Annual report 2018

Operating Room of the Future
The Operating Room of the Future (FOR), a research infrastructure that facilitates research and development within the surgical disciplines, with emphasis on minimally invasive image-guided patient care and medical technology.

The infrastructure currently consists of 6 operating rooms at St. Olav's hospital; one in each of the operating clinics. The operating rooms are built to develop, test and apply new technology, new treatment methods and testing. Here, new prototypes can be developed and tested in safe and controlled environments. The infrastructure is approved for carrying out experimental surgery and has the necessary approvals and expertise. Significant and important research equipment has been added to the infrastructure over the years, under the auspices of NorMIT - Norwegian Center for Minimally Invasive Image Guided Therapy and Medical Technologies - a collaboration between FOR and the Intervention Center at Oslo University Hospital (OUS). The overall infrastructure will contribute to increased clinical and technological research, which in turn improves patient treatment nationally and internationally.

FOR is taking part in several research projects and many of them, but not all, are led by FOR. In the present annual report we have included some projects where FOR and its staff has represented a prerequisite for the completion of the project.

The Operating Room of the Future is a collaboration between St. Olav's hospital HF, University Hospital of Trondheim and the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. FOR is an interdisciplinary arena for clinical research and for the development of medical technology.

FOR is set up to promote a close collaboration between clinicians, technologists, researchers and industrial partners who play a role in the development and innovation of the health care sector. This collaboration is reflected in the present annual report.

The principal activity at FOR is research to provide safer and better treatment, more efficient logistics and flexible architecture in the construction of new operating rooms. FOR has also become a center of competence for the construction of operating rooms outside St. Olav's hospital.

The FOR concept demonstrates synergy effects in letting representatives from various disciplines and medical specialists use equipment, areas and competence together.

Minimally invasive image guided treatment is an important research field at FOR. The scientific advisory board at FOR is going through all projects to ensure that a good quality of the research is obtained. FOR has excellent facilities for research projects based on a multidisciplinary approach. Investigations are performed by PhD-candidates, as well as students on a bachelor and master level. In addition FOR is running its own innovation- and research projects.

The tasks of the University Hospital is defined in the specialist health care act and include treatment of patients, teaching of patients and their relatives as well as teaching of health care personnel. Trondheim has a particular responsibility for research within the field of medical technology.

Lecturing in the application of electro-medical equipment has become an important task for FOR.

On behalf of the clinics FOR is organising courses and certification in the use of electro medical equipment. These courses are compulsory for all doctors in the FOR clinics and they are arranged via the so called “Portal of competence” at St. Olavs hospital. Patient safety is an important part of the FOR activity and so is the work to reduce the incidence of hospital infections.

We want to thank all our collaborators for their contributions at FOR and NorMIT.

And we hope that you will enjoy our annual report of 2018!
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St. Olavs hospital HF

St. Olavs hospital HF, University Hospital of Trondheim, is integrated with NTNU, Norwegian University of Science and Technology, and is owned by Central-Norway Regional Health Authorities RHF. Treatment of patients, teaching of patients and their relatives as well as research and teaching of health care personnel, are the main tasks of the hospital as defined in the specialist health care act. The hospital covers psychiatry as well as somatic health care.

St. Olavs hospital is running centers several places in Trøndelag county. In addition to the institutions in the center of Trondheim, hospital activity is taking place at:

- Orkdal Hospital
- Røros Hospital, Røros
- Departments of psychiatry at Østmarka and Brøset in Trondheim
- Three district centers for psychiatry; Orkdal DPS in Orkdal, Nidaros DPS and Tiller DPS in Trondheim
- Several psychiatry outpatient clinics for children and young patients in Trøndelag
- Department of psychiatry for children and youth at Lian
- Habilitation unit for adult patients at Brøset, Trondheim
- Several outpatient clinics for psychiatry in southern part of Trondheim

St. Olavs hospital is the university clinic of Central Norway for a population of 729,717 inhabitants, and local hospital for a population of 321,511 per 31.12.18.

Through excellent cooperation with the local authorities and the primary health care, we aim at optimal patient care in the hospital as well as the primary health care. Excellent cooperation with the primary health care has led to the establishment of district medical centers at Fosen and Værnes. In the Trondheim region such centers have been established at Øya health center and at Søbstad health center.

Our core values are integrity, equality, respect and co-determination, forming the background for our clinical activity and our students, colleagues and collaborators. St. Olavs hospital is integrated with the Norwegian University of Science and Technology, NTNU, and students, teachers and scientists are representing natural parts of the hospitals’ activity. Within teaching and research we are collaborating closely with several other institutions in central Norway.

In addition to the scientific activity, the University Hospital is responsible for the training of medical students and other health care professionals. It is also responsible for the training of medical specialists in central Norway.

In 2018 we had:

- 10,419 employees
- 43 operating rooms at St. Olavs hospital, Trondheim. In addition 5 operating rooms at Orkdal Hospital and 2 operating rooms at Røros hospital
- A total of 449,243 somatic outpatient consultations
- 746 beds (somatic)
Operating Room of the Future - a health catapult for the future

The health care sector and the demand for health care service is steadily increasing. Digitalisation is playing an important role also within health care, and “big data” is giving the possibility for every citizen to have their own “data-twin” and demanding individually tailored medical treatment. The demand and pressure from the patients regarding application of new pharmacological agents and new technology in our health care is increasing, even when Norway is supposed to have a health care service among the best in the world. In the near future we will need more hands in within the health care service to relieve today’s personnel and to teach the patients to help themselves to a greater extent. There is need for more knowledge and new solutions to make the health care service more expedient, smarter and better.

It is also our aim to promote a health care industry in Norway. This is a political goal which will be emphasized in a white paper from the Norwegian Parliament. We need more work-places and more productive labour in Norway and at the same time we have visions about a better health care service.

To fulfil those goals, we have to rely on some Norwegian advantages: We have a population which is easily adapted to new technology. We have a strong and well established public health care sector and finally we have authorities who are supporting development and digitalisation of public service in general. We have excellent data on our health care and good clinical registers and biobanks as well as strong academic and professional traditions which can support the development of new technology and new methods, and we also have strong traditions within health services research. We furthermore have a culture for cooperation between the various professions promoting a multidisciplinary approach to challenges addressed by piloting arenas like Operating Room of the Future.

There is great potential for innovation through collaboration between health professions, clinical medicine and the technologists, but also between scientists, clinicians and industry. FOR is important as an arena to bring forward this innovation potential and is a safe infrastructure where scientists, industry and health care workers together can develop and test new solutions based on the needs of the health care sector. Therefore, FOR has become a national infrastructure for research and innovation through the establishment of NorMIT (Norwegian center for Minimally invasive Image guided Therapy and medical technologies). In Norway we have extensive research generating new and important knowledge and competence which should be transferred into innovation projects. Through close collaboration with NTNU within “The integrated university hospital”, Operating Room of the Future is representing a unique “health catapult” for cooperation between various professional groups for the development of new competence and for translating knowledge from research into practical solutions. This is the core in the work to develop a Norwegian health care industry and to improve the health care service.

Toril Nagelhus Hernes
Pro-rector for innovation, NTNU
Professor of medical technology
Photo: NTNU
Operating Rooms of the Future

Since its inception in 2005, the Operation Room of the Future has contributed to characterizing St. Olav’s hospital and the Faculty of Medicine and Health Sciences at NTNU. FOR is a gateway to developing and testing new technological solutions in the treatment of patients and in the training of health professionals. The work in FOR has contributed greatly to better and more simple surgical treatment in the hospital, but also to other services such as distance treatment where the patient cannot or should come to the hospital for treatment.

Together with researchers, innovators and industry; high resolution visualization, holograms, robotics, artificial intelligence, and 3D printing has been adapted.

An important strength of FOR is the ability to tie together advanced medical environment at St. Olav’s hospital with NTNU, SINTEF, the Innovation Center at OUS and commercial industrial partners. This collaboration is national, as centers in Bergen and Tromsø are included in a national infrastructure.

It is a political desire to develop business activities in connection with the hospitals. For St. Olav’s hospital and the Faculty of Medicine and Health Sciences, FOR is a key instrument for establishing such business activities.

Many have contributed to the development of FOR over the years, but I would especially like to thank Professor Emeritus Hans Olav Myhre and Managing Director at FOR Jan Gunnar Skogås for a long-standing effort to build FOR.

Gunnar Morken
Director of Research, Innovation and Education
St. Olav’s hospital and
Faculty of Medicine and Health Sciences, NTNU
Photo: St. Olav’s hospital
A DRIVING FORCE FOR BETTER HEALTH AND HEALTH SERVICES

The Operating Room of the Future (FOR) is an important driving force for innovation in the integrated university hospital. In 2018, the Faculty of Medicine and Health Sciences established the innovation arena NTNU DRIV (https://www.ntnu.no/mh/innovasjon/ntnudriv), an infrastructure to promote innovation in health and health services.

The aim is to give:

• Students access to relevant health challenges, a network for innovation in their disciplines, as well as technical assistance and equipment.
• Employees and collaborating partners easier access to students as a resource in innovation projects.
• Business and the working world clearer contact within the organization to increase collaboration.

The arena aims to promote closer contact between students, researchers, employees in and users of health services, as well as the business community and the working world in general. Enthusiastic, knowledgeable students from different fields of study get a grip on tasks and develop solutions to meet the needs and challenges of health services. At the same time, they develop skills in innovation, an important basis for their role as future change agents in the workplace.

The Operating Room of the Future has been a constructive contributor to increased student innovation by working together with the innovation arena and the student organization DRIV NTNU (https://www.facebook.com/drivntnu) to organize the “Health-Tech Challenge”. Last year’s winning interdisciplinary student team proposed a solution to detect leaks after stent graft insertion for abdominal aortic aneurysms. It is gratifying to hear that teamwork for this event had another positive result: a student in the medical student research programme and two master’s students are now working on their thesis projects at FOR.

The Faculty encourages others to work together with the innovation arena NTNU DRIV on events or to report ideas, needs and challenges. NTNU DRIV will also open the way for innovation projects through initiatives such as innovation camps, bachelor’s and master’s theses, as well as theses for research training programmes and graduate theses.

NTNU DRIV is in dialogue with fields of study such as medicine, nursing, radiography, medical laboratory technology and computer engineering, as well as the master’s programme in global health, to explore how the innovation arena could benefit the programmes of study. Here, the innovation arena is also working together with the Centre of Excellence in Higher Education (SFU) ENGage (https://www.ntnu.edu/engage), which aims to educate students to face complex challenges in society through entrepreneurship. This initiative fits in well with the Norwegian Government’s ongoing project to develop guidelines for health and social care education (RETHOS) (https://www.regjeringen.no/no/tema/utdanning/hoyere-utdanning/utvikling-av-nasjonale-retningslinjer-for-hele--og-sosialfagutdanningene/id2569499/). The guidelines form part of a new governance system aimed at increasing the influence of the programmes of study, services and users on the programme content. The guidelines have been designed in line with the competence needs of services and users. According to the national regulations for a common curriculum for health and social care education, graduates should achieve the following learning outcome: “be familiar with new thinking and innovative techniques and be able to contribute to innovative practice systematic and quality-enhancing work procedures.”

This collaboration in innovation and entrepreneurship in health education is important and more people are invited to participate in this work.

NTNU DRIV is looking forward to further cooperation with Operating Room of the Future. It is especially interesting that a lab for 3D printing is now also being established at FOR. Exchange of knowledge in this area will be valuable. NTNU DRIV is also located together with the research and prototyping laboratory TrollLABs Medical, an important contributor with a great deal of experience in product development. In addition, a collaboration agreement on innovation is now being drawn up between NTNU’s Faculty of Medicine and Health Sciences and the Central Norway Regional Health Authority. It will also be interesting to follow the development of Government’s Report to the Storting on innovation in the public sector (https://www.offentliginnovasjon.no/) which was launched in 2018 with the aim of developing a national policy for innovation throughout the public sector.

We look forward to continuing our valuable cooperation with many more student projects in the coming years as well.

We are DRIVing innovation!

Bjørn I. Gustafsson, Dean of the Faculty of Medicine and Health Sciences, NTNU

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We are DRIVing innovation!

Bjørn Gustafsson, Dean, Professor
Faculty of Medicine and Health Science
NTNU
Photo: NTNU
Organization of Operating Room of the Future

St. Olavs hospital, Trondheim University hospital
Norwegian University of Science and Technology (NTNU)

Board
Gunnar Morken, Reasearch Director, St. Olavs hospital
Øystein Risa, Head of Institute of Circulation and Medical Imaging
Faculty of Medicine, NTNU

TestBed Facility
Innovation advisor
3D print LAB
Unimed Innovation AS

The FOR-infrastructure
Jan Gunnar Skogli
Managing Director
Ivar Rossvoll
Scientific Adviser

Research coordinators

FOR Neuro-surgery
FOR ENT, Ear, Oral surgery
FOR Gastro-intestinal
FOR Vascular
FOR Orthopedic Surgery
FOR Gynecology

Operating Room of the Future (FOR)

Overview of the FOR research infrastructure
Staff

Hans Olav Myhre
Emeritus Professor of surgery

Jan Gunnar Skogås
Head of department
Managing director

Ivar Rossvoll
Assistant professor
Leader Scientific Advisory Board

Ronald Márvik
Assistant professor
Consultant surgeon at
Department of Gastrointestinal surgery

Marianne Haugvold
Adviser R&D
Cand. Scient.

Liv-Inger Stenstad
R&D coordinator
Radiographer
MSc, Clinical research

Geir Andre Pedersen
Project coordinator
NorMIT
Assistant professor
MSc Biomedicine

Gabriel Kiss
Engineer / Scientist
NorMIT coordinator

Jan Magne Gjerde
R&D coordinator
Engineer

Vigdis Schnell Husby
R&D coordinator
Associate professor

Frode Manstad-Hulaas
Assistant professor
Consultant surgeon
Intervention radiologist

Alexander Moen
Innovation developer

Jan Gunnar Skogås
Head of department
Managing director

Ivar Rossvoll
Assistant professor
Leader Scientific Advisory Board

Ronald Márvik
Assistant professor
Consultant surgeon at
Department of Gastrointestinal surgery

Marianne Haugvold
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Cand. Scient.

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MSc Biomedicine

Gabriel Kiss
Engineer / Scientist
NorMIT coordinator

Jan Magne Gjerde
R&D coordinator
Engineer

Vigdis Schnell Husby
R&D coordinator
Associate professor

Frode Manstad-Hulaas
Assistant professor
Consultant surgeon
Intervention radiologist

Alexander Moen
Innovation developer

Photo: St. Olavs hospital
An important task for the Operating Room of the Future (FOR) is to improve the quality and quantity of clinical research. Therefore the scientific advisory board is going through all research protocols, giving advice to those who are doing projects under the direction of FOR. FOR has special guidelines for projects, including the tasks of the scientific advisory board as well as a description how to make research protocols (Professor Per Farup). These documents are forming the basis for the collaboration between FOR and those who are conducting research projects there. In addition we are making separate agreements between FOR and the project leaders. The scientific advisory board has assisted in the period with the work and protocols Scientist with relationship to FOR. FOR additionally contributes a great deal to students for the research line at The faculty of Medicine (NTNU), an offer for medical students who are interested in research and a possible future research career possibly parallel to clinical activities.

The scientific advisory board has the following members:
Assistant professor Ivar Rossvoll (leader)
Emeritus professor Hans Olav Myhre
Professor Per Farup
Professor Olav Haraldseth
Professor Ståle Nordgård
Assistant professor Frode Manstad-Hulaas
Assistant professor Knut Haakon Stensæth
Research director Thomas Langø
Highlights of 2018

New appointments

Jan-Magne Gjerde
3D printing is coming – new employee at FOR
3D printing is a technology in growth within healthcare. The ability to create complex physical models, manufactured locally with short lead times, offers many new opportunities. Using patient specific anatomical models for visual support and surgical planning is just one example of how this technology can improve the treatment of complex cases. Patient adapted instruments and implants can also be manufactured in a cost efficient way with 3D-printing. Bio-printing (3D-printing with living cells) may hold the potential to change medical treatment radically in the future.

FOR NorMIT would like to establish a 3D – print lab at St Olavs Hospital. This lab will give surgeons at St Olavs hospital the opportunity to utilize the potential of this technology at its current state, but also to contribute in the development of new applications for 3D printing. Presentation of the new lab, and analysis of the hospitals needs for such a lab, has already started. This work is lead by Jan-Magne Gjerde who is newly appointed at FOR.

Jan-Magne has a master of mechanical engineering from the Department of Machine Design and Materials Properties at NTNU. He has 16 years’ experience from the medical device industry, specifically with development and production of CT-based patient matched instruments and implants. He has a strong passion for advanced 3D modelling and 3D printing, and how these technologies can improve patient care and simplify the work for the surgeons.

All departments that can benefit from 3D printing will be visited for a presentation of this new service. If you have questions about 3D printing, or you find yourself in need of a 3D modelling, do not hesitate to contact Jan-Magne.

Vigdis Schnell Husby was appointed at the Operations Room of the Future in 2018. She will work as research coordinator and researcher at FOR.

Vigdis is a operating nurse and has a PhD in clinical medicine. Research areas are training and special training after hip and knee replacement surgery. Vigdis has worked at NTNU for the last 12 years within bachelor’s degree in disability nurse education and nursing, and is now working with education in operating nursing.
Geir Andre Pedersen - Master’s degree

Geir Andre Pedersen at the Operating Room of the Future graduated with a Master’s degree in Biomedicine at OsloMet 15.12.18 and celebrated properly with cake and a lecture for his colleagues. Photo: FOR

Our good colleague at Operating Room of the Future, Geir Andre Pedersen, graduated from OsloMet 15th December 2018! The thesis was entitled “Quality assurance and technical aspects of embolization of uterine myomas” and this was an exciting part of systematic quality work to elucidate whether the patients receive the treatment they are entitled to, and whether it is in line with current national and international recommendations. Both the effect of the embolization procedure and patient safety were investigated! The thesis was carried out at St. Olav's hospital. Supervisors were Knut Haakon Stensæth, Berit J Brattheim and Siv-Marit Lamøy.

Dissertations 2018

Mads Henrik Strand Moxness – Disputation the 22th of June 2018
Faculty of Medicine and Health Sciences, NTNU
Department of Neuromedicine and Movement Science
“The influence of the Nasal Airway in Obstructive Sleep Apnea”

Lars Erik Bo – Disputation the 14th of September 2018
Faculty of Medicine and Health Sciences, NTNU
Department of circulation and medical imaging
“Ultrasound in Image-guided spine surgery - Enabling technologies and first steps”

Páll Jens Reynisson – Disputation the 20th of March 2018
Faculty of Medicine and Health Sciences, NTNU
Department of circulation and medical imaging
“Multimodal image fusion in minimally invasive interventions”

Hanne Sorger – Disputation the 8th of March 2018
Faculty of Medicine and Health Sciences, NTNU
Department of circulation and medical imaging
“Development of navigated ultrasound in bronchoscopy”

Congratulations to everyone!
The annual Røros FOR seminar 2018
This year’s FOR Seminar was held at Røros January 25th-26th. We had two inspiring days together - and the number of participants has never been higher. This suggests that such a conference is of great importance for the environments - to meet at a different arena than in the daily life. In this way new ideas and relationships are created and the research infrastructure is strengthened. The participants represented different institutions such as St. Olav’s hospital, NTNU, SINTEF, industrial partners and other collaborative partners in FORs research network.
This year’s first lecture were patient stories - putting the patient in focus, then followed by topics such as robotics in surgery, virtual reality and augmented reality, holograms as well as the health platform. The day ended with a ”Feelgood lecture”. Day two had the topic of artificial intelligence, drones and drone technology, 3D printing, digital communication and innovation.
A very good academic program with varying and highly relevant topics!

Welcome back to the annual FOR seminar!
Newsletters FOR
In October 2014 the first newsletter from FOR was available. So far the newsletters have been a great success. Three-four newsletters are distributed annually. They are focusing on the activity at the FOR operating rooms and are including visits at FOR, meetings, courses and information about scientific projects. In each issue, we try to focus particularly on one of our clinics. We think this is a useful way of inform about FOR and we hope you will enjoy it.

If you would like to read the newsletters please visit this link: https://stolav.no/fag-og-forskning/kompetansetjenester-og-sentre/for#nyhetsbrev

Visit from the State Secretary
Maria Bjerke, along with Vidar Kårkstad and Anders Vestli, visited St. Olav’s hospital the 28th August, the topic of the visit was innovation. The visitors enjoyed the program and appreciated that innovation was a focus area at the hospital. They were impressed by the ultrasound technology developed in collaboration between St. Olav’s - NTNU and the industry. They gained insight into some of the latest research on ultrasound and sepsis. The development that is done within the sepsis field and the underlying technology is groundbreaking. Gabriel Kiss presented the FOR-NorMIT infrastructure and provided an insight into the projects in progress. He also demonstrated HoloLens and explained how augmented reality is intended to be used by the hospital. The visitors were impressed by the clear picture and discussed the opportunities this technology could offer.

Nyhetsbrev fra FOR
I oktober 2014 ble det første nyhetsbrevet sendt ut fra FOR. Nyhetsbrevene fra FOR har vært en suksess siden. Det publiseres tre til fire nyhetsbrev per år.

Nyhetsbrevene viser bredden i hva som til foregår på FOR; alt fra besøk, møter, kurs til kontaktinformasjon samt nyttige tips som er forskningsrelevant. I hvert nyhetsbrev setter vi fokus på en klinikk som vi vier spesiell oppmerksomhet. På denne måten viser vi aktiviteten som foregår ved FOR stuene.

Hvis du ønsker å lese nyhetsbrevene – gå inn på denne linken: https://stolav.no/fag-og-forskning/kompetansetjenester-og-sentre/for#nyhetsbrev

Det ble publisert 4 nyhetsbrev i 2018 – april, juni, oktober og desember

Newsletters 2018

Photo: Alexander Moen
The National Association of Medical Technology
The annual meeting of the National Association of Medical Technology was held in Trondheim 2nd-4th of May 2018. This year’s program covered the topic of medical technology such as procurement, security and future technology as well as technology tools in patient care.

On Friday, May 4th, Operating Room of the Future by Jan Gunnar Skogås delivered a lecture with the topic "NorMIT" as a research infrastructure for medical technology and new treatment methods. Gabriel Kiss, researcher FOR-NorMIT presented 3D and 4K in neurosurgical procedures the same day.

The Operating Room of the Future also had an exhibition in the exhibition area.

Visit from the Parliament’s Health and Care Committee
The Parliament’s Health and Care Committee has visited St. Olavs hospital and the Operating Room of the Future (FOR) was selected to hold a presentation with the topic: Simulation and the future operating room. An overview of FOR’s activities, including on-going projects and future initiatives was presented by Gabriel Hanssen Kiss (FOR). Several research and development projects were presented where FOR and its collaborators (NTNU, SINTEF and industrial partners) are involved. This was followed by 25 minutes of discussions related to the feasibility of adopting methods developed at FOR in a broader context, active collaboration with the Oslo group at the intervention center as part of NorMIT, as well as future areas of focus for FOR.
**DRIV and FOR Workshop; Health-Tech-Challenge**

DRIV NTNU wanted to use the FOR-NorMIT infrastructure in a workshop where the purpose was to bring medicine and technology into joint projects. The workshop was organized over two Saturdays 3rd and 17th February 2018. At the first workshop Jan Gunnar Skogås held a presentation on the research infrastructure FOR. The relevant issues provided by the specialist council at FOR were presented. The groups consisted of students at the medicine education as well as from the technological subjects at Gløshaugen. The student organization was attended by Milena Egiazaria and Dag Håkon Haneberg.

5 teams of medical and technology students were given the opportunity to work for two weeks with issues from St. Olav. The winners of first and second place received NOK 25,000 and NOK 15,000, respectively, to use to develop their ideas further. We would like to thank the staff of DRIV NTNU, NTNU medicine and health, Engage - SFU, and not least all the participants - for a great and inspiring commitment!

You can read more about the event via the following link: https://engage-centre.no/the-future-hospital-operating-rooms/
Innovation at St. Olavs hospital

In 2018, St. Olav’s hospital passed over 60 good and active innovation projects. There are probably several other projects that we do not know about. During the year, we have been working on the innovation process and making it visible. This is to make it more understandable and easy to use, and build it up to an improved workflow. During each step there are some sub-items that should also be easy to follow. If you or your department wants to get a better knowledge of this process or other things that have to do with innovation, you are most welcome to contact us.

There are many good initiatives from the employees and the competition for obtaining funds to run the projects is hard. This is confirmed through feedback from external jury members, who were evaluating the applications submitted Helse Midt-Norge. This meant that the level of applications from Central Norway was of a high standard. Now, the Improvement Program has also received service innovation as one of the focus areas, which means that the hospital receives even more good projects in the portfolio.

From 2019, it has been decided to count the number of innovation projects at the health enterprises in Norway. This count will record the phase in which the various projects are located and will especially look at the utility value. The count will result in increased resources in the form of money, but how much and in what way is currently unclear. The count will be carried out in the web page Idea Reception to St. Olavs hospital, which is the system we use to register projects and keep them updated. The idea receipt can, also be used as a project web for innovation projects.
What will we offer in the future?

Efforts are now being made to strengthen the innovation initiative. We believe it is important to strengthen the competence of the team working with innovation projects. Therefore, we will work to offer competence development and project development in addition to our role as advisors and coordinators. We also want to start work on collecting and sorting out challenges existing in departments to see if there will be future projects.
3D printing is a manufacturing technique where parts are made by adding material layer by layer. There are quite a few different ways of building the parts, but the term 3D printing is used for all because of the similarities with ink-printing. The printing process is slow, but fully automated, making the leap from 3D-computer model to physical model short. The technique enables manufacturing of complex geometries that are difficult or impossible to make with conventional manufacturing methods. 3D printing is therefore best suited for making complex parts needed in small quantity.

The list of printable materials is expanding fast. 3D printing has been referred to as Rapid Prototyping in the past because printing of plastic models for visualization of design was the most commonly used. Introduction of printable metals and professional polymers has enabled printing of useable parts.

Medical 3D-printing

3D printed anatomical models make it possible to start the surgery in the surgeons office. Standard plates can be adapted to the model beforehand instead of directly to the patient during the surgery. This leads to reduces operating time.

Photo: Jan-Magne Gjerde

The medical industry were among the first to identify and exploit the potential of 3D printing. Anatomical shapes are difficult to obtain by traditional subtractive manufacturing such as milling and turning, and the initial costs of shaping manufacturing techniques such as molding and forging are extremely high.

Rapid prototyping has enabled faster and more cost efficient development of new products. 3D printing has also enabled the industry to supply customized products for an acceptable price. These customized products can be used in cases where standard solution will not give an acceptable result for the patient.

Patient specific anatomical models for visualization is still the most popular application for medical 3D printing. In difficult cases, dealing with patients with large anatomical defects, using physical models can be an extremely powerful tool for understanding the complexity of the case and making the best plan for treatment of the patient.

Point of care - service

Hospitals have also started to 3D-print locally. Some hospitals use 3D printing to manufacture spare parts for medical equipment, but most hospitals are exploiting the benefits of patient specific anatomical models. Some hospitals also make customized instruments, and a few hospitals even make customized implants in-house.

Local 3D printing requires some investment in equipment and expertise, but the benefits can be great. Establishing a point of care service eliminates the need to transfer medical images to a third party, and the delay caused by transport of the physical models. Faster delivery enables use of 3D printing before elective surgery with a long planning horizon. Close proximity also improves the
communication. The ability to discuss issues face to face, and arrange a meeting on short notice to fit the surgeons busy schedule, reduces the obstacles of using 3D printing.

**St. Olavs hospital**

The international trend is to locate all 3D printing in a dedicated department that will serve all 3D printing needs at the hospital. FOR-NorMITs 3D printlab is planned as such a centralized unit for 3D-printing at St. Olavs hospital. The establishment of the lab commenced in March 2018, and the initial plan was to spend the first year presenting the concept and evaluating the needs for 3D print facilities at the hospital. It only took a few weeks before the lab was urged to contribute in solving a very challenging case for the orthopedic department. The plans for a 3D printlab received great enthusiasm from many departments at the hospital, and it was decided to immediately invest in printers and get started delivering a highly requested service as soon as possible. After one year of operation, the lab has delivered many models, both for clinical treatment of patients, but also prototypes for research and development. Several departments have now started using the service on a regular basis.

**Solid Materials**

The labs current equipment is best suited for printing hard plastic models. Consequently, most of the anatomical models produced so far have been bone models. Both the Cranio-Maxillofacial and orthopedic department were familiar with, and had some experience with the use of 3D printed patient specific models/instrument/implants for treating complicated cases. Both departments had been using well-functioning but costly services from the industry. The possibility of local production of such parts allows more patients to benefit from the service, and reduce the obstacle of testing out new applications for the technology.

Medical images such as CT, MRI and ultrasound can easily be represented as 3D images on the computer screen, but holding a physical model in your hand is something quite different. Based on the medical images the surgeon has an idea of how the anatomy/anomaly of the patient looks like, but faced with the 3D model he/she often realize that their idea was not completely correct. The increased understanding of the anatomical conditions makes it easier for the surgeon to plan the most suitable treatment of the patient. Furthermore, the plan can be evaluated by performing a test surgery on the plastic model. If it is challenging to obtain sufficient accuracy executing the plan during the surgery, patient adapted surgical guides can be printed. In cases where standard plates will be used, these plates can be pre-adapted for a perfect fit using the plastic model, and thereby reduce the time spent in surgery. Good planning and precise surgery increases the chance of a perfect result, and reduces the operating time. This is very good news for the patient, and economically beneficial for the hospital.
Soft Materials

In 2019 the main focus for clinical use will still be related to bones and hard structures. Ongoing and planned research projects will also involve printing of models of internal organs, which will be used for visualization, training and simulation. Such models require soft and flexible materials mimicking the material properties of soft tissue. More and more surgeries are performed using minimally invasive technique guided by medical images obtained in advance. Exactly how the shape of the soft organs is affected when stiffer instruments are introduced is difficult to foresee. If the materials properties of the 3D-printed models are realistic enough, it will be possible to predict and train for this in advance of difficult procedures.

In one ongoing project the lab provides patient-specific models of aortic aneurysms. These models are used for testing a new technique for endovascular placement of stent grafts. The size and material requirements eliminates the use of the local printers for these models, and production will take place with a subcontractor. The plan is to be able to provide such complex models that can consist of different materials and colors as a point of case service in the future. These models can be used to plan intervention on for instance the heart, lung, liver, kidney and brain.

Two models of the same aorta aneurism. The model to the left is a downscaled hard model. The model to the right is a fullscale flexible model.
Photo: Jan-Magne Gjerde

Living Material

3D printing with living cells has great potential, and can radically change medical treatment in the future.
Illustration photo: 3ders.org

Bio printing is the process of 3D-printing with living cells. The potential usage of this technique is huge, and the ultimate goal is to be able to manufacture living spare parts based on the patient's own stem cells. This could eliminate the need for donor organs in the future. Printing complex living organs is still a distant goal, but research in this area is in fast progress. Printing of living skin is already in clinical use, and test printing of less complicated structures such as heart-valves and urine bladder show promising results. Printing of living bone could also dramatically change orthopedic treatment in the future.

Stacking cells will not be sufficient to obtain organs with the right mechanical properties. Therefore it is necessary to place the cells in a scaffold. The main challenge is to find the material and printing technique that allows for the scaffold to gradually be replaced by living cells.

Several clusters at NTNU are involved in issues related to bio printing, and For NorMIT 3D-lab seeks collaboration in order to contribute to this exciting research.

Network

The US leads the way in medical 3D printing, but the rest of the world follows. In Norway the use of 3D-printing still limited, but in steady growth. By establishing networks, hospitals can collaborate across the health trusts and reap the benefits of a larger professional environment than achievable locally. If hospitals collaborate, investment in expensive equipment with insufficient utilization can be avoided. FOR NorMIT 3D-print lab will continue to work towards the establishment of a national network for medical 3D-printing.
Photo: Jan-Magne Gjerde
Activity at the FOR operating rooms

FOR activity in the Surgical Clinic

FOR arranged a very successful seminar at Røros in January 2019, where we got information about particle counting and air quality studies for different types of ventilation in operating rooms. This contributes to the infection control work that is conducted in the surgical clinic. The projects also bring us back to the start of FOR, as the purpose among other things was to gather experience in building design of operating rooms for new hospitals.

Vascular surgeons and radiologists regularly use the FOR-operating room in the emergency center. The number of endovascular procedures for aneurysms is high and there are several and complex procedures for aneurysms involving the blood vessels of internal organs such as liver, intestine and kidneys.

TAVI operations go on, and we notice that the X-ray installation is getting worn. There will probably be a need for replacements and renewals within a few years, and we hope that the industrial cooperation established by FOR will ensure modern and future-oriented equipment when that time comes.

There has been somewhat less experimental studies on FOR 1, but the work on navigation and steerable catheters in vascular surgery continues in collaboration with the National Competence Service for ultrasound and image-guided treatment. FOR’s newly-acquired expertise in 3D printing opens up new opportunities for studying navigation by producing anatomical models based on real patient data.

Simulator training with the entire operation team the day before endovascular surgery is perceived as very positive, and the tasks are defined in advance and make the team well prepared. However, it is still difficult to set objective goals for this, and preparation of the simulator with programming of the patient’s CT data has been laborious for participating radiographs. The simulator has been in regular use, and provides opportunities for individual training and team training. The FOR-operating room in the Gastro Centre represents a large and good operating room for laparoscopic surgery. Technical problems have delayed the work of incorporating perioperative ultrasound images into the patient’s CT images. Therefore, multimodal imaging is still being considered for laparoscopic treatment of liver metastases.
Operative activity AH-1F
Surgical clinic 2018

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAVI</td>
<td>83</td>
</tr>
<tr>
<td>EVAR</td>
<td>107</td>
</tr>
<tr>
<td>Various vascular operations</td>
<td>54</td>
</tr>
<tr>
<td>Thoraco-abdominal stent-grafts w/ side branches</td>
<td>7</td>
</tr>
<tr>
<td>Combined procedures (open operation + PTA/stent)</td>
<td>70</td>
</tr>
<tr>
<td>Various endovascular procedures (coiling etc.)</td>
<td>3</td>
</tr>
<tr>
<td>Removal of infected pacemaker wires</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>350</strong></td>
</tr>
<tr>
<td>Experimental surgery and other research</td>
<td>4</td>
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</tbody>
</table>

Operative activity FOR - OR 4
Gastro intestinal surgery, Surgical clinic 2018

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper gastro</td>
<td>46</td>
</tr>
<tr>
<td>Middle gastro</td>
<td>124</td>
</tr>
<tr>
<td>Lower gastro</td>
<td>311</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>481</strong></td>
</tr>
</tbody>
</table>

TAVI 2018: 83 procedures, 44 ♀ 39 ♂. Average age: 81 years (53-90 years). 3 patients med 2 valves, 73 transfemoral, 5 transapikal, 4 subclavia.
FOR activity in the Clinic for Medical Imaging

It has been an active year at FOR operating room in AHL in 2018. The collaboration with the other clinics involved and FOR has been good, which has contributed to promoting good productivity and a good working environment. These are important conditions for implementing both advanced treatment methods and good research.

Research:
A major collaborative project between Clinic for Medical Imaging (KBD), Surgical Clinic and Medical Simulator Center with pre-operative planning of EVAR on the angio simulator has been completed, and two articles have been completed by Cecilie Våpenstad. One article deals with the feasibility of using the simulator, entitled Feasibility and operators’ appraisal of patient-specific rehearsal prior to endovascular aortic aneurysm repair (EVAR). The second article deals with quantitative data entitled Influence of patient-specific rehearsal on operational metrics and technical success for EV. Both are sent to MITAT (minimally invasive therapy and allied technologies), and are part of the Ph.D. work for Våpenstad.

Erik Nypan completed his research line project in 2018. He has conducted studies on model, animals and patients using advanced catheter and image-guided technology in the main artery. The first article was accepted in 2018, but published just over the New Year. The project will generate more scientific articles and in autumn 2018 Erik Nypan was accepted as a PhD student at the Faculty of Medicine and Health Sciences, NTNU. Reidar Brekken and Frode Manstad-Hulaas are supervisors.

Clinical activity:
In 2018, 15 thoracic stent grafts were inserted, of which 8 acute, 7 thoracoabdominal stent grafts with side branches or phenesters and 85 abdominal stent grafts. Of these, 85 were 12 acute. In addition, 15 stent graft repairs and 13 embolizations of leaks were performed. Aortic balloon was also used in one case.

Through our collaboration with the vascular surgeons, 40 combined procedures have also been performed, combining traditional open surgery with image-guided endovascular techniques on the vascular system. Doctors from KBD are also involved in the planning of the TAVI procedures that take place at the FOR- operating room in AHL in collaboration with cardiologists and thoracic surgeons.
Picture of the interventional radiologists at St. Olav's hospital
From left: Dordi Stensvåg Midelfart, Tommy Hammer, Edmund Søvik, Asbjørn Ødegård, Knut Haakon Stensæth, Frode Manstad-Hulaas and Martin Herje.
Photo: St. Olav's hospital
FOR activity at the Department of Women and Children’s Diseases

The Clinic of Women and Children's Diseases has had a good cooperation with FOR over several years. At the FOR-operating room in the Clinic of Women and Children's Diseases, mainly laparoscopic surgery is performed today. An Endo Alpha system has been installed including HD technology for imaging and visualization. Advanced platform for electro surgery with focus on vessel sealing is available. Gynecological department is active in robot surgery, and robot is currently used both for the operation of general gynecology patients and for gynecological cancer. The da Vinci robot at St. Olav hospital was obtained through FOR. In 2012, a second da Vinci robot was placed at Orkdal Hospital - as a gift from the Norwegian Women’s Public Health Association. Gynecologists operate with the da Vinci robot two days a week at St.Olavs hospital and one to two days a week at Orkdal Hospital. Robot surgery is a good example of FOR activity; High-tech, innovative and has a great potential for the future. The department has conducted prospective studies related to ovarian cancer surgery (tumor reductive surgery) and surgical techniques in hysterectomies. Doctors at the department have recently concluded a prospective study on primary lymph nodes in endometrial and cervical cancer. Fluorescence camera attached to the da Vinci robot provides the opportunity to study this. FOR assists the clinic with the mandatory EMU certification of The Clinic of Women and Children's Diseases. This is placed in the competence portal so that the individual doctor can follow his own plan for EMU training and follow up when and it is time for renewal.

We look forward to continuing the good cooperation with FOR in 2019.

Kjell Åsmund Salvesen
Head of Clinic of Women and Children’s diseases
Photo: St.Olavs hospital
### Operative activity FOR operating room 7
Department of Women and Children’s diseases 2018

<table>
<thead>
<tr>
<th>Department</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternity unit</td>
<td>18</td>
</tr>
<tr>
<td>Gyn Cancer</td>
<td>13</td>
</tr>
<tr>
<td>Gyn General</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>58</strong></td>
</tr>
</tbody>
</table>

Operating Room of the Future at the Department of Women and Children’s diseases

Photo: Gabriel Kiss, FOR
FOR activity at the Department of Neurosurgery

Active clinical research is conducted at the FOR-NorMIT operating room at the Neurosurgical Clinic. The research at the department is carried out in collaboration with the "Center for Ultrasound and Image-Guided Treatment". The research is directed by clinical needs and, through an interdisciplinary clinical and technological approach, a more optimal patient treatment is developed. When it comes to research activity at the FOR operating room at Neurosurgical Clinic, the research activity that is going on there is integrated into daily operative activities.

The department’s most important research profile is the use of 2D and navigated 3D ultrasound in image-controlled minimal invasive neurosurgery. The technology is adapted to several applications, including pituitary surgery, brain tumor surgery, AVM operations and hydrocephalus surgery. Also in 2018, research related to 3D ultrasound navigation during the mentioned interventions has been conducted.

In addition, a new BrainLab Curve navigation system was purchased by the clinic and it is now integrated with FOR-NorMIT’s BK 5000 ultrasound scanner. In this way, we can use the latest navigation software from BrainLab with built-in 3D ultrasound navigation support.

The project to compare BrainLab’s method for 3D ultrasound based intra-operative navigation with Sonowand’s solution was completed and BrainLab received expert feedback from the department. FOR has contributed during testing, data anonymization and processing.

A new BK pituitary probe was tested in 2018, it is a high frequency ultrasonic probe designed to provide better image quality during surgery. The first pituitary surgery with the new probe was performed at St. Olav’s hospital by Ole Solheim. In addition, the benefit of using the probe during glioma surgery was also tested in collaboration with BK. Based on the feedback from the surgeon, BK has optimized their acquisition parameters and new tests are expected in 2019.

On behalf of the clinics, FOR has been given the task of arranging the compulsory courses in electromechanical equipment (EMU course). Training and courses in electromechanical equipment for doctors are well established and all surgeons receive continuous offers and invitations to courses that are systematically registered and documented under the auspices of FOR. These EMU courses fulfill the requirements for EMU training for all LIS doctors and surgeons. The cooperation with FOR has been positive and we look forward to continuing this good cooperation in 2019.

Tomm Brostrup Müller
Head of the Department of Neurosurgery
Photo: Alelis
### Operative activity at FOR operating room 3  
**Department of Neurosurgery 2018**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craniotomies/intracranial operations, vascular lesions and head trauma</td>
<td>134</td>
</tr>
<tr>
<td>Shunt surgeries</td>
<td>20</td>
</tr>
<tr>
<td>Surgeries on the spinal canal and spinal cord</td>
<td>107</td>
</tr>
<tr>
<td><strong>Other surgeries:</strong></td>
<td></td>
</tr>
<tr>
<td>• Spinal cord</td>
<td>61</td>
</tr>
<tr>
<td>• Nerve root</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>322</strong></td>
</tr>
<tr>
<td><strong>Research days</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

FOR operating room Department of Neurosurgery  
Photo: Gabriel Kiss, FOR
FOR activity at the Clinic of Ear-Nose-Throat, Eye- and Maxillofacial Surgery

The FOR-operating room at Department of ENT is a modern operating room that incorporates high tech technological solutions, with special lighting and a cockpit solution. It is a popular place to work and is a central arena for tonsillectomy and the use of navigation equipment.

Since the opening of the operating room in 2013, the FOR concept has focus on research projects within medical technology, good audiovisual solutions, testing of new technological equipment and good logistics around the patient. The establishment of the 3D print lab at FOR enables for a very close collaboration with several pre- and intraoperative applications.

We consider FOR an important team-builder and by facilitating cooperation and bringing together different disciplines it promotes creativity and innovation. We have experienced that FOR is responsible for a smooth cooperation with medical industry. Not least, we are pleased that our FOR contacts participate in the clinic’s research committee and contribute with input and innovative ideas as well as information about opportunities within research support. We hope that this cooperation will evolve further.

Examples of ongoing projects where we have in close cooperation with FOR:

- Botox injections against ganglion sphenopalatine by nasal polyps.
- One project that is in the planning phase: Injection of Botox against the sphenopalatine ganglion in patients with persistent idiopathic facial pain. This is a study of 30 patients where half get a placebo injection. There is a crossover after 6 months, patients undergo new injection round but the opposite substance to the initial injection in given, thus a total of 60 injections.
- Sialoscopy (tools for diagnosing tumors and stones in the salivary glands): Currently, ENT is the only department in Norway next to Stavanger that offers this minimally invasive method. We therefore receive references from the entire country. The number of examinations increased in 2017 to 29 from 27 the previous year.

We thank FOR for a good cooperation in 2018 and look forward to the continuation.

Marit Fagerli
Head of Clinic
Photo: Private
Operative activity at the FOR operating room 1 Department of ENT, Maxillofacial and Eye diseases

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthroscopy</td>
<td>10</td>
</tr>
<tr>
<td>Conchotomy</td>
<td>18</td>
</tr>
<tr>
<td>FESS - Functional endoscopic sinus surgery</td>
<td>45</td>
</tr>
<tr>
<td>Multi-guide injections</td>
<td>3</td>
</tr>
<tr>
<td>Neuro-navigation</td>
<td>20</td>
</tr>
<tr>
<td>Septal plasty</td>
<td>37</td>
</tr>
<tr>
<td>Sialoscopy</td>
<td>29</td>
</tr>
<tr>
<td>Other interventions</td>
<td>465</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>627</td>
</tr>
</tbody>
</table>

FOR operating room at ENT, and Maxillofacial surgery

Photo: Geir Mogen / NTNU
FOR activity at the Clinic for Orthopedic-, Rheumatology and Skin Diseases

The Clinic for Orthopedic, Rheumatology and Skin Diseases uses the research infrastructure Future Operating Room, FOR. The FOR-operating room is used for example to major routine activities within prosthetic surgery. The operating room is equipped with LAF ceiling. In international research, it is a paradox that operations performed in LAF operating rooms seem to have a higher incidence of infections when one should expect the opposite. An important work that has started to investigate how different devices, such as the operation lamps, affect turbulence in the airflow.

Measurements of airflows under laminar airflow roofs have been performed since 2015, considering whether operating lights and screens hanging in the field can affect airflow and if heat from patient and operator / personnel can affect airflow. Particle measurements and CFU were performed. So far, 3 articles have been published from this work that has attracted great interest internationally. 1 PhD and 2 master students are working on the subject and 3 master’s thesis is completed.

In the meantime, a grant was received for cooperation with SINTEF Applied Economics, around improvement of operational planning, investigating whether different algorithms or action rules can lead to higher operating room utilization. This work was finished in 2018, and was primarily a collaboration between SINTEF, Department of Patient Logistics and the Operating Department in Orthopedic surgery. In spite of a lot of research on these issues, the practical application in most cases is rather unclear. The project didn’t reach a conclusion and further research is needed.

We hope that the technology in the FOR-operating room at our clinic will be optimized and improved emerging as a good innovation arena for further development of the orthopedic area. Development of new treatment methods and medical technology is of great importance in the field of orthopedics. Over the past few years, several different research and development projects have been reported; indicating that FOR is a useful infrastructure.

FOR, on behalf of the clinics, is leading the mandatory training and checkout of electro medical equipment for the surgeons and LIS. FOR arranges the courses and manages this registry through the competence portal.

Vigleik Jessen
Head of Clinic for Orthopedic, Rheumatologic and Skin Diseases

Photo: St. Olavs hospital
### Operative activity FOR operating room 8
#### Clinic of Orthopedic Surgery 2018

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary hip prosthesis</td>
<td>49</td>
</tr>
<tr>
<td>Revision of hip prosthesis</td>
<td>47</td>
</tr>
<tr>
<td>Knee prosthesis</td>
<td>220</td>
</tr>
<tr>
<td>Other operations</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>342</strong></td>
</tr>
<tr>
<td>Research days</td>
<td>9 days</td>
</tr>
</tbody>
</table>

Mainly total prostheses of the knee are included in the fast-track project.

The picture shows a simulation of an operating situation in connection with Air flow measurements project that has taken place in the FOR-living room in 2018. Photo: Professor Guangyu Cao, NTNU.
Live streaming

NorMIT has built expertise and technology related to broadcasting and live transmissions from the operating room. This means that today we are able to perform high quality live streaming from all operating rooms at St. Olavs hospital in a cost-effective way without the need for permanent installation. The production systems we use are mobile solutions that are easily rigged in the operating room and in the conference auditorium. With access to high-speed internet, live surgery and other medical procedures can be shared quickly and painlessly with colleagues internally as well as globally. Cost effective transfers and recordings of all forms of medical procedures are now possible, regardless of surgical speciality. We transfer both images and support two-way sound from the operating room to the lecture hall. We also perform the recording of the live transfer so that it can be shared afterwards.

Live streaming under shoulder prosthesis surgery, by Bernd Wünsche

Shoulder prosthetists at the orthopedic department at St. Olavs hospital had the pleasure and honor of organizing the Orthomedic / De Puy user meeting for shoulder prostheses in Trondheim 24th to 25th of June. This brought shoulder surgeons and traumatologists from different parts of the country to the conference rooms at Scandic Nidelven Hotel. The academic program was organized by Gunnar Lidegran from St. Olavs hospital / Orkdal Hospital, Arild Aamodt from Lovisenberg Hospital, Tom Ludvigsen from Ullevål Hospital and Bernd Wünsche. The goal was to create the program to cover as many aspects of our practical work as possible, but at the same time it includes developments and controversial topics within the field. Prosthetic surgery in the shoulder joint has undergone dynamic developments over the past 10 years, where the multiplicity of implants, possible procedures and research has increased significantly.

In addition, the program included the live transfer of an operation, which we conducted with a reverse shoulder prosthesis directly from the surgery suite at St. Olavs hospital. This demonstration of the procedure and the simultaneous communication between participants and operators led to exciting questions and discussions. The participants “rewarded” this with very good grades in the questback: 6 out of 6 for professional content and 5.9 for technical quality. The high score is mainly due to the brilliant efforts of Orkdal hospital, the anesthetic nurses and anesthetists from St. Olav hospital and not least Jan Gunnar Skogås and Gabriel Kiss from the Operating Room of the Future.

In particular, the technical part of such a live transmission involves many challenges and pitfalls. The area of surgery is deep inside the dorso-lateral side of the body and is difficult to visualize. Therefore, a good transfer requires that the cameraman know the procedure well, adapts to the position of the patient and the operators and of course excellent technical equipment. All of this, Gabriel Kiss performed amazingly, and the quality of the transfer was felt very well at the conference rooms. It was reassuring to be able to practice together in advance to optimize the process. The technical part of the image and audio transmission was also tested the day in advance, so that we could start the operation without stressful moments in a calm and safe atmosphere.

All in all, our user meeting was a good platform for education, discussions and academic exchanges between surgeons and at the same time an achievement for St. Olavs hospital.

Live streaming under bladder surgery, by Carl-Jørgen Arum

On 21-23 November, a “Scandinavian course in Transurethral Resection of Bladder Tumors” was held at St. Olavs hospital / NTNU. This course has previously been held in Copenhagen and at Lund University Hospital and has as target group young doctors who are in teaching positions and aim to become specialists in urology. There were participants from Finland, Sweden, Denmark, Croatia and Norway. Lecturers and operators from all over Scandinavia were recruited. 9 live operations were performed by the “best” in Scandinavia so that participants could see experts at work and get detailed insight into these procedures. The expectations for the course were high. Outstanding feedback to course with live transfer of surgery!

Experiences with previous live TUR courses have been poor and the streaming quality was not good enough, highly undesirable when experts from all over Scandinavia were participating. This time, Jan Gunnar Skogås, Gabriel Kiss and Jan-Magne Gjerde, from FOR-NorMIT, were consulted and involved early in the process. They promised that everything would work this time. We prepared for the live transfer of surgeries from operation room 6 at Gastrocenter both to 1902-Building and to KA11 auditorium in the Knowledge Center. Tests were performed on 3 different endoscopy systems including (Wolf, Olympus and Karl Stortz) and we thought everything would work and this was how it was. Never have we received so many positive feedbacks from both course participants and guest operators. A live surgery course was held at St. Olavs with international standard. We are looking forward to using FOR-NorMIT and their expertise in future live-surgery courses!
Photo: FOR
Medical Technology and Information Technology FOR-NorMIT

FOR is featured in the National ICT Strategy Plan for 2013-2020, and the Government’s ICT research and development strategy sets out areas for ICT research and development in the future and signals how the government wishes to prioritize public resources allocated for research and development in ICT.

ICT in combination with medical technology is becoming increasingly widespread. The Government wishes to utilize ICT to achieve more growth and value creation in Norway. To achieve this goal, we rely on strong and good knowledge environment in ICT, and we rely on research and development in areas that are important to Norway. Although there is a lot of international activity that we can benefit from, it is particularly important in some areas that we have both our own expertise and our own research and development environment.

The government has identified three areas of action for ICT research and development in the future:

- ICT R & D of high international quality
- Business development and value creation
- Important societal challenges


The pace of digitization challenges us massively. Technology companies and developers identify the health sector as a major focus area for innovation. The society’s expectations that the health sector will become more modern and technology-based will be strengthened in the years to come. Employees will expect the health service to be ahead of the development of using new therapies and technology.

Younger people are raised with extensive use of internet-based “items”. The proportion of people gathering and sharing information both at work and in free time from their networks will increase for each year. The community will therefore become more network-based by 2035. Both employees and patients will expect that necessary information and answers “always” are available. This requires that we change the way we are organized and work.

Medical technology and information technology gives us new opportunities to improve our knowledge base through an explosive growth in available data. Future analysis platforms will provide integrated patient data, including data from MTU, and will provide a better and more accessible basis for own research.

Using Big Data, strategies can be developed to prevent disease and to provide better treatment. The development in technology and medicine will provide a good basis for research with available and integrated data.

It is important to ensure that research results and new innovative solutions are taken into service and that they form the basis for a knowledge-based and future-oriented health service.

FOR-NorMIT with its unique relation to technical competence environments by for example NTNU, SINTEF and international research and industrial environments have an outstanding opportunity to also take advantage of clinic-initiated development to a greater extent as technology evolves. There will be a standardization and coordinated development / innovation throughout the health service. In this work, patient needs and requirements, as well as clinic-initiated innovation, should be considered and new measures evaluated through research.

FOR-NorMIT is an established research infrastructure at the University Hospital in collaboration with NTNU. Under the auspices of FOR-NorMIT, different professional environments can try out new technology in a safe way.

The NorMIT initiative emphasizes that FOR is a research infrastructure that will benefit the entire health region - and beyond it, nationally and internationally. It is interesting for the health care companies that there will be a lot of new technology that requires testing in clinical practice. It will also be rational in the future that some heavy technological investments are concentrated to make the most out of the resources.

For FOR-NorMIT it is interesting that there will be a lot of new technology that requires testing in clinical practice. Through co-operation with environments and forums where development in the future is a topic, FOR-NORT can capture trends / new technologies at an early stage. Examples are:

- Nanotechnology
- Biotechnology (Gene therapy / diagnostics)
- IT revolution that will continue (Big Data)
- Neurotechnology
- Quantumtechnology

Several conditions that previously had to be treated at larger clinics, can eventually be done at the local hospital level. There will be more technological equipment in the operating rooms. Operation of this requires considerable training. Engineers get a more important role. There will be a centralization of the most complicated interventions. Other conditions that do not require much multidisciplinary collaboration between many different specialists can be done at the local hospital level. Analysis and interaction technology can provide very good opportunities for comprehensive innovation in mental health care and TSB.

The trend towards 2035 will be more personalized medicine, technology that enables even more decentralized treatment, as well as better utilization of health data from various sources. Consequences of this may be that with more accessible research data, time from research to results will be shortened and clinical practice may become even more adaptable.

Advanced digital image processing and large data power provide new ways of visualization and image production with higher information value with ever better resolution and shorter recording time. Development on equipment and software increases diagnostic precision combined with lower amount of ionizing...
radiation. Other non-ionizing diagnostic equipment gets new applications. Both 3D printing and holography provide better possibilities for modelling and simulation. Large amounts of diagnostics and reprocessing of data for new image representations are largely in proprietary software. Therefore, it is important that such systems are integrated so that documentation comes in the patient’s chart directly.

Navigation with electromagnetic tracking system in the endovascular system is in development. The effect reduced the use of radiation and is time saving. You depend on good visualization in the treatment situation. The development in MR spectroscopy could replace the need for biopsy in many situations.

Intervention radiology improves and utilizes all imaging modalities and combinations of them for increasing precision with many treatment technologies, such as thermal-, radio frequency-, microwave- and laser abnormalities.

Future focus will be even more use of high-resolution camera systems and visualization equipment combined with 3D ultrasound and radar technology will make use of holograms and hololens in hybrid operating rooms.

Medical robots are already being used and medical personnel and robots will be expected to work even closer together in the near future. Medical robots can include help improve surgical precision, medicine production, laboratory analysis, logistics and cleaning tasks, including disinfection of hospital rooms and surgical rooms. Used correctly the biggest effect is release of health personnel time spent on routine tasks. Robotization will also be able to streamline administrative and technical tasks in the health services. Many argue that anything that can be robotized if labor costs exceed investment and operating costs with the robotization. In the health context, such a cost/benefit assessment will be too simple.

Robotic parts attached to the body can speed up rehabilitation of injured patients or allow people with paralysis to walk again. Robots come in all sizes and shapes, today’s miniature robots are in millimeters of magnitude. These robots can be swallowed and allow for less invasive surgical procedures and targeted drug delivery. However, it is expected that nano-size robots will be developed and these can be placed in the bloodstream. They can be used to repair damaged cells or to help the body fight bacteria or infections.

Human contact will nevertheless be the core of good patient care. The development plans should include how medical personnel and robots can work together, and how patients can best adapt to the presence of a robot in the healthcare sector.

Artificial intelligence (AI). The data produced daily in the clinic and stored digitally in PACS systems doubles every other year. The vast amount of information makes it impossible for healthcare professionals to keep up with all that is stored or to use this information in daily practice. However, artificial intelligence-based (AI) tools can help to keep track of and extract relevant information from the database and adapt it to the particular situation they face. AI in medical education will improve the learning process and enable the students to have a much wider experience than they encounter in the traditional period of stay at the clinic.

It is expected that AI will have a beneficial effect in all areas of the health sector. Patient logistics, treatment planning, drug development or surgical procedures can all benefit from using AI, using intelligent medical information systems and devices. Access to large data will allow more accurate decision making and targeted medication. The decision on treatment and medication will be tailored for each patient and based on the outcome of those with a similar medical history. AI will enable to establish a correlation between a disease and genetic information, medical records or DNA mutations.

These new developments will also require the public to be informed and accustomed to AI. Furthermore, a new set of ethical standards must be developed to update existing guidelines and ensure that AI is used appropriately in the healthcare sector.
**FOR-NORMIT infrastructure**

In 2018, the NorMIT infrastructure was used extensively, and many of the publications refer to research that has used NorMIT. NorMIT had an increase in users from 284 in 2017 to 321 users in 2018. The proportion of external users has remained at the same level with approx. 100, and from industry and business there is just over 35.

In 2018, the planned infrastructure was installed and put in place at the Future Operation Room at St. Olav’s Hospital (was mainly carried out in 2017), and all the equipment can now be booked via normit.no. Here the usage is logged automatically, and the users can receive invoice sent annually, half-yearly or quarterly by agreement such as, for example, annual round sum. The use of the infrastructure can be booked in a simple manner at normit.no. Users say this is an easy way to make a booking. User logs form the basis for billing and reporting when needed.

NorMIT IGT is a sub-project of NorMIT and is managed by the Intervention Center. A common NorMIT Navigation platform for image-guided treatment (NorMIT IGT) will be developed through the integration of the NorMIT Plan from the Intervention Center and NorMIT-Nav from SINTEF and where new software modules are developed for this common platform. In 2018, it was agreed on a data format for the integration of file formats between NorMIT-Plan and NorMIT-Nav. Integration between these modules has been developed, and the entire pipeline from CT / MR images from patient, through segmentation and resection planning in the NorMIT plan transferred to NorMIT-Nav as a navigation map. At normit.no you can now download the software.

NorMIT has repeatedly been in the forefront in lectures, seminars, workshops and other in 2018 to provide information about the project and how it can be used in research projects.

At the Future Operation Room, the following equipment is available at NorMIT:
- Brainlab optical and magnetic system
- DaVinci minimal invasive surgery system
- FUS instrument’s ultrasound system
- Medical visualization equipment
- Tricaster video editing system
- Siemens Artis Zeego C-arm
- Verasonics’ ultrasonic devices (with HIFU option)
- Hydrophone Scanning system; for quality control of ultrasonic probes
- Ultrasound bronchoscopy equipment (EBUS)
- Intraoperative ultrasound (BK5000)

An overview of all equipment that can be booked at FOR-NormIT is also available at normit.no

At FOR-NormIT in Trondheim, there are currently 6 ongoing PhD candidates and 4 PhD candidates have defended their thesis. In 2018, 4 candidates graduated with a Master’s degree, as well as 7 Bachelor’s students in collaboration with FOR. An important partner is the ”Competence Center for Ultrasound and Image-Guided Treatment” which is a national competence service appointed by the Ministry of Health and Care Services

**Newsletters**

The first edition of the NorMIT newsletter was published in October 2017 and presented the latest news and research results based on NorMIT equipment. At least 3 editions per year were planned for the newsletter, but in 2018, 5 editions were produced that reflect some of the activity of NorMIT. All NorMIT partners and users are welcome to submit relevant texts and images.
NorMIT in Trondheim and Oslo

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<td><strong>Users</strong></td>
<td>2018</td>
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<tr>
<td>Total number of users</td>
<td>321</td>
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<tr>
<td>Total number of internal users (at host institutions)</td>
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<td>Total External Users (users not belonging to the host institution(s))</td>
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<td>Number of scientists</td>
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<td>Number of users from industry / industry</td>
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<th><strong>Type of projects (funding) where the infrastructure is used</strong></th>
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<td>Total number of projects</td>
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<td>Number of projects with international funding (EU, Nordic, etc.)</td>
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<tr>
<td>Number of projects with external national funding</td>
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<td>Number of projects funded by host institution (e.g., through basic grant)</td>
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<td>Number of projects with funding from industry / business</td>
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<th><strong>Utilization</strong></th>
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<td>Utilization rate (%) in relation to the infrastructure’s available capacity</td>
<td>70</td>
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Medicine and media technology

Medicine and Media Technology originated from the resource network AV Arena Norway at the Operating Room of the Future, which since the start in 2005 has had a strong focus on the development of image-controlled surgery and image-guided treatment. Digital media Technology is an important driver in the development of these disciplines. This type of resource network is important to bridge the gap between a digital media technology competence and health care tasks in the learning and interaction and establishment of projects to trigger medical and operational benefits in the healthcare sector.

The resource network's portfolio in 2018 has largely focused on improved health communication and telemedicine as well as building capacity for innovation in the public sector. The interaction with the oil sector remains an important factor for activity related to future telemedicine.

FOR has a good advantage as we have a strong media technology focus and are used to working with both Norwegian and international industrial partners and research environments. The media technology infrastructure is closely linked to clinical environments, making it easy to extract the transmission value between the environments, where we also have a central role in planning and design of operating theaters.

Medicine and media technology will be an enrichment in many areas, which will make us more attractive to many partners - and reinforce the organization's position as an important research and innovation hub.
Future telemedicine

Digital interaction solutions both within the hospital and between treatment levels, such as in pre-hospital services, mean that the focus on telemedicine in the future is becoming increasingly relevant. The trends up to 2040 are that all information and communication services are digital and integrated. The Operating Room of the Future contributes to the focus and will be a facilitator of this work. Both diagnostics and treatment is expected to be transferred to decentralized institutions, with increasingly shorter length of stay and transfer of responsibility to the municipal health service. Such changes require new solutions, and with the help of the Virtual Examination Room (VER) one has tailored a solution for colleague-guided decision support that can welcome these future changes.

The workflow and the processes in decision support are prepared in dialogue with both those who are providing support, and those who are receiving colleague-guided decision support. The user experience, also called the user interface, has been the main focus in 2018, and a prototype has now been made, which is now to be implemented on the Norwegian shelf for use between offshore installations and their contact point on land. In central Norway, in 2019, it will be decided whether VER should be offered to both primary and specialist health service providers. VER will thus be able to contribute to the implementation of new ways of working that previously were impossibly be done in the absence of sufficiently usable solutions. We are looking forward to being a part of the development in telemedicine of the future!
Courses arranged by FOR

EMU-courses arranged in 2018:

12th January: EMU-course for Department of orthopedic surgery
• Irradiation protection and use of C-arm for fluoroscopy
• High energy equipment and Endoscopy

24th April: EMU-course for the Department of orthopedic surgery and Department of Surgery
• High energy equipment

24th May: EMU-course for the Department of orthopedic surgery and Department of Surgery
• Irradiation protection and use of C-arm for fluoroscopy

EMU courses

On behalf of the operating clinics FOR is conducting compulsory courses in the use of electro-medical equipment. In 1999 a new regulation regarding “Use and maintenance of electro-medical equipment” was passed. This regulation has its background in law on medical equipment from 1995. According to § 13 training and instruction in the application of such equipment is necessary because: Personnel who are going to use electro-medical equipment must have training and instruction in the application of such equipment. They should know potential side-effects connected to the application of electro-medical instruments and know how to prevent them. The training program must be systematic and include documentation.

The Systematic training program should include:
• Training when new equipment is introduced
• Training of new employees
• Maintenance of the knowledge achieved during this training program.

At present, the training program including the documentation is well established at all operating clinics at St. Olavs hospital. All surgeons, including surgeons in training as well as staff surgeons, are getting invitation to the courses as part of the continuing medical education.

Competence portal

All courses in electromedical equipment and infection protection are now assigned to the individual doctor and LIS in the competence portal. Everyone can now see which courses are valid and which courses need to be renewed. When you click on the course in the competence portal, you will automatically come to the course in the learning portal, if it is an e-learning course. Initially, this applies to infection protection and parts of the radiation protection course. High-energy devices and endoscopy, as well as the use of C-arm is still classroom teaching.

Training of the staff

Medical personnel affiliated to FOR is going through annual certification in compliance with national regulations regarding use and maintenance of electro-medical equipment. All surgeons at St. Olavs hospital are also going through courses on an annual basis regarding the use and maintenance of electro-medical equipment. The personnel at FOR is including so-called super-users having special focus on modern, advanced medical technology. They need to go through refreshing courses on a regular basis. The personnel at FOR is contributing to training of personnel from other departments at St.Olavs hospital as well as personnel from institutions focusing on clinical procedures, research and application of medical technology.

FOR has through visits and hospitants from other hospitals in Norway helped to provide important information and training on new technologies, methods and integration of laparoscopic / endoscopic surgery. Organization and design of operating rooms has also been the subject. At the simulator course organized by the National Center for Advanced Laparoscopic Surgery (NSALK), FOR has been used as a venue for transmission of operating procedures and information on the integration of new equipment.
Experimental surgery

All FOR operating rooms are authorized for experimental surgery including animal research. Such experimental procedures can be ordered at FOR who will then organize them. This arrangement is well established among clinicians and scientists. We have a “package” where FOR is organizing and planning the animal experiments in collaboration with the Department of Comparative Medicine (AKM). FOR has trained and authorized personnel assisting during the whole process.

Personnel who is planning or taking part in animal experiments must go through courses in animal experiments approved by the Norwegian Food Safety Authority. An important part of this course is to understand laws and regulations connected with the use of animals in medical experiments. The regulation regarding animal experiments demands that all persons planning or performing such experiments should have passed the courses and be registered in the electronic system (FOTS) of the board for animal research. Both the responsible scientist and his co-workers involved in the practical performance of the experiments, including those who are taking care of the animals, should be included in the registration and have documentation that they have passed the course in animal experiments, category C.
Research Collaboration

National and international partners

Together with the Intervention Center (IVS) at Oslo University Hospital, FOR has established the national research infrastructure, NorMIT; Norwegian center for Minimally invasive Image guided Therapy and medical technologies, which now has its infrastructure in place with several ongoing projects. The NorMIT infrastructure is available both nationally and internationally.

During 2018 we have concentrated on cooperation with partners in our own health region; Nord Trøndelag county, the health register HUNT and Møre and Romsdal county where the FOR-NorMIT infrastructure is available and where new research projects have been established.

SINTEF is one of FOR’s most important collaboration partners. The cooperation is among other things built around the “National Center of competence for Ultrasound and Image Guided Therapy”. FOR has also a very good collaboration with NTNU through the MH faculty, at the Department of Circulation and Medical Imaging, Department of Energy and Process Engineering, Department of Design, Department of Mathematical Sciences, Department of Electronic Systems and the Department of Technical Cybernetics and the AI lab. The students at the Faculty of Health Sciences at NTNU use the FOR infrastructure for tasks related to their bachelor’s and master’s degree in collaboration with FOR. Various competence centers such as the “National Center of competence for Ultrasound and Image Guided Therapy” and the “National Center for Advanced Laparoscopic Surgery”, NTNU Technology Transfer (TTO), Center for Interdisciplinary Research in Space (CIRiS) are important partners, and it is important to maintain the synergy effect of this collaboration.

Furthermore, FOR has a good cooperation with a number of industrial partners: Sony, Medtronic, Brainlab, Intuitive, Siemens, Stryker, Karl Storz, IBM, Apple, ConocoPhillips, Total, Olympus, and Smith & Nephew. Good practice and guidelines for collaboration with industrial partners have been developed together with experts in this area.

FOR has an established joint research projects with several international partners such as Vanderbilt University Medical Center in Nashville, TN, USA. Together we investigate what is the impact of new treatment modalities on technological solutions and decisions made in the operating room. We also want to collaborate on efficient use of ICT in the operating rooms in order to optimize workflow and patient flow. We also work with Albert Einstein Hospital in Sao Paulo, Brazil and UFF Universidade Federal Fluminense in Brazil. Mainly focusing on telemedicine and “decentralization of specialist healthcare services”.

There are several other international partners who wish to cooperate with FOR. So far, we have focused on establishing research collaboration with the Massachusetts General Hospital in Boston, the Operating Room of the Future in Tubingen and research groups at Krakow University Hospital in Poland. A collaboration with the Yonsei University Health System, Seoul, Korea has also been established. Handling of the increasing number of elderly patients, the intelligent hospital and the transmission of high quality medical information are some of the projects that have been initiated, and which we want to focus on in the next few years.

FOR also collaborates with organizations such as the European Association for Endoscopic Surgery (EAES), the Society for Minimally Invasive Therapy (SMIT) and Technoport in Trondheim.
Research and development in cooperation with SINTEF and Norwegian National Advisory Unit for Ultrasound and Image-Guided Therapy

The Operating Room of the Future (FOR) is the arena and infrastructure provider for several ongoing research projects, including projects at the Norwegian National Advisory Unit for Ultrasound and Image-Guided Therapy (USIGT, www.USIGT.org). SINTEF is a key and important research partner and partner for FOR and USIGT. Thomas Langø at SINTEF has a coordinator position at St. Olavs hospital related to this advisory unit. One of the largest activities in 2018 was linked to activities of USIGT, which is national and appointed by the Ministry of Health and Care Services. The advisory unit uses FOR as the arena for a number of clinical and technological research and development projects ranging from technology development, prototyping and clinical trials/studies of new solutions, which improve patient care. In 2018 there were 12 PhD projects in progress and 9 ongoing Postdoc research projects. 4 PhDs were successfully completed in 2018. About half of the 12 PhDs have workplace at SINTEF, with a shared position between SINTEF and NTNU. Often, a technologist and a clinician are working together on PhD projects related to the same topic, which illuminates the problem from both a clinical and a technical perspective. 32 scientific papers with peer review at were published at USIGT in 2018, some from projects conducted at FOR, St. Olavs hospital.

Through several user-driven projects supported by the Research Council and EU, USIGT has been an important competence environment for innovation and industrial cooperation. The USIGT advisory unit has a broad national and international network and extensive activity related to the development and dissemination of expertise and knowledge, one of the core tasks of the service. Through participation in several EU projects: VECTOR, IIIOS Marie Curie Initial Training Network, 3MICRON, FUSIMO, MISTELA, RASIMAs, TRANS-FUSIMO, HiPerNav ITN and Eurostars Mariana project we “import” expertise from international academic environments, while at the same time generating and contributing to the dissemination of local expertise both nationally and internationally. St. Olavs hospital at FOR and SINTEF have applied for a new ETN EU project, ORConnect, in 2018, in collaboration with 11 other European resent groups.

The USIGT advisory unit focuses on image-guided minimally invasive therapy with areas of interest related to surgery, neurosurgery, laparoscopic surgery, pulmonary medicine (bronchoscopy) and radiology/urology. In addition to the use of ultrasound, navigation is also an important field of research. An important software platform and infrastructure at USIGT is the CustusX Navigation Platform, developed and maintained by SINTEF, and available as an open source package at www.CustusX.org. The purpose is to make the diagnosis better and the treatment safer. This platform is also disseminated nationally through the NorMIT infrastructure project and internationally as an open source platform in the form of customized versions for clinical applications. An example of the latter is Fraxinus, a project that will create and distribute a free software package for bronchoscopy guidance, and thus making the diagnosis of pulmonary lesions easier and more accurate. An important activity in recent years is artificial intelligence (machine learning), in particular at SINTEF. Many of the projects is focused on automatic detection and classification of structures in medical images.

The activity of the National advisory unit for Ultrasound and image-guided therapy is a good example of how the future operating rooms can support research, development and testing of new technology and methods, while strengthening national and international cooperation. In addition, FOR contributes with expertise related to courses and publishing popular science articles in close cooperation with SINTEF. SINTEF also brings considerable expertise into the collaboration and is using its basic funding for strategic efforts to develop new technology for minimally invasive surgery/therapy and diagnostics.

Thomas Langø
Chief Scientist, Medical Technology
SINTEF

Photo: SINTEF
Digitization and medical technology is of utmost importance for the treatment we offer our patients. For the last two years NTNU has promoted the efforts in building up digitization within the health care sector. Institute of Circulation and Medical imaging (ISB) is heavily involved in this process, which is organized in cooperation with the technology campus at Gløshaugen, Trondheim and St. Olav’s hospital. In this cooperation the infrastructures at Operating Rooms of the Future-FOR and NorMIT are important platforms that allows testing of new medical technologies for better patient treatment under safe conditions. The need for this arena was emphasized in connection with the visit at the Ultrasound Research group at ISB of the Norwegian minister of finance in February 2019. Then the minister herself, Siv Jensen, became aware of the significance of close collaboration between technologists, doctors and other health care workers in the same research-areas at the hospital. Infrastructures like FOR and NorMIT are important to apply the knowledge created by the research groups for the development of better patient treatment. The collaboration platform which has been created between the industry, NTNU, SINTEF and St. Olav’s hospital is giving unique possibilities for clinical research. It is therefore a great pleasure to observe that there has been an increasing number of published scientific articles from research groups cooperating with FOR and NorMIT in 2018. It has also been recognized internationally that we have managed to promote multidisciplinary cooperation, through an integrated “state of the art” infrastructure including various sectors (health and education). Thereby we are becoming competitive and attractive as a research co-worker also from an international standpoint.

Another part of NTNU’s social mission is to build competence for a life-long career (further education and upgrading) and multidisciplinary arenas for learning. Here FOR and NorMIT are excellent arenas which we hope will make it possible for us to reach our goals for the future. After the fusion of institutions which took place in 2018, we have even more health care centers giving education under the same NTNU umbrella. Thereby we are able to give better health education including more practice placements and an increasing number of MGs and BSc theses. They are delivered through excellent research groups and are based on the needs and challenges which are met in the daily working life and are addressed within this infrastructure.

Innovation has become more and more important and has therefore received high priority at NTNU. The Faculty of Medicine and Health Sciences has therefore in 2018 opened a new student-promoted innovation lab, Student Health Innovation Centre (SHIC), in cooperation with Troll Labs at The Faculty of Engineering Science and the student organisation DRIV NTNU. The various research groups connected to FOR and NorMIT are making several master projects and other interesting projects available for SHIC, where medical students and engineering students are working together on a subject. This is an excellent example how a good infrastructure together with excellent research groups can promote research-based multidisciplinary education.

NTNU has also intensified the activity within innovation by employing innovation leaders at well established research groups with a potential within this field. Thus, Tormod Njølstad has recently been employed as innovation leader at the research group of ultrasound at our faculty. We are looking forward that our well established cooperation with FOR and NorMIT will create synergies with our efforts within this field, since we have a common goal of creating and developing new ideas together with the health care sector and industry to offer our patients the best treatment. In conclusion, we have great expectations for a good cooperation with FOR and NorMIT in the years to come.

Øystein Risa
Head of The Department of Circulation and Medical Imaging
Faculty of Medicine and Health Sciences, NTNU
Photo: Geir Mogen/NTNU
Minimal invasive techniques now characterize more and more medical specialties. Image-guided minimal invasive treatment represents one of the major innovation areas within the specialist health service. Such procedures have been an important factor in creating a more efficient and gentle treatment. Several surgical procedures are now being performed as day surgery, and the patient is returning faster to everyday life and to working life. It is likely that this trend will continue in the years ahead, with more focus on non-invasive surgery.

The work to involve new subject areas will continue in 2019, and it is particularly gratifying that navigation technology in surgery has gained access to several of the operative clinics at St. Olav’s hospital. Everything suggests that new technology will give us better opportunities, increased quality and improved patient safety compared with previous diagnostics and therapy. Evaluation of robotic surgery is a field that FOR has focused on. Work is continuing on new techniques for treating patients with morbid obesity.

There are increasing numbers of older people in the population. Open surgery in elderly patients presents specific challenges because the risk of complications is higher than in younger patients. In addition, it takes longer before the patient is back to everyday life after treatment. Particularly with regard to these patients, minimally invasive treatment is an advantage.

It is being built, renovated and planned a significant number of hospitals in Norway and in other countries. The operating rooms are expensive to build and expensive in operation. We want to make experience and lead in the field so that one can optimize the investments. We focus on architecture, material use, ergonomics, ICT solutions, logistics and health economics, so we can build more affordable and drive more rationally. It is important to do this in a systematic manner so that we get a lasting knowledge of different conditions at the operating departments. There is still a need to structure the testing of equipment and techniques in operating departments, and FOR will continue to contribute support for the creation of contracts, implementation and evaluation of the projects. The infrastructure of FOR currently consists of 6 operating rooms, with the overlay of an AV-ICT structure that enables live transfers and interactive communication in full 4K. Further refinement of intraoperative imaging will take place. 3D manufacturing and holography may be a routine after all. At the same time, the disease perspective will change over time.

The need for multifunctional intervention rooms and the EI-Phys lab is increasing, but the capacity of today's FOR-operating room at AHL is now fully utilized. There is a strong desire for hybrid multifunctional FOR-living rooms, in several disciplines, because there is an increasing need for hybrid interventions in radiology, cardiology, surgery, thoracic surgery and pulmonary medicine. It will have significant consequences for future operation capacity within minimal invasive imaging guided intervention at the hospital if one do not prepare for increased capacity within this type of activity. We aim to get more international fellows at FOR. FOR has set a realistic and sobering goal by obtaining two PhD and four master's degrees a year. We notice that there is an increasing need for master's degree assignments and bachelor assignments and this will increase in the coming years. By creating main tasks (Medical Student's Research Programme) for medical students, you can also get in touch with future candidates for fellowships. Here, FOR can be a good platform.

FOR has also continued and further developed a systematic and documented program for the training of doctors at the operating clinics in the field of electro medical equipment, EMU, in 2017. The introduction of new medical technology in patient treatment results in an increased need for personnel training. Such training is also required by law, and systematic training of those who operate the equipment involves, among other things, training on new acquisitions, training of new employees / temporary staff and maintenance of the training given. All physicians at operating departments are now offered and invited to continuous courses, which are systematically registered and documented. The training is now included in the established Expertise Portal, so that the employee himself and the respective management have a full overview of the status. The system has the possibility of integration with other systems. Training in radiation protection and infection protection is now available as e-learning. This is an innovation project that has great transfer value to other health institutions and health regions.

FOR has a close cooperation with many different actors. It concerns international industry, clinical environments and technological environments. The main actors are St. Olav's hospital, the Faculty of Medicine at NTNU and SINTEF Technology and Society. Various competence centers such as the “National advisory unit for Ultrasound and image-guided therapy” and "National Center for Advanced Laparoscopic Surgery", the Health Sciences Education at NTNU, NTNU Technology Transfer (TTO) and the Center for Interdisciplinary Research in Space (CIRiS) are important partners. The synergy effect of this collaboration is important to take care of in the future. The cooperation with SINTEF on navigation technology equipment continues, and we have great hopes for the use of steerable vessels and catheters for endovascular treatment of diseases in the vascular system. Within lung medicine, one has used navigation in conjunction with endoscopy and endobronchial procedures. The operating room of the future has been, and is, an internationally preferred collaborator in the design of imaging and visualization technology for medical use in the image guided, minimally invasive treatment. We want to strengthen international cooperation, and many international players want to cooperate with FOR. So far we have concentrated on the Massachusetts General Hospital in Boston, the Future's Operations Room in Tubingen and research groups at the Krakow University Hospital in Poland. We cooperate with the Vanderbilt University Medical Center, Nashville; TN. FOR also cooperates with organizations like EAES and...
Furthermore, cooperation with Yonsei University Health System, Seoul, Korea has been established. Collaboration with UFF Universidade Federal Fluminense in Brazil has begun, which has resulted in a MoU and collaboration in telemedicine and the use of holograms. The work will be given priority in 2018 and will be seen in connection with projects related to Hololens and VER decision support.

NorMIT «Norwegian Center for Minimally Invasive Image Guided Therapy and Medical Technologies» as a common infrastructure and platform will bring us wider nationally and internationally. This platform was developed between FOR and the Intervention Center, OUS Rikshospitalet and supported by funding from the Norwegian Research Council. Both Helse-Nord and Helse-Vest have now participated in this cooperation and are represented on the board. The purpose of the collaboration is to improve patient treatment and raise the quality and scope of research and innovation in such a way that it puts Norway on the map internationally. During 2018, the activity has started well. We are focusing on research and development based on the established infrastructure and research tools now available at the Intervention Center and FOR. We wish FOR to be a research infrastructure of good international quality. The goal is, among other things, to increase the quality and scope of research relevant to FOR. FOR will also be at the forefront of internationally regarding image-guided minimal invasive treatment, partly as a result of cooperation with the R & D environments of the international industrial partners. St. Olav’s hospital and FOR is therefore an international pioneer in the intersection of a digital media technology industry and the development of new medical technology and new applications in the field of image guided minimally invasive treatment. FOR has helped set the standard for such treatment in an international context.

A Lab for 3D-printing is established by FOR in 2018. The technology provides exciting opportunities. In the development of implants, instruments and planning of complicated interventions. Technological developments in areas such as gene therapy, nanomedicine, artificial intelligence and "big data" will have an impact on diagnostics and treatment in the future. These are areas that FOR is oriented towards through a multidisciplinary approach.
Scientific production

PhD degrees - completed in 2018

**Pall Jens Reynisson**

The thesis presents a development and evaluation of a new visualization method for planning and guidance in bronchoscopy, anchored to the Centerline Curved Surface (ACCuSurf), which consists of more complete viewing for navigated bronchoscopy in tube-like structures. The technology can also be combined with other methods such as VB, PET and ultrasound images by adding these data sources on the screen. At the same time as giving an overview of the lungs and tools, ACCuSurf can be zoomed in and display more anatomical details than the conventional endoluminal display. First, a comparison of different approaches to airway segmentation was performed to establish a route to the target. Second, ACCuSurf was developed by slitting the segmented respiratory tract in half and creating a 3D volume representing surrounding anatomy along the way to the target. Finally, the ACCuSurf method was evaluated by pulmonologists who used it as a planning tool before performing bronchoscopy on a phantom with a mixed data set from a patient and phantom. Conventional 2D (axial, sagittal, coronal) visualization was comparative reference. The study is an attempt to facilitate and simplify visualization for navigation in bronchoscopy.


**Hanne Sorger**

PhD project title: Development of a navigation system for bronchoscopy. The main objective of the project is to improve minimally invasive lung cancer diagnostics using a new image guidance system based on electromagnetic navigation and multimodal image fusion. In the case of lung cancer, the patient’s prognosis depends if the disease has spread to mediastinal lymph nodes, which excludes radical surgery. Endobronchial ultrasound with aspiration using a thin needle from lymph nodes (EBUS-TBNA) is the first choice in the stage division. New clinical guidelines now recommend systematic EBUS-TBNA also of small (<5 mm) mediastinal lymph nodes if the patient may be appropriate for curative lung cancer treatment. Future EBUS-TBNA will therefore become increasingly technically challenging, requiring an effective and gentle procedure so that the patient can be investigated awake and on outpatient basis. We have developed a prototype EBUS bronchoscope, where a millimeter sensor mounted on the tip allows tracking of the ultrasound head position in an electromagnetic field around the patient’s chest. The patient’s own preoperative images (usually CT) are imported into the navigation program, automatically registered to the patient’s position on the operation table, thus serving as a 3D map for the sampling equipment. The ultrasound images from the EBUS bronchoscope are merged with preoperative CT images in the navigation program, and provide real-time information during the survey (see figure). The bronchoscope can navigate quickly and accurately to each single lymph node for sampling. Diagnostic precision and success rate for EBUS-TBNA can be increased. More precise and effective selection of curable lung cancer patients will be possible without the need for invasive methods with higher complication rate.

The defense of the PhD thesis took place March 8th 2018.

Main supervisor: Håkon Olav Leira
Assistant supervisors: Thomas Langø and Tore Amundsen

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*Photo: hun.is*
Mads Henrik Strand Moxness

Modelling of Obstructive Sleep Apnea by Fluid-Structure Interaction in the Upper Airways – «Modellering av øvre luftveier ved obstruktiv søvnapne».

The Norwegian Research Council allocated NOK 10 million to a research project between DMF, Faculty of Engineering and Technology and SINTEF to develop a 3D model and data simulation of the upper respiratory tract in patients with obstructive sleep apnea before and after nasal surgery 2014 -17.

The model was based on CT and MR images and airway measurements in patients. In a part of the project, 30 patients were operated at FOR and the results were correlated between postoperative measurements on patients and results from the model.

Results:
OSA patients have smaller nasal cavities and volumes than non-OSA persons, and their ability to breathe through the nasal cavity was impaired compared to non-OSA persons. There is a correlation between the width of the soft palate and the simulated closing pressure of the upper airways, and a linear correlation between the transverse strain of the soft palate and the closing pressure in the models. Commercial CT scans are not sensitive enough to yield correct numeric mathematical results in CFD modelling.

The multidisciplinary research resulted in a total of 3 Ph.d. theses, 9 M.Sc thesis and 6 project reports on time, as well as 11 journal publications and multiple conference presentations. All publications are available at the project web page: www.osas.no

Supervisors: Ståle Nordgård and Vegard Bugten

The project is still actively seeking new funds.

The defense of the submitted and approved PhD thesis June 22nd 2018.

Lars Eirik Bø

Ultrasound in image-guided spine Surgery - Enabling technologies and first steps

In this PhD project, new methods have been considered to guide surgeons in back surgery. Today many interventions uses X-ray imaging, but he wanted to develop methods that allow a combination of ultrasound and MRI imaging to be used instead. In this way, the surgeon gets three-dimensional and more detailed images to navigate, as well as reducing the use of X-rays in the operating room.

Supervisors: Toril A. Nagelhus Hernes, Ingerid Reinertsen, Frank Lindseth og Ole Solheim

Dissertation took place 14th September 2018
Master’s degree - completed in 2018

Anders Mostrøm Nilssen

During the summer 2018 Anders submitted his master thesis at the Department of Energy and Process Engineering at NTNU Trondheim. The thesis was a collaboration between NTNU and the Operating Room of the Future. The thesis was based on the challenges related to surgical site infections and how the ventilation system may affect the risk of developing such infections. The main objective of the thesis was to characterize the airflow distribution in close proximity to a patient in a supine position in two operating theatres with different ventilation systems. The two investigated systems were a mixing system and a vertical, laminar airflow system. Hence, Anders performed measurements in two operating theatres at St. Olavs hospital in order to investigate the impact of various factors in the operating zone, and also to identify the characteristics of the airflows of the two systems.

The results indicated that the airflow close to the patient, in both operating theatres, was affected and altered due to the presence of heat sources and physical obstacles. The results from the operating theatre with a laminar system demonstrated a larger range of values for both the velocity and turbulence intensity than those of the operating theatre with a mixing system. Also, the results suggested that the laminar airflow was unable to suppress the impact of the heat sources, causing the supply airflow to decelerate because of the convective airflow originating from the patient. The operating theatre with a mixing system demonstrated in general higher levels of turbulence intensity than the one with LAF. It was also observed that the values of both air velocity and turbulence intensity were less affected by the heat sources and obstacles. A third observation was that the largest variations occurred 15 cm above or closer to the patient. Therefore, future design of operating theatre ventilation should consider the patient, surgical team, surgical lighting and equipment both as heat sources and physical obstacles.

Geir Andre Pedersen

Master of Biomedicine at the Department of Natural Sciences, Faculty of Health Sciences, OsloMet - City University. Performed at St. Olavs hospital.

“Quality assurance and technical aspects of embolization of uterine myomas”

Radiological intervention procedures are constantly growing as a result of new and more modern devices and examination methods. Due to the fact that the largest man-made contribution in radiation dose to the population comes from radiological procedures, it is important to provide a knowledge base on the quality and efficacy of such procedures. It is important to meet national quality requirements and that the treatment they receive is effective and safe.

The purpose was to carry out an internal quality assurance study of the procedure UAE at St. Olav’s hospital as part of systematic quality work. This quality assurance study was conducted to elucidate whether the patients receive the treatment they are entitled to, and whether the treatment is in line with current recommendations. It was therefore chosen to look at a well-established method for embolization of uterine myomas (UAE) to assess this. Both efficiency and patient safety were in this quality study compared to international and national findings.

Supervisor: Knut Haakon Stensæth, St. Olavs hospital
Supervisors: Berit J. Brattheim, NTNU and Siv-Marit Lamøy, St. Olavs hospital
Date: 15.12.2018.
Martin Henrik Hassel

Perioperative monitoring of cardiac function based on transesophageal echocardiography.

Major cardiac interventions are known to have a negative impact on heart function. Patients that undergo cardiac surgery have their heart carefully monitored perioperatively in order to determine whether the heart restores well and maintains/improves the desired functionality. The aim of this master was to develop methods that compute cardiac function parameters automatically by a combination of speckle tracking and velocity estimation from tissue Doppler measurements and allow for automatic monitoring of heart function.

The methods have been validated on in vivo acquisitions of B-Mode images and tissue Doppler measurements for the three most used cardiac planes: 4 chamber, 2 chamber and long axis, recorded from five patients that all underwent cardiac surgery that required bypass.

The results from the application have been compared with manually derived ground truth measurements. The results show that MAPSE was derived with a mean difference of 4.4%, for cardiac regions with good image quality. The results show great promise for practical use and have shown that it is possible to automatically compute MAPSE on images acquired in the operating room.

Guri Bråthen

The master’s thesis “Simulation and Experimental Study of the Indoor Environment in a Norwegian Hospital”, written by Guri Bråthen, was conducted in cooperation with St. Olavs hospital and the Norwegian University of Science and Technology, NTNU during the spring semester of 2018. In the master’s thesis, the indoor air quality and thermal environment, and how this affect the health of the medicine staff at the Mobility Centre at St. Olavs hospital were investigated. The perceived indoor air quality and indoor-related symptoms were evaluated in correlation to health, by performing field measurements and a survey, in addition to creating a simulation model of the respective floor to simulate the indoor climate and possible measures to improve the current indoor air quality and thermal environment by using the simulation tool IDA ICE.

The findings of this master’s thesis show an overall sufficient indoor air quality and thermal environment at the second floor of the Mobility Centre based on the results from the performed field study. The results from the survey show that the most reported perceived indoor related symptoms were dry air (40%), poor air quality (32%) and too low temperatures (19%). Seen in correlation with the literature review, the perception of these indoor related symptoms can cause significant health effects, which can result in a higher sick-leave by decreased motivation and productivity for the hospital workers. The results from the simulation investigating the same parameters in three representative rooms, show a deviation from the measured results from the field study. In Norway today, few studies have been conducted regarding indoor climate in hospitals. Hence, this master’s thesis can hopefully raise the possibility of future research and health strategies to improve the working environment for medical workers in Norwegian hospitals.
Bachelor degrees - completed in 2018

Faculty of Medicine and health sciences, NTNU
Bachelor’s degree program Nursing

Sigrid Utvik
«Group Nursing and Patient Nursing at the Surgical Department. With particular emphasis on the nurses’ perspective on how the organization of the nursing group affects the nurses’ working day and the patients’ safety»

Marte Bygdås
«Models of care at surgical units and identification of patient deterioration»

Sigrid Voll Eek
«The correlation between model of care and medication administration at a surgical unit»

Julie Åsmul Landrø
«Model of care and pain mapping of surgical patients»

Faculty of Medicine and health sciences, NTNU
Bachelor’s degree program Radiography

Anne Martine Lundberg, Anne Beth Hoie and Kristin Overvik Myran
«Ultrasound Related Applications in Augmented Reality. Can AR better understand the relationship between anatomy and ultrasound?»

Student presentation, May 2018
Photo: FOR
Postdoctoral staff affiliated with FOR

Erik Smistad, Postdoc ISB, NTNU / Researcher SINTEF

The use of navigation technology in combination with 3D models from images partly overcomes the difficulties of minimally invasive interventions, such as the reduction of field of view, lack of agility and tactile feedback.

Erik works with automatic segmentation of cancerous tumors, heart, blood vessels, nerves and respiratory tract from MRI, CT and ultrasound images in several areas such as lung, neuro, anesthesia and cardiology.

The research interests of Erik include: image segmentation, machine learning and neural networks, parallel and GPU processing, ultrasound.

David Bouget, NTNU(ISB/CIUS)

3D CT imaging for automatic detection of lymph nodes. To perform diagnostic and to choose the right treatment for lung cancer, it is important to detect lymph nodes in the mediastinum and identify their exact specific anatomical location. While the primary tumor is usually easy to identify in the lungs, finding out if the cancer has spread to nearby lymph nodes is more challenging. Therefore, the goal of this project is to develop methods for improving the automatic detection of the lymph nodes from 3D CT images. For this, we propose a combination of deep learning networks for performing concurrent pixel-wise segmentation of fifteen different anatomical structures and instance detection of the lymph nodes. The segmentation knowledge of all other anatomical structures is necessary for performing lymph node station assignment. The result, planned to be forwarded to the surgical team, is an overview of identified lymph nodes with centroid position and full-extent segmentation. A first prototype of the software has been developed and validated on CT data from 15 patients for the task of lymph node detection. Preliminary results show that the algorithm can detect all relevant lymph nodes.

Lymphnode detection
Photo: Private
Håkon Olav Leira

Håkon Olav Leira, is a consultant at the Department of pulmonary diseases, St. Olavs hospital and researcher at ISB, NTNU. The focus is research on lung cancer, especially bronchoscopy navigation system as part of USIGT, FOR and NorMIT.

In the project they develop advanced diagnostics equipment for lung cancer. Small lung tumors can be difficult to find when you want to sample them. The reason for this is that the airways in the lungs have myriads of small branches, and it's easy to get lost when you try to control equipment down to the tumor. They are developing a tracking system that remind you of the GPS systems used in cars. As a map they use the patient's own CT images.

From 2018 we have started a European cooperation with centers in the Netherlands and Ireland, and the purpose is to develop a complete navigation system for the lungs. This was presented in Adresseavisen (https://www.adressa.no/pluss/nyheter/2018/02/26/Slik-vil-kreftlegene-finne-skumle-lungesvulster-16158295.ece) and Gemini (https://gemini.no/2018/02/teknologiutvikling-gir-nytt-hap-pasienter-lungekreft/).

Sigrid Berg and Rune Hansen, NTNU / SINTEF

Imaging of ultrasound contrast bubbles at high frequencies. Microbubbles, consisting of thin lipid shell and gas core, are used in the clinic to provide better images of microcirculation in echocardiography and cancer diagnostics. With clinically available ultrasonic machines, bubbles can be depicted at relatively low frequencies (2-5 MHz) and low pressure (MI = 0.1). At high frequencies, one must typically use higher pressures to activate bubbles, and thus it will no longer be possible to suppress the signal from the tissue in a satisfactory manner. We have been working on implementing a new method for depicting bubbles at high frequencies on the research scanner Verasonics (Normita). By combining high frequency imaging pulses with low-frequency manipulation pulses, we achieve both a high signal from the bubbles and a good suppression of the tissue. The method is patented proceeding and has been implemented on linear transducers with frequencies from 5 to 25 MHz, this includes transducers from Verasonics, GE and Visualsonics. When methods for imaging bubbles are developed, it is important to have validated information about the pressures and frequencies of the transducer transmits. To characterize transducers we have used NorMIT’s Onda AIMS III system.

To the left: Lab setup for optimization of imaging methods of microbubbles. The bubbles are pumped from a plastic tank and through one flow channel in a tissue-smoothing material. To the right: Example of ultrasound recording from flow model, were you can see strong signal from bubbles flowing through the channel and weak signal from the material around.

Photo: Private
Sébastien Muller, NTNU / INM / SINTEF

Project Title: MultiGuide; Development and Safety. The main focus is implementation of feasibility and usability (human-machine interaction) studies for quality assurance and documentation of the operating procedures. An automatic detection of surgical phases based on machine learning has been completed and published. Technical validation of the new display device being developed for the MultiGuide is on its way with a special focus on navigation accuracy related to different elements of the navigation system (hardware and software). Furthermore, the clinical validation for each application is carried out in close cooperation with clinicians. For each clinical study, the postdoc will be responsible for registration of adverse device effects (ADEs). This is harmful events that occur due to error or lack of procedures, software or the medical device (MultiGuide). These registrations will be based on "Clinical investigation of medical devices for human subjects - Good clinical practice, ISO 14155". Such registration is necessary for future CE marking of the MultiGuide.
PhD degrees – Ongoing

Amar Aganovic

As a part of the PhD study on “Control of airflow distribution methods enabling better indoor environment in health-care facilities” we investigated the impact of surgical lights on the velocity distribution and airborne contamination level in two operating rooms equipped with laminar airflow systems at the orthopaedic department of St.Olavs hospital. The work was carried out in collaboration with Liv-Inger Stenstad and Jan-Gunnar Skogås from FOR and under supervision of Guangyu Cao from the department of Energy and Process Engineering at NTNU. The study [1] showed that the wakes created behind the three differently shaped surgical lights were characterised by relatively high turbulence intensities and by velocities low enough for microbiological particles to deposit on critical surfaces such as wounds. This was confirmed in the same study by the occurrence of bacterial counts in the sterile field during mocked surgeries performed under surgical lights. An additional mock surgery that was performed without lights did not record a single bacteria count. The conclusion was that medical equipment such as surgical lights may impede the ventilation system’s ability to clear contaminants from the sterile field. We are currently analysing the combined effect of surgical lights and the fluoroscopy imaging device on the airborne contamination in operating rooms with laminar airflow systems.

Anna Rethy

“Navigated 3D laparoscopic ultrasound in treatment of liver tumours.”

Clinical PhD candidate.
Research of the use of laparoscopic ultrasound in primary tumors and metastases in the liver. She has also investigated position changes in solid organs by establishing air in the abdominal cavity for laparoscopy, and how navigation technology can be used as well. She has worked with multimodal liver models to simulate tumors and test multimodal image formation and training with laparoscopy and navigation instruments.
Supervisors: Ronald Mårvik and Thomas Langø

Kent Are Jamtøy

Botulinum toxin type A blocked by sphenopalatin ganglion by chronic pain and inflammatory conditions in the craniofacial region.

Innomet is a research group based at St. Olavs hospital and the Norwegian University of Science and Technology (NTNU) in Trondheim. A new method of blocking ganglion sphenopalatinum (SPG) with botulinum toxin type A (BTA) has been developed. This is done using a navigation-based instrument (MultiGuide) to ensure accurate deposition of BTA. The method is performed in 10 patients with headache pains with transnasal access under the anesthesia of the endoscopic block of the sphenpalatine ganglion in intractable cluster headache. A pilot study on chronic migraine has also been published, where the injection is done with lateral access (through the cheek). This study also shows acceptable side effects and good potential for effect. In addition, there is also a pilot study on the injection of botulinum toxin against SPG by trigeminus nephralgia. In this PhD project, Jamtøy will inject botulinum toxin against SPG by chronic rhinosinusitis with nasal polyps and atypical facial pain. Jamtøy plans to complete his research with a 50% position over 6 years.

Amar Aganovic
Photo: Private

Anna Rethy

Kent Are Jamtøy
Photo: NTNU
Javier Pérez de Frutos

Intraoperative registration techniques for improved ultrasound based navigation in laparoscopic soft tissue surgery. Technological PhD linked to the HiPerNav EU project (ITN), SINTEF/NTNU/IDI.

One-click registration method Lab study of the feasibility of the one-click registration method, implemented in the foundations of NorMIT-navigation software, before doing clinical tests. This study was presented in CARS 2018 conference.

Assessment of tracking systems target registration error. This study aims to assess the performance of optical and electromagnetic tracking systems in terms of target registration error. For this, both tracking systems where tested in a real OR environment using a phantom made specifically for such tests. This study was carried out as a collaboration between The Intervention Center in Oslo and SINTEF Medical Technology research group. Pending of acceptance in EMBC 2018 conference.

Those were the two publications which Javier Pérez de Frutos authored and co-authored in 2018:

- The first one (CARS 2018) presents laboratory tests of the Single Landmark Registration Method (SLRM). A patient-to-image registration technique developed by the medical technology research group of SINTEF. This algorithm is meant to be quick, reliable and easy to use in minimally-invasive surgery, and it is already available in the open-source CustusX platform.
- The EMBC 2018 paper assess the accuracy of the two most used tracking technologies in minimally invasive surgery: optical and electromagnetic tracking systems. Also details the pros and cons of each technology, highlighting the accuracy of the optical tracking systems and the possibility of track with no direct line of sight of the electromagnetic technology.

Cecilie Våpenstad

“Exploring and validating simulation-based minimally invasive surgery training”

Technological PhD candidate.

Looking at how technology enhanced learning using simulators can improve and ensure quality on surgical skills within laparoscopy.

Supervisors: Toril A. Nagelhus Hernes, Ronald Márvik and Petter Aadahl

Arne Kildahl-Andersen

PET and advanced ultrasound in navigated bronchoscopy

The project is part of the activity in the research group LUNA – Lung Navigation (part of the National Competence Center for ultrasound and image-guided treatment) which is a collaboration between Sintef, NTNU and St. Olavs hospital. The group has long track record with electromagnetic navigation integrated in the bronchoscope. Together with the project group, Arne will continue to work on ultrasound bronchoscopy integrated with electromagnetic navigation and PET-CT. A clinical trial of Fraxinus, a navigation software for virtual bronchoscopy will be performed. In addition, Arne will explore the possibilities for improved diagnostics of peripheral lung tumors by combining ultrasound and navigation.

Main supervisor: Håkon Olav Leira
Geir Arne Tangen

"Enhanced Minimally Invasive Therapy". Technological PhD candidate.
The purpose of the project is development and testing of methods for integration of navigation technology in endovascular procedures. This involves accurate match between image information presented to the operator and catheter/guidewire movements inside patient vascular anatomy.
Supervisors: Petter Aadahl og Toril A. Nagelhus Hernes

Rita Elmkvist-Nilsen

“Mapping Brain Plasticity”
Rita Elmkvist-Nilsen’s PhD project examines the formative role of newer imaging technologies playing as knowledge-producing, diagnostic and therapeutic tools in neuroscience research practice. The project addresses newer approaches in cognitive neuroscience that considers the brain as an adaptive and dynamic body of plastic potential and, through diffractive reading, actualizes recent human-scientific perspectives on human perception and cognition as bodily rooted, relational, situational, action-oriented and shaped by technological medias.
Supervisors: Aud Sissel Hoel and Anne Beaulieu
Medical Student`s Research Programme Faculty of Medicine and Health Sciences, NTNU

At the Faculty of Medicine and Health Sciences, NTNU, a separate research programme has been established around the ordinary study in medicine. The research programme involves two additional semesters devoted only to research, and that research is organized in parallel with the medical studies.

The research programme is an offer for medical students interested in deepening research and a possible future research career, possibly in parallel with clinical activities.

Admission to the research programme takes place after two or three years of medicine studies at NTNU. From the autumn of 2002, the research programme was established at all four medical faculties in Norway, based on a wish to recruit more medical students to research, improving the organization of research education, and promoting scientific attitude for the practise of medicine.

Erik Nypan

Three-dimensional visualization and navigation in endovascular procedures.

Abdominal aortic aneurysm (AAA) can be treated endovascularly by stent graft insertion. Endovascular treatment is not possible for all aneurysms depending on anatomy, but more advanced stent grafts allowing fenestrations or branches through the graft is becoming increasingly prevalent. Image fusion, which allows more detailed anatomic information to be used intraoperatively, is introduced in the last years. The aim of this project is to facilitate better endovascular visualization and navigation in endovascular aortic procedures. The project has several sub studies, and consists of studies conducted on phantoms, animal models and in patients. An integral part of the project is to study the feasibility of combining preoperative imaging to the patient on the operating table. By using a position sensors integrated into instruments, it is possible to record position data inside the patient. The position data may then be registered to the preoperative imaging and can be used for navigation. To further ease navigation during the operating, we also study the feasibility of a steerable catheter with an integrated position sensor.

Erik defended his medical student research thesis in November of 2018. He is now finishing his medical studies and will start as a PhD-candidate at ISB, NTNU 1. September 2019 where he will continue on the project.

Main supervisor: Frode Manstad-Hulaas
Assistant supervisor: Reidar Brekken

Henrik Runde

The study "Mortality, Physical Function and Quality of Life in Patients Treated within the Standardized Patient Care Fast-track Hip Fractures" is a prospective cohort study including 118 patients treated at the Department of Orthopaedic Surgery, St. Olavs hospital. The aim of the study is to investigate how altered biomechanics in the hip affects physical function and independence in patients treated for hip fractures. While the patient was hospitalized, prefracture function and quality of life were measured with EuroQol EQ-5D-5L and two days postoperatively Short Physical Performance Battery (SPPB) was carried out with physiotherapist. Other information, such as medical history, x-ray findings and information related to the treatment, were recorded in the registry for hip fracture patients. 58 patients met to the 1-year control during spring 2018, where pelvic x-rays with calibration ball were gathered along with the clinical outcome measures EQ-5D-5L, SPPB, Haris Hip Score, Trendelenburg and VAS for pain in the affected hip. Measurements of biomechanical variables such as femoral offset, LLD (leg length discrepancy), CCD (caput-collum-diaphyseal angle) and collum shortening has been performed and will be analyzed in conjuction with the clinical outcome measures during summer 2019.

Main supervisor: Lars Gunnar Johnsen
Assistant supervisor: Trude Basso
In the first part of the project, we will perform a national multicenter study to assess patients that are treated with endovascular aortic repair (EVAR) for thoracoabdominal aortic aneurysms (TAAA). Open surgery for TAAAs are comprehensive operations, and mortality rates have been reported as high as 20% in small volume centers. Many patients are deemed too high risk to undergo open surgery. Recent years’ advancement in endovascular techniques have made it possible to treat TAAAs with an endovascular approach. In such interventions, a combination of the four main visceral arteries are incorporated into the stent graft. In the study we assess the short and medium term outcomes in patients treated with branched EVAR (t-Branch, Cook Medical) at the Norwegian centers. Patients from all four university hospitals in Norway are included. Mortality, complications and comorbid data will be compared with that of patients having undergone open surgery for their thoracoabdominal aortic aneurysms.

In the second part of the student research thesis, we will 3D print human aortic aneurysms and assess whether or not in situ fenestration is a feasible technique to revascularize the four main visceral arteries. In situ fenestration is a technique where a standard, non-fenestrated stent graft is implanted in the abdominal aorta in such a way that it covers the ostia of the visceral arteries. Thereafter, the stent graft is perforated at the artery ostia to revascularize the visceral organs. We will use an electromagnetic navigation system, which is not based on traditional fluoroscopy technology, to visualize the surgical instruments. An important research question is whether the electromagnetic navigational system is sufficiently accurate to localize the ostia of the visceral arteries. Two other major questions are how fast the superior mesenteric artery can be revascularized, and whether or not we can restore blood flow to at least one kidney within 30 minutes.

Main tutor: Frode Manstad-Hulaas
Side tutors: Reidar Brekken and Arne Seternes
Other projects

It is an important part of the Operating Room of the Future’s mandate to develop R&D projects and initiatives where researchers, clinical health professionals and industry/business partners can cooperate.

FOR’s goal is to create new knowledge and new solutions that are useful and used for the benefit of patients/relatives and healthcare providers. We are located at the intersection between research and innovation – between building new knowledge and new solutions and taking it into everyday use. Innovation is for us: Development of new products, services or organizational forms that contribute to strengthening health service, in terms of increased quality, improved work processes, increased safety for patients and employees, and thus contributes to value creation.

The interaction with the clinical partners is very important in order to ensure that the newly developed solutions, methods, processes and new knowledge is actually taken into use. We have our own infrastructure for testing of new medical technology and new treatment methods to ensure the bridge between the new and what is already routine. The Operating Room of the Future also carries out extensive cooperation with industry via national and international partners through various research and development projects. Cooperation with industry and business is an important part of creating good applications for the results of the research and development projects.

By funding NorMIT, the Norwegian Research Council has acknowledged that the Operating Room of the Future has methods and systems to be able to collaborate effectively with industry, business and clinical professionals and to create applications for new knowledge. The Norwegian Research Council as well as the EU’s framework programs for research and development emphasize that the use of research results is an important criterion for the allocation of research funding development programs. The allocation of NorMIT, which is now well underway, we see as a recognition of our focus on innovation and new applications. This also constitutes an important landmark in our strategic focus on new international research and development projects. In an international perspective we are experiencing great interest for our work and that we are increasingly attractive as a partner for EU’s framework programs for research and development as well as for industry and business partners.

TPO-150 study - Use of depot-opioid as pre- and postoperative pain relief in primary knee joint prosthesis

One of the studies in the project is the TPO-150 study. We know that multimodal pain treatment is effective for postoperative pain. It is known that patients with knee injury have more pain than patients with hip prosthesis. It has therefore been a goal to further optimize the pain treatment for this group. By testing an opioid that has two mechanisms of action (Tapentadol), the hypothesis is that the analgesic effect is at least as good as other morphine preparations, but that the drug is tolerated better due to minor side effects. The study is a randomized controlled three-arm study that compares Tapentadol with gold standard Oxycodone and placebo. Inclusion of patients ended in 2018.

Project Manager: Torbjørn Rian, Senior anesthesiologist, Clinic of Anaesthesia and Intensive care, St. Olav’s hospital

Prophylactic treatment with negative pressure at closed surgical incisions – Development project

In recent years there have been technological innovations and product innovations in wound healing treatment with negative pressure. This makes it interesting to evaluate the latest version of the treatment principle in a clinical context. A qualitative project with the purpose a systematically evaluating of patient satisfaction and user-friendliness/ease of use where NPWT is used.

Such a systematic evaluation of the treatment principle will therefore be able to provide important knowledge in the design of the service offer and in systematic improvement work.

The project will take place in a safe and controlled environment at The Operating Room of the Future, St. Olav’s hospital, University hospital in Trondheim, Norway.

Project Manager: Marianne Haugvold, The Operating Room of the Future, St. Olav’s hospital.

PAFFA-prosjekt
(Pain and function after fast track arthroplasty)

Head of the PAFFA-prosjekt: Tina Strømdal Wik

In the PAFFA project (Pain and function after fast track arthroplasty) they look at pain and function after surgery with total prosthesis in the hip or knee. Prosthetic surgery in the hip and knee joint are common procedures, and only in Norway more than 9000 patients are operated annually with new hip or knee joint. Long-term results after these operations are well-known, but many patients still have a lot of pain postoperatively and the days after surgery. The PAFFA project focuses on perioperative conditions that affect pain, function and quality of life.
Pilot for data-driven operation planning at the orthopedic department

The purpose of the project was to improve the utilization of operating rooms and personnel in operations at the orthopedic department at St. Olav's hospital by developing a prototype of a new decision support tool. Existing planning methods are manual and different for the three locations Trondheim, Røros and Orkdal. Although the innovation project was limited to a department at St. Olav's hospital, the hope was that the results could provide insight into the potential for resource improvement at several locations and departments. The prototype would be based on a master’s thesis at the Department of Industrial Economics and Technology Management (IØT) at the Norwegian University of Science and Technology (NTNU), which looked at planning methods based on optimization methods that take into account uncertainty in the duration of operations and the arrival of emergency patients. The models were to be used to plan the order and start time of operations at an operating room over a day. However, it became clear in the project that not all the preconditions for the model in the master thesis, such as data access and coding, were fulfilled, so that direct application of the model became difficult. The project therefore concentrated on developing better prediction for time use (time matrices) for a section of the orthopedic department and evaluating its use, both through tests against historical data and by testing in the planning of operations on this section for a period. The project was completed in November 2018. A phase two of the project is desirable.

New light and imaging technology in endoscopy

Over the last few years, many technological advances have taken place in endoscopic diagnosis and treatment. Fujifilm is one company that is at the forefront of this development. By using LED light as light source, researchers and product developers at Fujifilm have shown that by processing different wavelengths of light, the visualization of digestive tract lesions can be significantly improved when compared with conventional light sources. The different light modes used are BLI (Blue Light Imaging) and LCI (Linked Color Imaging) - see photos and images below. The potential of this technology is related to the earlier discovery of malignant tumors, and more accurate diagnosis and treatment of disorders of the digestive tract. Several controlled studies are under way internationally, which hopefully will clarify the benefit of the method. FOR in collaboration with gastro-lab performs a 6-month evaluation project of this technology, primarily aimed at the investigation and treatment of Barret's esophagus, a condition of the esophagus characterized by the development of an abnormal mucosa which can develop into cancer. The evaluation is led by Professor Reidar Fossmark. The project started in December 2017 and ended at the end of May 2018.

Radiation Hygiene Project "A Step Back"

FOR has acquired a dosimeter system that will raise awareness to the staff at the operating room when it comes to radiation protection. The dosimeter system shows on a screen how much radiation an individual is exposed to at any time, and how the movement pattern, distance and time can decrease or increase the received radiation dose. Eight dosimeters can be used simultaneously. There is great focus on radiation protection at St. Olav's hospital. There are many occupational groups within an operating room, including anesthesia staff, surgical nurses, surgeons, cardiologists, radiologists, radiographers, etc. Many of these can be exposed to scattered radiation from the patient. By raising awareness of individual movement patterns, and visually showing how their behavior affects received radiation dose, one can show how they can minimize radiation hazards, and provide radiation knowledge.

Want to try it out? Contact Liv-Inger Stenstad at FOR. liv-inger.stenstad@stolav.no

Radiosafe i2, «like a canari in a colemine»
Photo: Liv-Inger Stenstad, FOR
Health care personnel use much of their time to “cut and paste” information from various sources. This time is used at the expense of patient oriented activity.

Existing technology; “Robotic Process Automation” can tell you where the information can be retrieved and then do it by itself.

By using this technology health care personnel could get more time for direct patient contact. Thereby the patients can get the result of blood tests and other examinations quicker and perhaps reduce the risk of human errors.

The technology is already used by other professions. A challenge is that the RPA’s are not off the shelf and are not safe enough for hospital use.

St. Olav’s hospital and HEMIT will therefore develop PRA’s which are fulfilling the Norwegian safety requirements.
The digital employee

Operating Room of the Future is experiencing increasing interest in the automation of information flow and processes related to information processing. Clinicians want this to reduce "unnecessary" time spent so that more time could be spent on patient contact. The hospitals want this to increase productivity in line with the needs outlined in Strategy 2030. Patients see that they can get faster responses and treatment, as well as higher quality of service.

Traditionally, automation of information flow and information processing has required very labor-intensive integration between various IT systems. Moreover, integrations can be destroyed by software updates. We have therefore been in search of better and more effective approaches that do not present challenges of the kind I have outlined above.

Robotic Process Automation (RPA) is a very promising technology for both much more efficient integration and for the automation of information flow and information processing. An RPA can be implemented faster, cheaper and more flexibly than today’s solutions. To distinguish RPA from industrial robots, ie mechanical and physical robots that have existed for over 50 years, here comes a definition and description of what RPA is:

RPA is the use of technology that automates work processes primarily for administrative work. It is a type of automation where a computer mimics a person's action in performing rule-based and repeatable tasks. In the context of important administrative day-to-day functions, RPA work automation is a software on a computer that uses existing software in the same way an employee does. For example, this may be in a bank where the staff must enter data in 20 different systems to register a new customer. This is often repeatable and rule-based work. By automating the existing process without changing the workflow and IT systems, a computer with RPA software can automatically key in and record most of the customer data. RPA is thus software that is installed on a computer and performs work on existing systems according to defined rules. This means, unlike traditional software, that RPA is a tool or platform that operates and orchestrates other software through existing user interfaces and is not integrated in that sense. RPA is not part of the information structure of a business, but is at the top of it. This enables a company to implement the technology quickly and efficiently without changing existing infrastructure and systems. The software is not designed to be a business application, but to represent an employee using business applications. Unlike mechanical robots, RPA is virtual robots. You don’t want to see or hear a physical robot in front of a PC that eats eagerly, but RPAs are computer robots that run on virtual computers.

In 2018, a Proof of Conception was set up, at the Medical Clinic, which showed how an RPA automated a regulated administrative task that doctors and other health personnel perform manually on the keyboard today. A number of areas have been uncovered at St. Olav's hospital where one can make use of this technology, and the benefits are: Administrative time spent becomes lower, time resource for other tasks becomes larger, significant cost reduction on administrative work, faster response time, reduction of risk of minimizing human error.

The RPA technology is developing rapidly, and we have now proven that it will work with us through an internal (St. Olav’s hospital) project with an external partner (Deloitte) in a test environment. The next step is to put it into operational operation as a pilot before it spreads out.

The future operating room will be project owner and have project management. Increased expertise in robotisation of resources at HEMIT and implementation of software could benefit the rest of the organization.

RPA technology handles information retrieval and compilation of appropriate information from different sources / applications without any outsider needing to set up structure. The RPA technology works automatically and 24/7.

The project will add increased value to St. Olav's hospital as a business, will facilitate the workday of many employees, will give the patient safer and faster follow-up and contribute to transferring resource use from administration to other important tasks. This measure is only a start on the opportunity to automate processes in many areas in different parts of the organization.
Translating earphone

St. Olav’s hospital annually spends a lot of money on the purchase of interpretation services. In many cases, there are ethical challenges in relation to the use of an interpreter, in other more personal reasons where the patient preferably sees that an interpreter is not present. The interpreting service now delivers telecommunications services, but then one loses important information such as the body language. Furthermore, the interpreter can make his own interpretations and does not necessarily tell verbatim what is being conveyed from the patient.

Waverly Labs develops the world’s first smart earphone that translates between languages. Pilot uses the latest technology in speech recognition, machine translation and portable technology to allow users to speak without language barrier.

Pilot Translating Earpiece is designed to allow two people who speak different languages to communicate freely with each other. How? Pilot Translating Earpiece uses specially designed noise-canceling microphones to filter out ambient sound from speech to someone who speaks. The speech then goes through the Pilot app, where layers of speech translation technology occur. Waverly Labs’ translation engine is a hybrid system that uses various statistically based speech translation technologies from several different sources. The translator process includes speech recognition, machine translation and machine learning, then speech synthesis. At the end of the funnel, the translated language will be sent to the other user carrying the second earpiece. Everything occurs simultaneously and without interruption, when two people talk to each other.

Pilot Translating Earpiece introduced with support for the following languages: English, French, Italian, Portuguese, Spanish, German, Russian, Hindi, Polish, Greek, Arabic, Turkish, Chinese Mandarin, Japanese, and Korean that will be added to multiple languages in succession.

The project will test and explore whether new technology can replace traditional interpretation services, or be an option in some cases.

Currently, tests are being conducted to see if Pilot translates well enough. The way this is done is through a control group consisting of personnel who speak two or more of the languages supported by the product. Participants read up pre-defined sentences to each other and provide feedback on the translation that Pilot makes good sense.

If the results are good, the project will further investigate what kind of impact this technology will have (either time saved and / or money saved)?

Alexander Moen
Innovation developer/ Operating Room of the Future
**Mixed reality and augmented reality in the operating room**

One of the main challenges for the surgeon during a minimally invasive intervention is to process the data coming from various image sources displayed on several screens, scattered around the operating room, and extract the most relevant information for the current stage of the surgery.

The main aim of this work is to test if it is possible to use augmented reality glasses in the operating room in order to display imaging data coming from different sources in either one selected field (surgical field view) or following the surgeon’s movement. The idea is to study if augmented reality glasses are of benefit and can be used to fuse and display various image sources. Second, we want to test the feasibility of displaying several live streams in one scene and merge this with the navigation scene (i.e. CustusX) and the image of the surgical field and display the fused result on an off the shelf holographic device (i.e. Microsoft Hololens).

**Sialoscopy - an aid in the diagnosis of tumors in salivary gland**

Sialoscopy is the inspection of the salivary gland with a thin, flexible instrument. The project aims to study the benefits of this method in the investigation of salivary stones, tumors and others diseases of the salivary glands. Currently St. Olavs hospital is the only place in Norway that performs these minimally invasive procedures, so patients are referred to us from all over the country.

**Botulinum toxin type A blocking of sphenopalatine ganglion in persistent idiopathic patients facial pain: a randomized, double-blind, placebo controlled pilot study**

The aim of the study is to investigate the effect and safety of injecting botulinum toxin A in the sphenopalatine ganglion in patients with persistent idiopathic facial pain.

**Injection of botox against SPG by persistent idiopathic facial pain:**

A study of 30 patients with half receiving placebo injection, then crossover after 6 months where patients will receive a new round of injections but with the opposite substance. Thus, a total of 60 injections are planned. This study started in 2018.

**Quality register for nasal sinus surgery and “Fast-track”**

St. Olav hospital established a quality and research register on 1st of January 2012 for patients undergoing endoscopic sinus surgery, where the quality of life is measured before, and 6 months after treatment. All endoscopic and open interventions are recorded on a continuous basis with regards to procedures and results. Fast-track is a standardized patient course for specific groups undergoing nasal sinus surgery that includes patient training, scheduling and follow-up. This allows for an efficient and socio-economic patient care. Furthermore, all this data is included in the quality register.
Scientific articles

Nilsen, Ann Helen; Thorstensen, Wenche Moe; Helvik, Anne-Sofie; Nordgård, Ståle; Bugten, Vegard.
Improvement in minimal cross-sectional area and nasal-cavity volume occurs in different areas after septoplasty and radiofrequency therapy of inferior turbinates.
European Archives of Oto-Rhino-Laryngology 2018 ;Volum 275. (8) s.1995-2003 NTNU STO

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BMC Ear, Nose and Throat Disorders 2018 ;Volum 18:2. s.1-10 NTNU STO

Moxness, Mads Henrik Strand; Wülker, Franziska Sophie; Skallerud, Bjørn Helge; Nordgård, Ståle.
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Crespi, Joan Vidal; Bratbak, Daniel Fossum; Dodick, David W.; Matharu, Manjit; Jamtøy, Kent Are; Aschehoug, Irina; Tronvik, Erling Andreas.
Measurement and implications of the distance between the sphenopalatine ganglion and nasal mucosa: a neuroimaging study.
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Manually Steerable Catheter With Improved Agility.
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Munkvold BKR, Jakola AS, Reinertsen I, Sagberg LM, Unsgård G, Solheim O.
The Diagnostic Properties of Intraoperative Ultrasound in Glioma Surgery and Factors Associated with Gross Total Tumor Resection.
World Neurosurg 2018 Jul;115():e129-e136. Epub 2018 apr 6 PMID: 29631086

Iversen DH, Wein W, Lindseth F, Unsgård G, Reinertsen I.
Automatic Intraoperative Correction of Brain Shift for Accurate Neuronavigation.
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Ultrasound-mediated delivery and distribution of polymeric nanoparticles in the normal brain parenchyma of a metastatic brain tumour model.

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Pérez de Frutos J, Hofstad EF, Solberg OV, Tangen GA, Lindseth F, Lange T, Elle OJ, Mårvik R.
Laboratory test of Single Landmark registration method for ultrasound-based navigation in laparoscopy using an open-source platform.

Anthropomorphic liver phantom with flow for multimodal image-guided liver therapy research and training.

Reynisson PJ, Hofstad EF, Leira HO, Askeland C, Lango T, Sorger H, Lindseth F, Amundsen T, Hernes TAN.
A new visualization method for navigated bronchoscopy.
Reynisson PJ, Leira HO, Langø T, Tangen GA, Hatlen P, Amundsen T, Hofstad EF.
Pulmonologist evaluation on new CT visualization for guidance to lung lesions during bronchoscopy.
Minim Invasive Ther Allied Technol 2018 Apr 27. Epub 2018 apr 27
PMID: 29703098

Ciobircaa C., Langoc T., Gruionuc G., Leira HO.,Gruioneu, L.G, Pastrama S.D.
A new procedure for automatic path planning in bronchoscopy

Geir Arne Tangen, Frode Manstad-Hulaas, Erik Nypan and Reidar Brekken.
Manually Steerable Catheter With Improved Agility
Clinical Medicine Insights: Cardiology Volume 12: 1–4, 2018

Guangyu Cao, Madeleine C.A. Storas, Amar Aganovic, Liv-Inger Stenstad, Jan Gunnar Skogås.
Do surgeons and surgical facilities disturb the clean air distribution close to a surgical patient in an orthopedic operating room with laminar airflow?
American Journal of Infection Control, 2018

Experimental Measurements of Thermal Plumes Profiles over a Simulated Patient on an Operating Table Indoorair, 2018

Anders Mostrøm Nilssen, Amar Aganovic, Guangyu Cao, Liv-Inger Stenstad, Jan Gunnar Skogås.
The effect of the thermal obstructions on the velocity and temperature field in an operating room with laminar airflow Indoorair, 2018

Kiss, Gabriel; Palmer, Cameron Lowell; Mjølstad, Ole Christian; Dalen, Håvard; Haugen, Bjørn Olav; Torp, Hans.
Augmented Reality-based Visualization for Echocardiographic Applications
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Spatial and Temporal Adaptive FIR Clutter Filtering
2018 IEEE International Ultrasonics Symposium (IUS)

Avdal J, Ekrol I, Torp H.
Fast Flowline Based Analysis of Ultrasound Spectral and Vector Velocity Estimators
IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, 2018

Fiorentini S, Espeland T, Berg EAR, Aakhus S, Torp H, Avdal J.
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Ekroll I, Wigen M, Fadnes S, Avdal J.
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Golfetto C, Ekroll I, Torp H, Avdal J.
3D Coronary Blood Flow Imaging: A Comparison of Automatic Adaptive Clutter Filters
2018 IEEE International Ultrasonics Symposium (IUS)

4-D Intracardiac Ultrasound Vector Flow Imaging–Feasibility and Comparison to Phase-Contrast MRI

Rindal HOM, Rodriguez- Molares A, Austeng A.
A Simple, Artifact - Free, Virtual Source Model
2018 IEEE International Ultrasonics Symposium (IUS)

Rodriguez-Molares A, Rindal HOM, D’hooge J, Måsøy SE, Austeng A, Torp H.
The Generalized Contrast-to-Noise Ratio
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Avdal J, Rodriguez-Molares A, Berg EAR, Torp H.
Volume Flow Estimation in Valvular Jets Using 3D High Frame Rate Ultrasound
2018 IEEE International Ultrasonics Symposium (IUS)

Adaptive Color Gain for Vena Contracta Quantification in Valvular Regurgitation
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Karabiyik Y, Ekroll I, Eik-Nes SH, Lovstakken L.
Quantitative Doppler Analysis Using Conventional Color Flow Imaging Acquisitions

Fatemi A, Torp H, Rodriguez-Molares A.
A dynamic Generalized Coherence Factor based on Van Cittert-Zernike theorem
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Bernard O, Bradway DP, Hansen HHG, Kruizinga P.
The Ultrasound File Format (UFF)-First draft
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Cao G, Nilssen AM, Cheng Z, Stenstad LI, Radtke A, Skogås JG.
Laminar airflow and mixing ventilation: Which is better for operating room airflow distribution near an orthopedic surgical patient?

Aganovic, A., Cao, G.Y., Stenstad, L.I., Skogås, J.G.,
Poster

Parts of Anders Møstrem Nilssen’s master thesis was presented at «Roomvent Ventilasjon» conference in Helsinki Finland, June 2018. Anders comes from the Department of Energy and Process Engineering, and the focus is on operating room ventilation. He has looked at the differences between mixed ventilation and Laminar Airflow Ventilation.

Lectures

Individual lectures / presentations at conference

Jan Gunnar Skogås. Fagdag Laboratoriemedisinsk klinikk. FOR-NorMIT som forskningsinfrastruktur, muligheter og samarbeide. 03.01.18.

Jan Gunnar Skogås. HEMIT fagdag; Virtuelt Undersøkelsesrom VER, prosjekterfølge og interessenter. 17.01.18.


Gabriel Kiss. FOR Fagseminar: Hololense. 25.01.18.

Gabriel Kiss. FOR Fagseminar: Hologrammer. 25.01.18.

Jan Magne Gjerde. FOR Fagseminar: 3D printing. 26.01.18.

Alexander Moen. FOR Fagseminar: Innovasjon og eksempler. 26.01.18.

Alexander Moen. Regionalt statusmøte HEMIT: Innovasjon og Induct software. 01.02.18.

Jan Gunnar Skogås. NTNU, DRIV-workshop: Hvilke muligheter gir FOR til medisiner og teknologistudenter? Ulike problemstillinger. 03.02.18.

Jan Gunnar Skogås. Universitetssykehuset i Nord Norge UNN: FOR-NorMIT som forskningsinfrastruktur. 06.02.18.

Jan Gunnar Skogås. Nasjonalt Toppledgerprogram kull 16, samling Røros: FOR-NorMIT som infrastruktur og muligheter. 20.03.18.

Alexander Moen. Nasjonalt topplederprogram samling Røros: Innovasjon ved St. Olavs hospital. 20.03.18.


Jan Gunnar Skogås. NFKH Kvalitetskonferansen 2018 - Endring og forbedring: Medisinsk Teknologi og minimal invasiv bildeveileddet behandling. 20.04.18.


Alexander Moen. Lungeavdelingens vårseminar: Innovasjon ved St. Olavs hospital og 3D printing. 25.05.18.

Jan Gunnar Skogås. MTF Landsmøte, Trondheim Conference Clarion Brattøra: NorMIT som forskningsinfrastruktur innen medisinsk teknologi og nye behandlingsmetoder. 04.05.18.

Jan Gunnar Skogås. Tongji University Shanghai: Operating Room of the Future, medical technology at St. Olavs hospital. 09.05.18.

Marianne Haugvold, Gabriel Kiss og Ståle Nordgård. Presentasjon og demonstrasjon av FOR stue ØNH, Kjeve ifm. Regional utdanningskonferanse. 07.06.18.

Jan Gunnar Skogås og Gabriel Kiss. Sony Corporation R&D. Operating Room of the Future, medical technology at St. Olavs hospital. 12.06.18.

Jan Gunnar Skogås, Alexander Moen, Liv-Inger Stenstad og Jan Magne Gjerde. Sint Maartens Clinic, visiting St. Olavs hospital. Infrastructure Operating Room of the Future, medical technology and NorMIT. 20.06.18.

Jan Magne Gjerde. Møte med seksjonsledere radiologi: Presentasjon av planer for 3d-print-lab 21.06.18.

Alexander Moen. CCSDI the co-creative interdisciplinary team. Innovasjon ved St. Olavs hospital. 23.08.18.

Alexander Moen og Gabriel Kiss. Statsrådssekretær Maria Bjerke med følge. Innovasjon ved St. Olavs hospital. 28.08.18.


Morten Uv, Otto Koch, Liv-Inger Stenstad. Omvisning på Dritosentralen i forbindelse med emnet TEP4315 - Inneklima, ved NTNU. 22.10.18.


FOR-related lectures

Konferanser med peer review av innsendt abstract/proceeding paper:


Andre inviterede foredrag o.l. (konferanser/symposier/ workshops/seminar):

Reinertsen I. Midt-Norge bidrar til å utvikle nye, avanserte behandlingsmetoder. HEMIT konferansen, Trondheim, mars 2018.


Fagseminar USIGT. 12 foredrag innenfor temaet til USIGT, alle prosjektene. Trondheim, januar 2018.

Lango T. Presentasjon ifm. møte ved UNN, Tromsø om NorMIT og USIGT. Tromsø, februar 2018.

Lango T. From medical imaging to models and decision support in minimally invasive interventions. Foredrag under Medical imaging Symposium, Haukeland, Bergen, mars 2018.

Reinertsen I, Lango T. Presentasjon av USIGT ifm møte med Patologi avdelingen, St. Olavs hospital, mars 2018.


Lango T. Foredrag om USIGT for elever fra KVT, Trondheim, april 2018.


Lango T. Presentasjon under Styringsgruppemøte NorMIT. Tilstede: alle 4 helseregioner, Oslo, juni 2018.


Lango T. Presentasjon av Trondheims samarbeidsmiljø innenfor USIGT og NorMIT under åpningen av de nye operasjonsstuene ved Intervensjonsenteret. 5. oktober 2018. Ca 180 deltagere, helsepersonell og helsepolitikere.


Leira HO, Langø T. Medical practice in 2050. Lecture in the session on Deep learning (DL) and artificial intelligence (AI) in medical diagnosis and clinical practice. SFI CIUS Fall Conference, November 27, 2018.


Våpenstad C. Presentasjon av pasient-spesifikk simulering ved EVAR prosedyrer ved Regional utdanningskonferanse i Trondheim 7. juni, 2018.


Langø T, de Frutos JP. Presentations at the annual HiPerNav meeting with the consortium and the EU commission project officer. Cordoba, Spain, September 17-18, 2018.

Langø T. Presentation of Trondheim medtech cluster incl USIGT for lung doctors in Cork during annual Eurostars Mariana meeting. September 20, 2018.

Langø T. Presentasjon av USIGT og miljøet i Trondheim på Skype for ca 50 ansatte ved BK Ultrasound i Danmark. 28. november 2018.


Gilstad, H. Examining communication, information exchange and decision-making in surgical patient pathways. ALAPP 2018; 2018-09-17 - 2018-09-19 NTNU.


Gilstad, H. Examining communication, information exchange and decision-making in surgical patient pathways. ALAPP 2018; 2018-09-17 - 2018-09-19 NTNU.
Visits at FOR 2018

7th June 2018 - Regional Education Conference 2018.
Presentation and demonstration of the FOR operating room ENT and maxillofacial surgery by Marianne Haugvold, Gabriel Kiss and Ståle Nordgård.
Regional Education Conference 2018 was arranged on the 6th and 7th of June at the Knowledge Center. Organizer was St. Olav’s hospital in collaboration with the Faculty of Medicine and Health Sciences, NTNU. The overall topic of the conference was "Collaboration on education for the future of health services - an optimistic approach to a demanding future image". The target group for the conference was trainers and practitioners in health and social education, managers and administrative staff from universities, university colleges and health services, students and users. On Thursday 7th of June, the participants at the conference had the opportunity to experience different teaching methods - and in this connection, the Operating Room of the Future invited the participants to a demonstration of FOR operating theater ENT and maxillofacial surgery. Professor Ståle Nordgård held a great demonstration of FOR operating room to great enthusiasm for the participants.

Professor Ståle Nordgård demonstrates the Operating Room of the Future, ENT and maxillofacial surgery
Photo: FOR
June 20th -21st Sint Maartens Clinic visits St. Olav’s hospital and FOR-NorMIT

FOR had a visit from the Sint Maartenskliniek in the Netherlands. A hospital specializes in orthopedics. We had, among other things, a tour of St. Olav’s hospital to show our hospital. There was also time to visit the exhibition at the Knowledge Centre.

We also visited Kirsten Rønning at NSALK. The participants from the Netherlands were fascinated by the simulators at NSALK. Then it was time for a visit to the orthopedic surgery department. They wanted to see how St. Olav’s hospital has organized the operating department since they are building seven new operating rooms at their own hospital.

August 28th State secretary Maria Bjerke, along with Vidar Kårkstad and Anders Vældi, gave a visit to St. Olav’s hospital. Theme for the visit was innovation. They were impressed by the ultrasound technology that are developed in collaboration between St. Olav’s - NTNU and the industry. They gained insight into some of the freshest research on ultrasound and sepsis. The development that are done within the Sepsis field and the technology that lies in it, is groundbreaking. Gabriel Kiss presented FOR- NorMIT infrastructure and provided an insight into the projects in progress. He also demonstrated HoloLens and explained how it is intended to be used by the hospital. The visitors was clearly impressed by the clear picture and what opportunities this could offer.
Visit from The Parliament’s Health and Care Committee
The Parliament’s Health and Care Committee has visited St. Olavs hospital and the Operating Room of the Future was selected to hold a presentation with the topic: Simulation and the future operating room. An overview of FOR’s activities, including on-going projects and future initiatives was presented by Gabriel Hanssen Kiss (FOR). Several research and development projects were presented where FOR and its collaborators (NTNU, SINTEF and industrial partners) are involved. This was followed by 25 minutes of discussions related to the feasibility of adopting methods developed at FOR in a broader context, active collaboration with the Oslo group at the intervention center as part of NorMIT, as well as future areas of focus for FOR. The visit took place in October 2018.

On Thursday 25th of October we had full-day visits from Orkdal hospital. A total of 23 operating and anesthetic nurses had taken the trip to the hospital to see what the operating room of the future has to offer. There were some lectures and guided tours of three of the FOR-operating rooms. We thank Oddrun Krogstad and her wonderful staff for the visit.
FOR media contributions

1. The Future Hospital Operating Rooms, workshop DRIV NTNU
   https://engage-centre.no/the-future-hospital-operating-rooms/

2. Dagbladet, 22.02.18
   Liten oppfølgnings kan gi store framskritt – Hils på doctor robot

3. NTNU
   https://innsida.ntnu.no/start#/feed/6ca5671b-85b5-3d7f-9b-ba-cf6eb6ae131c

4. SINTEF
   https://www.sintef.no/siste-nytt/3d-teknologi-forenkler-operasjon-mer-hovedpulseren/

Photo: Dagbladet
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www.stolav.no/en/for

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