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FOURMS, UNIVERSITY OF OSLO – LAB REPORT

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ABSTRACT

The paper reports on the development and activities in the recently established fourMs lab (Music, Mind, Motion, Machines) at the University of Oslo, Norway. As a meeting place for researchers in music and informatics, the fourMs lab is centred around studies of basic issues in music cognition, machine learning and robotics.

1. INTRODUCTION

How do we experience music? How does body movement guide our cognition? How can knowledge about movement and sound create better music technologies? These are some of the questions that we are working with in the interdisciplinary research lab *fourMs* (Music, Mind, Motion, Machines) at the University of Oslo.[1]

The fourMs lab was established in 2008 as a joint effort between the Departments of musicology and informatics. The initiative came after several years of contact between music researchers formerly affiliated with the *Musical Gestures project*[2] and informatics researchers from the group *Robotics and Intelligent systems* (ROBIN).[3] The common denominator is the mutual interest in studying both humans and machines as complex systems, and to analyse and synthesise such systems.

This lab report starts by presenting the facilities in the labs, followed by an overview of previous, ongoing and future research activities.

2. FACILITIES

Currently located in a temporary space on the northern side of the main university campus, fourMs will move into the new building of the Department of informatics in the spring of 2011. In addition to electronics labs, student workspaces and offices, we have four research labs: *motion capture*, *music interaction*, *rapid prototyping*, and *robotics*.

[1] `http://www.fourMs.uio.no`
[2] `http://www.fourMs.uio.no/projects/mg/`
[3] `http://www.ifi.uio.no/research/groups/robin/`

2.1. Motion capture lab

The motion capture lab is used for analysis of music-related movement and synthesis of sound and graphics from movement (Figure 1). The lab is currently being upgraded with state of the art motion capture, sound and video equipment. A 9 camera infrared marker-based optical motion capture system from Qualisys forms the centrepiece of the lab, and allows for very fast, precise and accurate measurement of body movement. Additional high speed video cameras complement the system, together with a wireless EMG sensor system, force plates, and other types of sensor systems. We are currently developing solutions that make it possible to record and play back data from all or any parts of the system in a flexible manner.

The lab will also be equipped with a 32 channel sound system, to facilitate studies of placement and control of sound in space through body movement. The speakers will be mounted so that the setup can easily be changed to test different types of spatialisation techniques and perceptual phenomena.

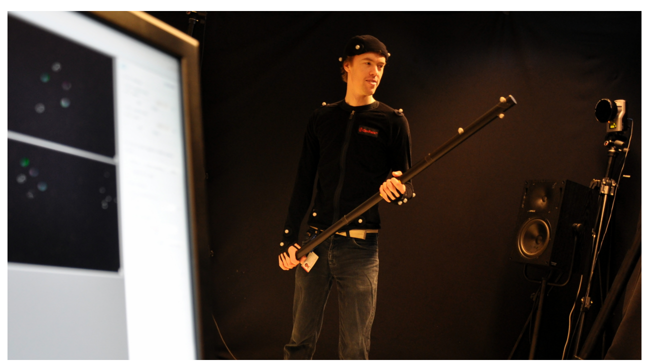

Figure 1. Research fellow Kristian Nymoen testing sonification of motion capture data from the Qualisys system.

2.2. Music interaction lab

The music interaction lab is used for temporary setups and flexible solutions. This lab also contains various types of motion capture systems: an XSens MVN BioMCH body suit for ambulatory motion capture, a Naturalpoint Optitrack infrared system, and a Polhemus Patriot 6D electromagnetic system. There is also a collection of video cameras, human input devices (HID), sensor systems, and custom-built devices.

For sound playback we have a collection of active speakers: large studio monitors, a 24 channel spatial audio rig (Figure 2), 12 portable active speakers used for laptop orchestra performances, bluetooth wireless speakers, hemispheric speakers, and various home-made speaker constructions.

Figure 2. Postdoctoral researcher Alexander Refsum Jensenius testing control of spatialisation in a 2D setup of the 24-channel speaker rig in the music interaction lab.

2.3. Robotics lab

The robotics lab contains the robot *Anna*, an advanced commercial Motoman IA20 industrial robot (Figure 3), in addition to a number of home-made robots and robotic systems.[4]

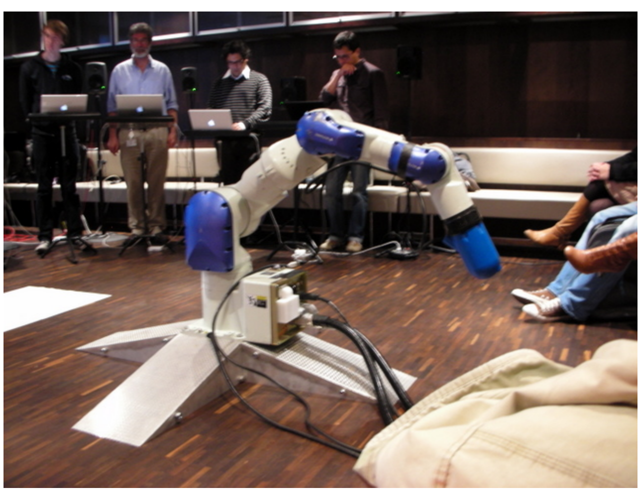

Figure 3. The robot Anna bows after conducting the Oslo Laptop Orchestra in a concert during Ultima 2008.

2.4. Rapid prototyping lab

The rapid prototyping lab contains different 3D printing and molding machines: a Dimension 768 and an Objet Connex 500. There are also a LPKF Protomat S62 circuit board plotter, and a fully equipped electronics workshop.

3. RESEARCH

The main research topic at the fourMs lab is that of *music-related movement*, meaning all types of movement that is connected to musical sound. This includes everything from the sound-producing actions of a performer, to various types of movements seen in people listening to music, or robot movements to music.

Our previous research has focused on body movements following some features in the musical sound, e.g. people performing ‘in the air,’ tracing sounds with a digital pen, and dancing to music. This research has been summarised in two recent publications, a text book in Norwegian [5], and a text book in English based on the EU Cost Action 287 ConGAS project [3].[5]

In the coming years we will continue to carry out such observation studies of various types of movements to sound, but will also increasingly explore the generation of movement in sound, animation and robots. Working on both analysis and synthesis of movement and sound ties into our general belief that performance and perception of music are inherently multimodal in nature, and that they co-influence each other.

3.1. Sensing music-related actions

The largest ongoing project in the lab is called *Sensing Music-related Actions* (SMA)[6] and involves 2 PhD students, 2 postdoctoral researchers, 3 professors and a number of master students. This interdisciplinary project applies scientific, technological and artistic methods to explore *action-sound couplings* in both performance and perception of music.

In the physical world there is a natural bond between how we perceive sounds and how we perceive the sound-producing actions and objects that generated the sounds [1]. In the digital world, however, such couplings between actions and sounds have to be designed. There is a tendency that this is reduced to a mapping problem, where a few input dimensions are connected to a few output dimensions. While this may result in satisfactory couplings in some cases, we are more interested in exploring action-sound couplings in more complex and composite systems, hence the need for advanced motion capture systems.

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[4] http://www.robotikk.com

[5] http://www.cost287.org

[6] http://www.fourMs.uio.no/projects/sma/

3.2. Motion capture

After working with video analysis and accelerometer based sensor systems for some years, we have realised that higher speed, accuracy and precision are necessary to capture the nuances and details in the material we are studying. Now we are able to do full body motion capture in a controlled lab setting using the new optical Qualisys system, and use the XSens MVN BIOCMH body suit for motion capture outside of the lab, e.g. in a concert hall. Combined with high speed video cameras, we hope this will give us the flexibility needed for studying a number of different types of music-related movements in various contexts.

A challenge we have been struggling with for several years, is that of being able to stream and store data from various motion capture systems together with related audio, MIDI, and video in a coherent and consistent manner. The need for solutions for recording, storing, synchronising and retrieving music-related movement data was discussed in a panel session at ICMC 2007 [6], and is still a big concern to many in the community. Our approach to this has been the proposal of the *Gesture Description Interchange Format* (GDIF) [7]. Since there already exist good solutions for streaming (e.g. *Open Sound Control* (OSC)) and storing (e.g. *Sound Description Interchange Format* (SDIF)) such data, we believe the main challenge here is to agree on *what* to store. A web forum has been set up,[7] and we plan to organise international workshops to develop GDIF further.

3.3. Machine learning

Working with the multidimensional data sets recorded in the motion capture lab calls for better machine learning techniques for being able to extract perceptually meaningful features from both movement and sound data. Here we are focusing on the design of self-learning and adaptable systems, to a large extent based on bio-inspired methods. In recent years our main focus has been on evolutionary computation, and the use of dedicated hardware, e.g. how *field programmable gate arrays* (FPGAs) can be applied in adaptable systems.

In the *Biological-Inspired Design of Systems for Complex Real-World Applications* project a general self-adapting classifier architecture implemented on a single FPGA chip was designed. It offers high speed classification with the same or better accuracy than many other classifiers. In the new *Context Switching sReconfigurable Hardware for Communication Systems* project[8] the goal is to introduce new configuration schemes to implement run-time reconfigurable hardware systems. This would allow high speed computing with hardware optimised for the task at hand.

[7] `http://www.gdif.org`

[8] `http://www.matnat.uio.no/forskning/prosjekter/crc/`

3.4. Music information retrieval

Up until now, music information retrieval (MIR) research has mainly focused on the retrieval of information from either symbolic music notation, metadata or audio. We believe it is a large and unexplored potential in also including knowledge and information about music-related body movement in MIR [2]. A body-centric approach could open new ways of retrieving, comparing, searching and analysing various types of sound and music.

3.5. Musical robotics

In addition to the analytical perspectives presented above, we are interested in exploring synthesis of both movement and sound. One such approach is to work with robot movements, and see how robots can be used to control musical sound, e.g. by performing on acoustic instruments or conducting an orchestra (Figure 3), or how they can move following features in the musical sound, e.g. dancing.

3.6. Rapid prototyping

Knowledge from the analytical studies is used to explore how music can be controlled through body movement. This is done through development of various new interfaces for musical expression. Here our rapid prototyping facilities open for quick and easy creation of new enclosures (Figure 4). We are particularly interested in exploring how the new Connex 500 printer can be used to create shapes of composite materials, e.g. controller/instrument enclosures with a hard inner structure and a soft shell. This will make it possible to protect the electronics on the inside, while at the same time give the user a better tactile experience.

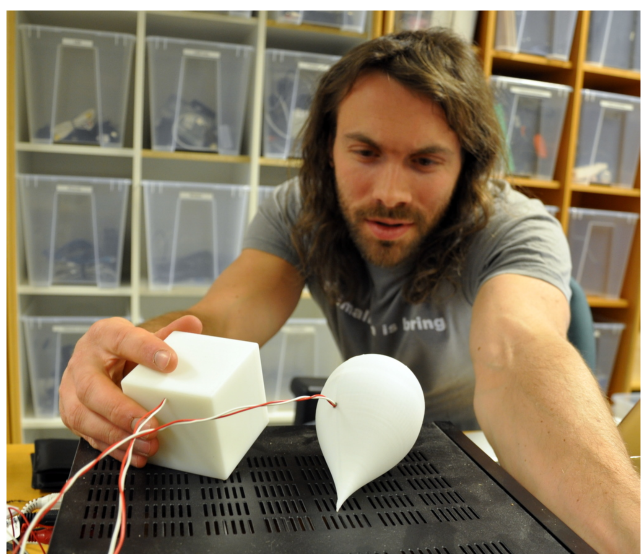

Figure 4. Research fellow Ståle A. Skogstad testing speaker enclosures printed on the Dimension 768 3D printer.

3.7. Sonic Interaction Design

Exploration of new interfaces for musical expression ties into our research carried out as partners in the EU Cost Action IC0601 *Sonic Interaction Design* (SID),[9] and the new EU FET project *Engineering Proprioception in Computing Systems* where we will contribute on bio-inspired computing and development of a mobile interactive media device.

3.8. Sound in space

The addition of a multichannel speaker setup in the motion capture lab opens up for exploratory research on sound in space. Our focus will not be on the spatialisation techniques themselves, but rather on how body movement can be used to control such techniques. Here we will work closely with spatial audio researchers, and work towards solutions for standardising movement and gesture descriptors so that they can be used to control spatial audio using the *Spatial Description Interchange Format* (SpatDIF) [8].

4. DISSIMINATION OF RESEARCH

The fourMs lab is mainly focused on basic research, but we also try to disseminate results from the research in various ways. This includes music and dance performances, installations, and displays in science fairs.

We do not have our own study program, but several courses are taught by researchers connected to the fourMs lab. These courses cover topics such as music technology, music cognition, machine learning and robotics, and prepare the students for carrying out coursework and master thesis projects in the labs.

One example of such a student project is shown in Figure 5. Through a collaboration with a neighbouring school, some students developed a video based system where children could play back and control their own recorded sounds by moving around on the floor in the school foyer. Programming was done using modules from the Musical Gestures Toolbox [4] (currently available in Jamoma[10]) and with sound processing in CataRT [9].

5. FUTURE PLANS

The fourMs lab has seen an exponential growth over the last few years, and we expect to be fully equipped and operational by the spring of 2011. Together with the Norwegian Academy of Music, we will host the NIME conference in Oslo 30 May – 1 June 2011.[11]

[9] http://www.cost-sid.org/

[10] http://www.jamoma.org

[11] http://www.nime2011.org

Figure 5. School children tests an interactive setup where they could play their own recorded sounds by moving on the floor.

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