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NordicSMC: A Nordic University Hub on Sound and Music Computing

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ABSTRACT

Sound and music computing (SMC) is still an emerging field in many institutions, and the challenge is often to gain critical mass for developing study programs and undertake more ambitious research projects. We report on how a long-term collaboration between small and medium-sized SMC groups have led to an ambitious undertaking in the form of the Nordic Sound and Music Computing Network (NordicSMC), funded by the Nordic Research Council and institutions from all of the five Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden). The constellation is unique in that it covers the field of sound and music from the "soft" to the "hard," including the arts and humanities, the social and natural sciences, and engineering. This paper describes the goals, activities, and expected results of the network, with the aim of inspiring the creation of other joint efforts within the SMC community.

1. INTRODUCTION

The Sound and Music Computing (SMC) research field approaches the whole sound and music communication chain from a multidisciplinary point of view. By combining scientific, technological, and artistic theories and methodologies it aims at understanding, modelling and generating sound and music through computational approaches. One challenge, however, is to be able to establish large enough research groups with sufficient critical mass.

While some large SMC research groups have emerged in recent years, such as the MTG Music Technology Group at UPF in Barcelona and the Centre for Digital Music at Queen Mary University London, most SMC research is still carried out in small or medium-sized groups. The lack of a large local community often makes it difficult to develop study programs and research education. Several European network projects have focused on bringing together researchers over the years, and the SMC Roadmap [1] has also helped in making the field gain momentum. But in parallel to the European/international initiatives, we still see the need for more local undertakings.

Our approach to handling this is through the establishment of the Nordic Sound and Music Computing Network (NordicSMC), funded by the Nordic Research Council NordForsk and including institutions from all of the five Nordic countries: Aalborg University (AAU), Aalto University (AALTO), KTH Royal Institute of Technology (KTH), University of Iceland (UoI), and University of Oslo (UiO). The aim is that this network will create a solid foundation for carrying out high-quality SMC research and research education.

2. WHY A NORDIC SMC NETWORK?

There are already strong research groups and projects in each of the partner institutions, so the added value of NordicSMC is to develop a closer collaboration with exchange of facilities and competencies. NordicSMC has a natural starting point in the institutions' activities within the SMC network. [2] In recent years, three of the international SMC conferences have been hosted by the NordicSMC partners: AAU in 2012, KTH in 2013, and AALTO in 2017.

Even though it may be less known to the general public, the Nordic countries have, in fact, several examples of internationally successful companies in the SMC field. The Swedish company Spotify and the Norwegian company Wimp (now Tidal) are two prominent music streaming services that in less than ten years have re-energized the economies of a pirate-ridden music industry, and launched the idea of selling music as a service in which consumers have access to millions of songs from their devices. The teleconferencing system Skype, originally developed in Sweden, is heavily based on digital sound processing and real-time coding of audio and speech. The world-leading Cisco audio/video conferencing systems are developed in Norway, and Denmark is home to three of the world leading hearing-aid companies (Oticon, GN Resound, Widex), all depending on real-time digital audio processing.

The Nordic countries are also home to some of the world's most sought-after audio hardware producers, including the Danish B&O, the Finnish Genelec, the Norwegian Electrocompaniet, and the Swedish Teenage Engineering and Clavia Digital Musical Instruments, to name but a few. Their recent products are heavily based on

[1] http://smcnetwork.org/roadmap

[2] http://smcnetwork.org/

digital audio signal processing techniques, such as digital calibration, equalization, and sound synthesis. Due to the excellent mobile infrastructure in the Nordic countries, there are numerous startup companies developing innovative apps and games with worldwide coverage. Examples here include Helsinki-based Yousician, which has 25 million online users in their music edutainment systems, and SoundCloud, which was founded by a graduate from KTH in Stockholm.

The different groups involved in NordicSMC complement each others in a way that makes the Nordic Region an even stronger player in the field. For example, AALTO has a 25-year audio signal processing research tradition [1, 2], which will be complemented by the human-computer interaction and human experience evaluation present in the other groups. That way, the high fidelity sound simulations produced in AALTO can be tested from a human-centred perspective. Furthermore, AALTO has one of the leading research teams in spatial audio research [3]. KTH is well known for their high-quality research on expressive music performance, including emotions [4] and interactive sonification [5] whereas AAU is known for their high-ranking expertise in sound models and design for multimodal interaction [6, 7]. UiO has an excellent reputation for top research in embodied music cognition and motion capture [8, 9]. While still fairly recent, the small SMC unit at UoI is already conducting research at a high international level in tactile and auditory displays as well as binaural sound technology [10–13].

3. THEMATIC AREAS

The NordicSMC network will have five thematic areas, which to a large extent overlap with the thematic areas described in the previously mentioned Sound and Music Computing roadmap [3] . This roadmap was developed in the European coordination action "Sound to Sense, Sense to Sound" (S2S^2), in which the KTH and AALTO researchers participated. Each thematic area, and how we envisage using PhD projects as a way to connect the researchers and groups, are described in the following sections. Network activities will involve both faculty members and students from the involved institutions, with a focus on creating interdisciplinary and cross-institutional connections in different ways. Each thematic area is associated with one PhD position mainly based in one of the institutions of the network, but collaborating with at least one of the other institutions through research exchanges (see *Short Term Scientific Missions, STSM* below).

1. **Sound and music processing** (AALTO)

   Sound and music processing involves digital signal processing and machine learning techniques applied to the analysis, synthesis, and modification of sound and symbolic music data. For example music synthesis, which is today used for producing almost all modern pop/rock music, is based on signal processing emulating the sounds and effects, which were formerly produced using traditional musical instruments and equipment. At the highest conceptual level are content analysis methods, which aim at understanding music signals or data, such as automatic music transcription.

2. **Sound and music interaction** (KTH)

   The sound and music interaction area is strongly multidisciplinary including several research topics, such as expressive music performance, sonic interaction design (SID), interactive sonification, affective computing, body motion analysis, music therapy, new expressive musical interfaces (NIME), music information retrieval (MIR), multisensory perception and processing, and music notation.

3. **Embodied sound and music cognition** (UiO)

   The field of embodied cognition is based on the idea that the human body is an active part-taker in cognitive processes. Music researchers use this paradigm to focus on how the body moves in relation to music, both when producing and perceiving (musical) sound. The field is highly interdisciplinary, combining music theory and music cognition with empirical studies using advanced motion capture. It is also common to use sound modelling and musical instrument development as methods to understand the (embodied) cognitive processes.

4. **Music appreciation** (UoI)

   Modern cochlear implant systems are – in most cases – good at delivering speech. This is because the speech signal can retain its information content despite the heavy processing it undergoes. However, music on the other hand looses a large part of its details, and the details contribute to its appreciation. In order to improve the music appreciation of cochlear implant (CI) recipients other sensory systems, such as the somatosensory system, can be used. Tactile representation of music has the potential of improving the music appreciation of CI recipients.

5. **Virtual and augmented reality** (AAU)

   Virtual reality refers to simulations engaging different sensor modalities, such as vision, touch and audition, proprioception, smell and taste, where the user is fully immersed in the simulations. Augmented reality refers to a combination of the real world and a virtual world merged together. Virtual environments offer a controllable setting that can be used as a test bench to investigate how sound interactions are controlled and experienced in specific situations.

Figure 1 visualizes the planned collaboration between the partners in this network.

4. ACTIVITIES

4.1 PhD and Master's thesis projects

NordicSMC has employed five PhD fellows, one for each institution involved in the network. They will follow the

[3] For more information see here: `http://smcnetwork.org/node/884`

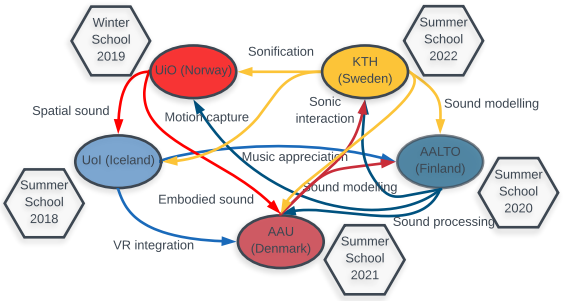

Figure 1. *NordicSMC partner institutions and the planned collaboration between them. The topic next to each arrow describes the shared topic of the collaboration. The arrow is pointing to the expert institution in that particular area whereas line colour refers to the home institute of each research visit. Each partner will arrange one summer school, as indicated by the hexagon with year next to each partner symbol.*

PhD training in their local institution, but will also benefit from the combined competencies of the network.

4.2 Short-term scientific missions

All PhD fellows within the network are encouraged to apply for one or more Short-Term Scientific Missions (STSMs) to other partner institutions for a period of 1–3 months. Such STSMs will also be available for other PhD fellows and excellent Master's students within the network.

4.3 Intensive PhD training schools

The NordicSMC network will organize one intensive PhD training school every year in 2018-2022:

2018: Reykjavik, Iceland
2019: Oslo, Norway
2020: Espoo, Finland
2021: Copenhagen, Denmark
2022: Stockholm, Sweden

The summer schools will be taught by professors and senior researchers from the five partner institutions, as well as a couple of world-leading international researchers each year. The added value of these summer schools will be high-quality intensive courses, which none of the partners would otherwise be able to offer. In addition to the students coming from the NordicSMC partner universities, the summer schools will be open to a limited number of students from other parts of the world. The summer schools will be an important arena for research exchange and networking among staff and students within the network.

4.4 Thematic workshops and seminars

The network will organize ad-hoc workshops and seminars in connection to the most prominent international conferences in the topic of Sound and Music Computing. This will be an arena to promote and disseminate research within the network, and to gather input from topical expertise outside the Nordic countries.

5. INNOVATIVE CAPACITY BUILDING

One of the added values of NordicSMC is to facilitate student entrepreneurship, by supporting the creation of students own startups in the field of SMC. This process has already started individually at the different institutions. For example, AAU has started a collaboration with the Danish Sound House in Copenhagen where students graduating from the SMC Master program can have a free seat and use the facilities for one year. This has inabled the creation of startups from students graduating from the program.

AALTO is a new, innovative, and multidisciplinary university combining three previous Finnish universities in the fields of art and design, economics, and technology, including Finland's oldest and largest technical university, formerly the Helsinki University of Technology. AALTO has several campuses, mainly in the cities of Helsinki and Espoo, where the Finnish ICT cluster is located. AALTO has a multistage structure for supporting innovation and startups., such as the Startup Sauna accelerator program. [4]

The Aalto Acoustics Lab [5] is located in the same building in which AALTO recently opened its new startup center A-GRID, the final stage of support for new companies, which has helped start 800 companies. The first startup company in the building, Hefio, designs and manufactures sophisticated headphones with a self-calibration capacity. Students of AALTO have developed *Slush* [6], Europe's leading startup event. AALTO's innovation ecosystem was recently ranked among the top five most promising ones in the world by MIT. [7]

UiO has a StartupLab on campus, serving as an incubator for startup companies, of which a handful are coming from former students connected to the network. The UiO also runs the highly popular entrepreneurial summer school ("Gründerskolen"), open for students from all disciplines and built around the idea of equipping students with the skills to start their own company. An example of successful innovation, is the commercialization project Computer-based Infant Movement Assessment (CIMA), in which computer vision tools and music-related motion analysis are used in a system for detecting the risk of cerebral palsy in early-born infants. The system is currently in clinical testing at several hospitals around the world, and is a proof that SMC research may lead to innovation also in other fields.

KTH has a structure for promoting innovation and entrepreneurship, KTH Innovation. [8] Since the beginning in 2007, KTH Innovation has played a central part at KTH when it comes to commercialising new ideas. "Through the years KTH Innovation has helped over 1900 new ideas from 1080 students and 850 researchers, including 275 professors. KTH Innovation specialises in the commercial-

[4] http://startupsauna.com/
[5] http://acousticslab.aalto.fi/en/
[6] http://www.slush.org/
[7] http://tinyurl.com/MITSkoltechInitiative
[8] https://www.kth.se/en/innovation

Figure 2. *A 64-channel Wavefield Synthesis setup and Virtual Reality equipment at the Multisensory Experience Lab at Aalborg University Copenhagen.*

isation of new technology at the earliest stages of development and offers free, objective, and confidential support in all areas relevant to taking an idea from research result to innovation." Successful companies such as Sound Cloud, Spotify, and Wallander Instruments [9] have been founded by students graduated from KTH.

NordicSMC will promote collective initiatives to support interested students to become entrepreneurs.

6. SHARING INFRASTRUCTURES

One important element of the NordicSMC network is the unique constellation of state-of-the-art infrastructures.

- AAU: A multisensory lab (see Fig. 2) including a motion capture system, a 64-channel wavefield synthesis system, different head mounted displays (VIVE, Oculus) and haptic devices, and an anechoic chamber. Additional facilities include stationary and mobile eye tracking devices and systems for psychophysiological measurements as well as extensive prototyping facilities (Fab-lab).
- AALTO: A large anechoic chamber, a small one with multiple spatial audio setups, another small anechoic chamber for other measurements, a standardized listening room with a high-quality multi-channel reproduction system, and sound-proof listening booths for subjective tests (see Fig. 3).
- KTH: Two rooms equipped with an optical motion capture system (16 cameras each) and 8-channel audio for sound spatialization, several inertial motion sensors, eye tracking systems (stationary and mobile), spatial audio (possibility to use the 29-speaker system at KMH Royal College of Music, Stockholm, through existing collaboration between KTH and KMH), several interactive humanoid robots (NAO), an interactive sound generation/control system with the new permanent installation at the Swedish Music of Performing Arts, *Ljudskogen* [10] (see Fig. 4) [14].
- UiO: The fourMs lab (see Fig. 5) is equipped with motion capture (optical and inertial), physiological sensing (EMG), eye tracking (stationary and mobile), and spatial audio systems (ambisonics and wavefield synthesis). The new Norwegian Centre of Excellence RITMO will house state-of-the-art neuroimaging facilities, rapid prototyping, and robotics.
- UoI: anechoic chamber (expected to be ready in 2018), binaural mannequin, HRTF measurement system, sound-proof listening booth for subjective testing, and eye tracking systems.

The added value comes from the fact that these infrastructures are shared within the NordicSMC network, exchanging know-how, methodologies, and tools.

Figure 3. *Parallel listening tests at Aalto Acoustics Lab.*

Figure 4. *The Sound Forest/Ljudskogen permanent installation at the Swedish Musem of Performing Arts (Scenkonstmuseet) developed by KTH.*

7. CONCLUSION

The NordicSMC network will identify and strengthen the Nordic potential in the field of SMC, and create new research pathways and agendas. Moreover it will create common guidelines for research and experimentation in the

[9] http://soundcloud.com, http://www.spotify.com, http://www.wallanderinstruments.com

[10] http://scenkonstmuseet.se/press/#/pressreleases/alla-kan-spela-i-ljudskogen-1926671

Figure 5. *The fourMs motion capture laboratory at the University of Oslo.*

SMC field, which are now dealt with using a wide variety of methods and tools, both hardware and software. Such methods/tools are today often incompatible and produce non-comparable results.

NordicSMC is designed to have an impact in the following areas:

- consolidation of the Nordic sound and music research domain;
- better integration of the Nordic researchers within the general international SMC research area;
- consolidation of music and sound research agendas in specific sub-domains, which are considered strategic in future societal arrangements, such as auditory display in disappearing and pervasive computing scenarios, human-computer interfaces, novel musical instruments, musical information retrieval and data mining, embodied interaction, gaming, design, rehabilitation, sports, robotics, and education.
- use the high-level scientific research to increase of Nordic innovation and competitiveness within SMC-related industries;

The NordicSMC university hub started its activities in the beginning of the year 2018, and PhD students will start their work in August 2018. The NordicSMC will tightly collaborate with the international SMC network.

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