Scientific Report

First name / Family name	Dirk Schröder
Nationality	German
Name of the *Host Organisation*	Q2S, NTNU Trondheim, Norway
First Name / family name of the *Scientific Coordinator*	Prof. U Peter Svensson
Period of the fellowship	15/05/2011 to 14/05/2012

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

I studied Electrical Engineering and Information Technology at RWTH Aachen University and continued as Ph.D. at the same university. I deepened in acoustics with special focus on physically based real-time auralization of rooms, which can be best described as the realistic simulation of how rooms sound. This is of special interest for creating immersive Augmented Reality (AR)/ Virtual Reality (VR) applications since their degree of immersion improves

drastically with the number of plausible simulated stimuli. During my time as ERCIM fellow, I carried out my research at the Centre for Quantifiable Quality of Service in Communication Systems (Q2S), Centre of Excellence, at the NTNU Trondheim in Norway. I had the great luck to work together with U. Peter Svensson, a well-known expert for the simulation of wave diffraction around edges – a task that is still unsolved in its entire complexity until today.

During my 12-month stay at Q2S my research encompassed basically three different topics:

(1) Audio realism in Augmented Reality/ Virtual Reality
Sound events in rooms originate from sound sources inside the user's room, but also from sound sources located in adjacent rooms. Depending on the current user's position some sound sources are in sight while others are occluded but still audible. Simulation methods that do not account for the wave phenomenon of diffraction produce sound field discontinuities and, thus, the auralization loses all of its perceptual realism as such discontinuities totally mismatch with real world experiences. In cooperation with HCU Hamburg, Germany, and RWTH Aachen University, Germany, fundamental research was carried out by Peter and me to further improve diffraction simulation methods with special focus on simulation accuracy and simulation performance.

(2) XML-based database exchange of acoustical material properties
In cooperation with HCU Hamburg, the open database project *openMat* was founded during my time as ERCIM fellow. The project is aiming at becoming a standard for the exchange of acoustic material descriptors. *openMat* is an open XML database format that supports a comprehensive characterization of both materials and objects. It supports not only all currently standardized acoustical properties but also meta-information in order to make the database applicable already during the early design stage of a room/complex of building.

(3) Interactive Real-Time Auralization for Immersive Augmented reality/Virtual Reality Applications
A software framework for the interactive and physically based auralization of virtual scenes is currently under development, which will integrated into Jordi Puigs's a-Me (Augmented Memories) immersive art project that will be exhibited at Meta.Morf 2012 in Trondheim. The key features of the auralization framework are 1) high quality audio rendering, 2) real-time capability and, most important, 3) ease-of-use.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

(1) INTERNOISE 2012, New York City, United States of America
On the accuracy of edge diffraction simulation methods in Geometrical Acoustics

Authors:
Schröder, D., Pohl, A., Svensson, U.P., Stephenson, U.M., Vorländer, M.

Abstract:

The most common methods for simulating room- and city-acoustics are based on the principle of Geometrical Acoustics (GA), where the sound field is decomposed into specular reflections and scattering components. Unfortunately, edge diffraction is not directly covered by this simplified model of wave propagation, but several approaches exist to add this important wave phenomenon to GA, mainly for the purpose of auralization and noise immission prediction. In this contribution, two approaches of edge diffraction modeling are discussed: a) Svensson's secondary source model that is directly derived from Biot-Tolstoy's wave-based theory and gives an exact solution for first-order diffraction, and b) Stephenson's energetic sound particle diffraction model, which is based on the uncertainty relation and known expressions for light diffraction from a slit. Both models are evaluated numerically for the examples of a single wedge, a slit and a double diffraction setup, where pros and cons of both approaches are elucidated. Furthermore, the applicability to different GA methods is discussed by analyzing numerical simulation errors and identifying areas of validity for the two approaches.

(2) INTERNOISE 2012, New York City, United States of America
OpenMat - an open XML-database for acoustical properties of materials and objects

Authors:
A. Pohl, D. Schröder, S. Drechsler, U.P. Svensson, M. Vorländer, U.M. Stephenson

Abstract:

The simulation of sound propagation in room- and city-acoustics is carried out by many researchers, acoustic consultants and others all around the world. Different software tools have been designed for specific simulation demands but usually rely on the same basic material characterizations. Unfortunately, there is no standard for the storage of such data yet. Many
file formats exist that are practically non exchangeable and, thus, hinder the data sharing withothers. To overcome this deficiency, the open database project openMat was founded. In this contribution, an open XML database format is proposed that supports a comprehensive characterization of both materials and objects, and that was discussed with many partners from the industry and research facilities during the first development stage. openMat supports not
only standardized acoustical properties, e.g., absorption and scattering coefficients but also meta information on the respective materials such as multilingual descriptions and data acquisition details as well as the link-up of arbitrary files such as textures and 3D models to make the database applicable already during the graphical design stage. For ease-of-use, an open-source and platform-independent database editor with a convenient

graphical user interface is available online at www.openmat.info.

(3) Acta Acustica united with Acustica, Journal
The publication of two journal papers is planned for 2012 in the Journal of the EAA (European Acoustical Assosication), Acta Acustica united with Acustica. These papers (approx. 40 pages in total) will be a joint work of D. Schröder, A. Pohl (PhD at HCU Hamburg, Germany), U.P. Svensson (Professor at NTNU Trondheim, Norway), U.M. Stephenson (Professor at HCU Hamburg, Germany) and M. Vorländer (Professor at RWTH Aachen University, Germany).

(4) ISMAR 2012, Atlanta, United States of America
In cooperation with Jordi Puig, two contributions are planned for the IEEE International Symposium on Mixed and Augmented Reality (ISMAR). The papers will describe the concept and implementation of the immersive audio-visual art project a-Me.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1) Forum Acusticum, Aalborg, Denmark, 26.06-01.07.2011
2) 1st ABCDE Seminar, Berlin, Germany, 10.11.-11.11.2011

Upcoming, after end of ERCIM fellowship:
3) INTERNOISE 2012, New York City, USA, 19.08-22.08.2012
4) ISMAR 2012, Atlanta, USA, 05.11.-08.11.2012

IV – RESEARCH EXCHANGE PROGRAMME (REP)

(1) SICS, Stockholm, Sweden

Duration: 16.04.2012 - 20.04.2012
Contact: Kristina Höök
Website: http://www.mobilelifecentre.org/

About
The Mobile Life VINN Excellence Centre was formed in 2007, and has established itself as an internationally recognized research locus in the area of mobile services. The centre is a joint venture between three research partners and nine industrial partners, in part funded by the Swedish funding agency VINNOVA. The research is interdisciplinary, involving researchers from computer science, interaction design, sociology, psychology but also game designers, artists, dancers, and fashion experts. (Excerpt from the website)

Experience
I experienced Mobile Life as an extraordinary institute, which can be described as an interdisciplinary melting pot of open-minded and creative people. All members of Mobile Life, especially Kristina Höök and Oskar Juhlin, warmly welcomed me and I felt

directly integrated in their daily work life. Since my own research is quite diverge to the work at Mobile Life, I gave a short presentation to all team members (and two visiting acoustic consultants from Stockholm) about my current work and, in return, I got many insights on their current projects
through many highly interesting discussions, where a lot of possible joint projects could be identified, especially for their on-going research on pervasive games.

(2) EPFL, Lausanne, Switzerland

Duration: 23.04.2012 - 27.04.2012
Contact: Christof Faller
Website: http://lcav.epfl.ch/

About
The mission of the Audio-visual Communications laboratory is to perform basic and applied research in signal processing for communications, provide undergraduate and graduate teaching of signal processing for communications and perform technology transfer to established as well as start up companies.
The audio processing group at LCAV performs research and education on various topics related to capturing, processing, and rendering of acoustic signals. Based on the foundations of signal processing and human auditory perception, techniques are investigated that target at improving storage and transportation capabilities for recorded signals and enhancing the perceptual quality of reproduced audio signals. (Excerpt from the website)

Experience
The visit at LCAV was a great experience for me, because the research that is performed at their audio processing group perfectly matches my own interests. My contact there, Christof Faller, is a well-known acoustician who has specialized on the reproduction of 3D-Audio. Since my own field of research is the simulation of 3D-Audio, I had many amazing and long discussions with him about all the facets of 3D-Audio. He even gave me the opportunity to visit
his own company Illusonic, where I could listen to their cutting-edge 3D-Audio reproduction system. Apart from that, I had also many great discussions with all other group members of the audio processing group at LCAV where joint projects are already planned for the near future. In addition, I held a presentation about my current research to all members of LCAV. I experienced LCAV as a great place for high-level research on audio-visual signal processing.