasonics Symposium

AUTHOR/AUTHORS	TITLE	LOCATION
Nordal T, Berg EAR, Aakhus S, Kiss G	Automated detection of Mitral Annular Plane Systolic Excursion (MAPSE) in transoesophageal echocardiography based on deep learning	EuroEcho
Holen AL, Ytterdal T	A High-Voltage Cascode-Connected Three-Level Pulse-Generator for Bio-Medical Ultrasound Applications	2019 IEEE International Symposium on Circuits and Systems
Mjølstad OC	Moderne kardiologi	Eldre Legers Forening - landskonferanse
Mjølstad OC	CRT- når er nok nok?	Kardiologisk høstmøte
Hjort-Hansen A	Implementering av ultralyd i primærhelsetjenesten	VälTels framtidskonferanse
Dalen H	Håndholdt ultralyd i klinisk praksis på sykehus	NFUD 2019
Løvstakken L, Østvik A, Smistad E	Kunstig intelligens for en mer effektiv og treffsikker ekkokardiografi	Kardiologisk høstmøte
Smistad E, Salte IM, Østvik A, Leclerc S, Bernard O, Løvstakken L	Segmentation of apical long axis, four- and two-chamber views using deep neural networks	IEEE International Ultrasonics Symposium (IUS)
Smistad E	Maskinlæring og kunstig intelligens i medisinsk bildeanalyse	Årsmøte den norske patologforening
Smistad E	Kunstig intelligens i medisinsk bildediagnostikk - muligheter og utfordringer	HEMIT konferansen 2019
Fatemi A, Rodriguez-Molares A	Increased Clutter Noise in Echocardiography Due to Specular Reflection at the Ribs	41st Scandinavian Symposium on Physical Acoustics
Smistad E	Machine learning and artificial intelligence in medical imaging	NTNU IKOM
Viggen EM, Måsøy SE	An introduction to Equinor's well logs — and what we can do with them	42nd Scandinavian Symposium on Physical Acoustics
Østvik A, Bø LE, Smistad E	EchoBot: An open-source robotic ultrasound system	IPCAI 2019
Måsøy SE	What causes reduced image quality in echocardiography - what we now know	42nd Scandinavian Symposium on Physical Acoustics
Østvik A,Smistad E, Løvstakken L	Machine learning in Echocardiography	Cardiac Imaging Day
Smistad E	Machine learning in medical imaging	Hadean ventures investor event
Smistad E	Machine learning in medical imaging	SINTEF Digital Kick off

Presentations - CIUS realated

AUTHOR/AUTHORS	TITLE	LOCATION
Snipstad S	Nanomedisin and ultralyd for målrettet behandling av kreft og hjernesykdommer	TEDxTrondheim ConnecTED
Dalen H	Nye spesialistregler i kardiologi -konsekvenser	Kardiologisk vårmøte
Wu G, Dong H, Ke G, Song J	Processing Ocean Ambient Nosie to Obtain Reliable Interface Wave Dispersion Measurements	FACA 2018
Godin OA, Dong H	Characterization of Soft Marine Sediments Using Vector Sensors	Annual meeting of Acoustical Society of America
Øen SK, Eikenes L, Keil T, Karlberg A	Evaluation of attenuation correction methods in PET/MRI Brian Imaging	MedFys
Sirevaag TL, Johansen TF, Larsen I, Holt RM	LABORATORY SETUP FOR IMPROVED LOGGING BEHIND CASING	SPWLA 59th Annual Symposium
Vvan Wamel A, Åslund A, Sontum P, Prentice P, Healey A, Snipstad S, Mühlenpfordt m, Kvåle S, Bush N, Bamber J, Davies CD	Acoustic Cluster Therapy: Microdroplets boost microbubbles enhanced drug delivery	23rd European Symposium on Ultrasound Contrast Imaging
Gederaas OA, Johnsson ACG, Berg K, Manandhar R, Shrestha C, Skåre D, Ekroll IK, Høgset A, Hjelde A	Photochemical Internalization (PCI) - Bladder Cancer	World Concer Action (WCA-2019)
Gederaas OA, Johnsson A, Berg K, Manandhar R, Shrestha C, Skåre D, Ekroll IK, Høset A, Hjelde A	Effects of Photochemical Internalization (PCI) - Bladder Cancer, in vitro and in vivo	World Congress on Functional Materials and Nanotechnology (WCFMN)
Kiss G, Ichino T, Myhre HO, Skogås JG	Early experience with 3D and 4K imaging for minimally invasive neurosurgery	The 23rd World Multi-Conference on Systemics, Cybernetics and Informatics
Snipstad S	Nanomedicine and sonopermeation for treatment of cancer and brain disease	Norwegian NanoSymposium 2019
Snipstad S, Yemane PT, Åslund A, Bjørkøy A, Grendstad K, Berg S, Mørch YA, Torp SH, Hansen R, Davies CD	Effect of ultrasound on the vasculature and extravasation of nanoscale particles imaged in real time	OxCD3 Oncological Drug Delivery Conference
Blachet A, Plets R, Sacchetti F, Austeng A, Hunter AJ, Hansen RE	MBES DATA SIMULATION: ASSESSMENT BY DIRECT COMPARISON WITH A HIGH-RESOLUTION MULTI-SETTINGS WRECK SURVEY	UACE Conference 2019
Snipstad S	Nanomedisin og sonopermeering for målrettet behandling av kreft og hjernesykdommer	Norwegian NanoSymposium 2019
Snipstad S	Nanomedisin og sonopermeering for målrettet behandling av kreft og hjernesykdommer	Norsk overlegeforenings Vårkurs

Posters - CIUS

AUTHOR/AUTHORS	TITLE	LOCATION
Hjort-Hansen A, Magelssen MI, Graven T, Andersen GN, Kleinau JO, Skjetne K, Mjølstad OC, Dalen H	Feasibility and accuracy of real-time automatic quantification of left ventricular ejection fraction by hand-held ultrasound device	EuroEcho 2019
Langlo KAR, Lundgren KM, Cittanti E, Ellingsen Ø, Aksetøy ILA, Hallan S, Dalen H	The association of diastolic dysfunction with chronic kidney disease in patients with heart failure	Kidney Week
Langlo KAR, Lundgren KM, Cittanti E, Ellingsen Ø, Aksetøy ILA, Hallan S, Dalen H	Peak Oxygen Consumption (VO2peak) is reduced at all levels of Chronic Kidney Disease (CKD) in Chronic Heart Failure (CHF)	Kidney Week
Østvik A, Salte IM, Smistad E, Løvstakken L	Adapting deep learning based motion estimation for myocardial function imaging	IEEE International Ultrasonics Symposium (IUS)
Fiorentini S, Ekroll IK, Torp H, Avdal J	Flowline tracking Doppler	2019 IEEE International Ultrasonics Symposium (IUS)
Daae AS, Støylen A, Løvstakken L, Wigen M	Initial diastolic vortex formation in the left ventricle relates to the atrioventricular plane motion of the outflow tract	Euro Echo 2018
Østvik A, Bø LE, Smistad E	EchoBot: An open-source robotic ultrasound system	IPCAI 2019

Posters - CIUS related

AUTHOR/AUTHORS	TITLE	LOCATION
Saxhaug LM, Hjort-Hanssen A, Hildrum H, Holm KI, Ellekjkær H, Stølen S, Skjetne K, Kleinau O, Graven T, Dalen H	Feasibility, accuracy and clinical influence of pocket-sized imaging of the carotid arteries performed by non-experts in patients with ischemic stroke or transitory ischemic attack	ESC Congress 2018
Sulheim E, Kim J, Van Wamel A, Kim E, Snipstad S, Vidic I, Grimstad I, Widerøe M, Torp SH, Lundgren S, Waxman DJ, Davies CL	Multi-modal characterization of vasculature and nanoparticle accumulation in five tumor xenograft models	Controlled release society meeting
Bush N, Healey A, Shah A, Box G, Eccles S, Kvåle S, van Wamel A, Favies CD, Sontum PC, Bamber J	Ultrasound, optical and photoacoustic imaging of Acoustic Cluster Therapy enhanced delivery to human tumor in mice	IEEE International Ultrasonic Symposium
Bush N, Healey A, Shah A, Box G, Kirkin V, Kotopoulis S, Kvåle S, van Wammel A, Davies CL, Sontum PC, Bamber J	Acoustic Cluster Therapy displays theranostic capability in enhancing the effectiveness of liposomal doxorubicin treatment of human triple negative breast cancer in mice	IEEE International Ultrasonic Symposium

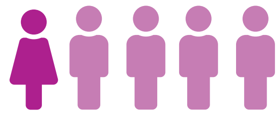
Books - CIUS

AUTHOR/AUTHORS	TITLE	PUBLISHER
Holm S	Waves with Power-Law Attenuation	Springer Nature
Dalen H, Forfang K, Haugaa K, Istad H, Wiseth R (Red.)	Kardiologi - Klinisk veileder, 3.edition	Gyldendal Akademisk
Viggen EM, Hoff L (red.)	Proceedings of the 42nd Scandinavian Symposium on Physical Acoustics	Norsk Fysisk Selskap

Degrees 2019

MASTER THESES

PHD THESES



MASTER STUDENTS OBTAINING THEIR DEGREE IN 2019 ON A CIUS TOPIC AND SUPERVISER		
Shankkar Balasubramanian	Behavioral Modelling and Design of Noise Shaping SAR ADC in 22nm FDSOI	T Ytterdal
Simon Kristoffer Relling Berg	A Chopper Offset-Stabilized Operational Amplifier in 22nm FD-SOI	T Ytterdal
Astri Mikalsen	Sensitivity of Transducer for Medical Ultrasound - Models and measurements	L Hoff
Md Ebne Al Ashad	Manufacturing and Characterization of acoustic matching layers for ultrasound transducers	L Hoff
Anders Hagen Jarmund	Cerebral Hemodynamics in Normal Neonates During Tilt	R Dias
Thanh Quyen Nguyen	A lumped parameters model for cerebral blood flow in neonates and infants with patent ductus arteriosus	H Torp
Adrian Meidell Fiorito	Age Estimation from B-mode Echocardiography with 3D Convolutional Neural Networks	L Løvstakken
Marianne Elise Lia	The impact of tumor associate macrophages in delivery of nanoparticles to tumor cells	C Davies
Karoline Bråten	Nanoparticle-stabilized microbubbles and focused ultrasound for targeted drug delivery to tumours: Characterization in the chicken chorioallantoic membrane model	C Davies
Stig-Martin Liavåg	Modeling nanoparticle transport in tumors with a pore network model	C Davies
Torjus Haukom	Basal Strain Estimation in Transesophageal Echocardiography using Unsupervised Deep Learning	G Kiss
Trym Nordal	Automatic Detection of Mitral Annular Plane Systolic Excursion from Transesophageal Echocardiography Using Deep Learning	L Løvstakken
Anders Johannessen	Affine Alignment of Ultrasound Volumes Using Deep Learning	G Kiss
Andreas Tesaker	Directive under-water transducer design for Doppler velocity log	H Dong

PHD CANDIDATES 2019 - CIUS FIANCED	
Marcus S. Wild, USN	Heat generation in underwater transducers, Supervisor: L Hoff

PHD CANDIDATES 2019 - CIUS RELATED	
Einar Sulheim, NTNU	Nanomedicine and sonopermeation in the treatment of cancer, Supervisor: C Davies
Anna Karlberg, NTNU	PET/MRI: Performance Characteristics and Diagnostic Assessment in Cerebral Gliomas, Supervisor: L Eikenes
Ole Marius Hoel Rindal, UiO	Software Beamforming in Medical Ultrasound Imaging - a blessing and a curse, Supervisor: A Austeng
Morten Wigen, NTNU	4D ultrasound vector flow imaging for intraventricular flow assessment, Supervisor: L Løvstakken

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