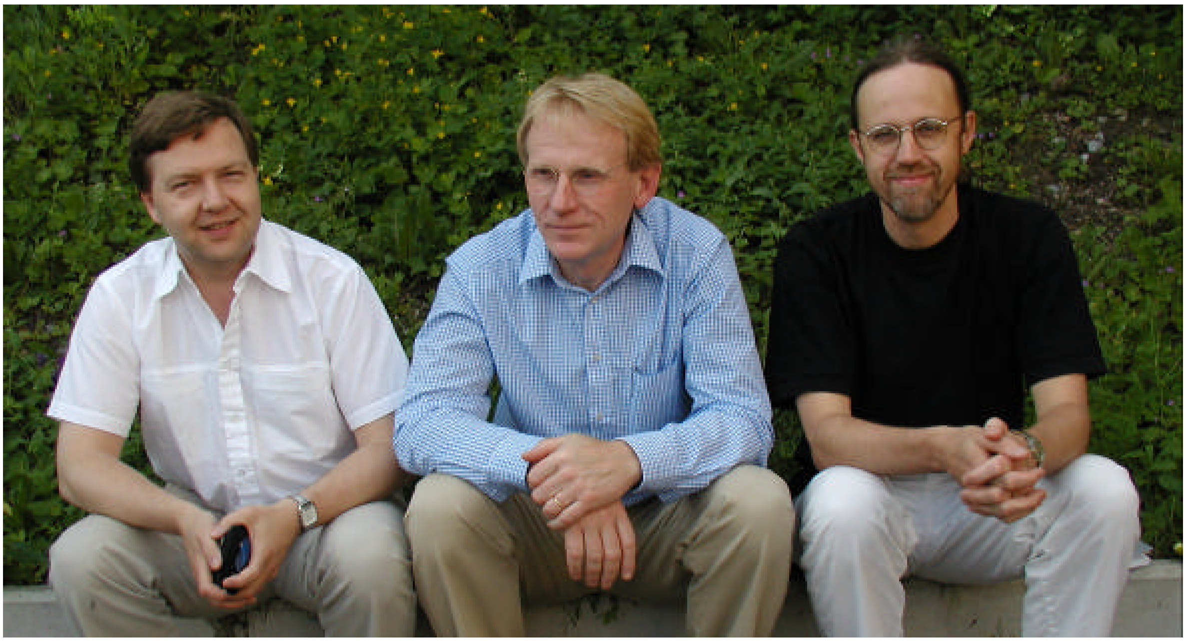
Music Acoustics



The Music Acoustics group is directed by three senior members: Sten Ternström, Anders Askenfelt and Anders Friberg (left to right).

The Music Acoustics Group is the second largest group at the department. The size of the group has increased continuously. During 2003, five senior scientists, three post-docs, and five research students, in all 13 persons, were working in the group. Ten international guests and five project workers joined the group during parts of the year. Two PhD theses and one licentiate thesis were completed.

Since professor Johan Sundberg's retirement in 2001, the Music Acoustics group has been directed by an executive committee consisting of three of the senior members. In October 2003, associate professor Sten Ternström was promoted to professor, which will result in a change in the formal leadership of the group during 2004. We are pleased to note that Johan Sundberg continues to pursue his research interests with undiminished energy, as professor emeritus.

For the period 2001–2004, the European Commission has appointed the group to be a Marie Curie Training Site in Music Acoustics. This enables us to receive doctoral students for a training period of up to a year each. The programme helps us to continue and extend the co-operation with our colleagues at music acoustic laboratories in the European countries, and also to make new acquaintances. In 200, we hosted six postgraduate research students within this programme from Germany, Spain, Italy and Finland, with an average visiting period of five months.

The other major exchange programme currently in operation is a bilateral agreement with the Media Engineering Research Group at the department of Electronics, University of

York. This is a four-year contract, funded by the Swedish Foundation for International Cooperation in Research and Higher Education (STINT). In 2003, this programme gained significant momentum, and several productive exchanges of teachers, students and researchers took place.

SMAC 03 and ASA Silver Medal

A major event of 2003 was the organization of Stockholm Music Acoustics Conference (SMAC 03), August 6-9, 2003, a conference which appears at regular ten-year intervals. This third SMAC gathered more than 240 participants. The broad perspective of the SMAC conferences, which covers the entire field of music acoustics including the physics of musical instruments, the singing voice, and music performance and perception, makes them unique. A series of 22 invited tutorials under the common theme *"… as we know it today"* gave an excellent overview of the research frontier in music acoustics and related research areas. A special session was dedicated to Johan Sundberg for his, so far, 35 years of internationally recognized research in music acoustics. The Sundberg Session was a homage to his important contributions to the understanding of the singing voice and music performance. Next SMAC will be organized in 2013.

During the fall of 2003, Johan Sundberg was honoured once more. The Acoustical Society of America decided to present the Silver Medal in Musical Acoustics to Johan Sundberg *"… for contributions to understanding the acoustics of singing and musical performance and for leadership in musical acoustics research."*.

RESEARCH

The activity in the group is devoted to three main research topics: voice, musical instruments, and music performance. Our major external research contracts are funded by the Swedish Research Council (VR), Swedish Council for Working Life and Social Research. (FAS), and the European Commission. During 2003 six EU projects within the Fifth Framework Programme were running.

Voice

Our voice is an essential component of our personality. We normally speak for a large part of the day, filling the hours we are awake with chats, telephone calls, quarrels, and meetings. A well-functioning voice is a must in many professions. For the professional singer and actor, the voice is the tool by which the artistic message is conveyed. Trained voices can be used in a much more complex manner than untrained, but both types share the basic principles and means of control that need to be mastered. A thorough understanding of the voice production, including all its physiological and acoustical aspects, is a long-term research interest in the Music Acoustics group. Our well-established co-operation with the Department of Phoniatrics and Logopedics at Huddinge University Hospital, Sweden, as well as other voice clinics in Europe, is of pivotal importance to this work.

One such collaborative project concerns how people exert their voices in noisy workplace environments. Using a high-precision noise cancellation scheme, we record the loud speech of subjects over realistic noise, and then remove the noise, leaving the strained voice exposed for conventional analyses. Some interesting results in 2003 were new data on how the voice spectrum in running speech evolves toward high effort levels. The work aims ultimately to establish risk levels for voice usage, to help prevent work-induced voice impairments.

Voice instrumentation is naturally a particular interest at an engineering faculty. For example, the advent of high-speed video laryngoscopy, with 2000 picture frames per second or more, has prompted the need for new data reduction methods. This is one of several topics in our work in the field of computerised voice instrumentation.

Another voice project concerns child and adolescent voice in a developmental perspective. Work in progress includes a longitudinal study of the voice break in puberty, and an investigation of effects on voice of pre-school noise levels. Voice topics pursued by our Marie Curie fellows included the speed of pitch shift correction in choir singers, X-ray studies of singer morphologies, and the voice source characteristics of call centre operators.

Professor emeritus Johan Sundberg, who continued to supervise external PhD students with undiminished intensity, produced studies on voice timbre and loudness, soprano vowels, nose resonances and nitrogen oxide ventilation, "overdrive" phonation in rock singing, the nature of breath support in singing, and the nature of "voice placement," all while also attending more conferences than anyone else in the group.

Musical Instruments

Tone generation in traditional stringed instruments, in particular the violin and piano, is a central research topic in the music acoustics group. Understanding the details of the design and their influence on the generated sound is an extensive task, which needs to be carried forward in co-operation with musicians and instrument makers. Numerical simulations allow estimations of the influence of material and design parameters which may be verified in controlled experiment series and listening tests. The differences in tonal quality that are important for the professional musician are, however, in many cases of no great magnitude. Their acoustical correlates may barely be detectable and are seldom clearly separable from 'natural' variations in the acoustical output due to playing technique and habits, or even environmental factors (e.g. humidity and temperature).

This year's studies of bow-string interactions have shed new light on why string musicians often tilt the bow, reducing the number of bow hairs that are in contact with the string. Simulations supported by experiments with a computer-controlled bowing machine have shown that the tilting stabilizes the periodic string motion by reducing the influence of string waves reflected against the bow. The tilting can also boost the high-frequency output. In the ongoing studies of the acoustics of the violin, it was unexpectedly found that an important high-frequency resonance previously attributed to the bridge ("bridge hill") may be due in part to vibrations of the edges of the *f*-holes. A prominent bridge hill is a feature of many important old Italian violins.

Three high-quality bows on display in an auctioneer´s catalogue.

Distance learning

As a partner in the EU-funded project Imutus (Interactive Music Tuition System), we are participating in the development of a virtual teacher of musical instruments, primarily the recorder which is popular with beginners. Our task is to create the musical heart of the system, the Performance Evaluation Module. This module will take the role of the teacher and "listen" to the student playing, detect significant deviations from the score, decide which mistakes and errors which need to be pointed out, and give structured feedback on how to correct them.

Performance

Every day we are exposed to artificially produced music which is delivered quite devoid of any musical intention. The common use of melodies as ring tones in mobile phones has made many people aware of the piercing discrepancy between the nominal score of *Für Elise*, as mechanically reproduced by the phone, and a musician's interpretation. Music performance is a research field which has gained tremendously by the development of computer-controlled synthesis of music. Research questions which many scholars thought to be out of the reach of analysis only a couple of decades ago, are now getting more and more reliable answers. Striking examples are how the interpretation of rhythm depends on the musical context, and how emotions are efficiently conveyed in music communication.

A future Imutus student?

Studies of music performance were initiated 30 years ago within the music acoustics group at KTH and have now expanded to be the largest research area. Our generative grammar for performance of music *KTH Director Musices* (DM) is today an internationally recognized tool for automatic transformation of MIDI files into musically expressive performances. Recently, means for emotional coloring of the performance (e.g. happiness, sadness, fear) have been added. DM is an important tool for studies in music performance, which helps to answer questions like how an artist transforms a score into a musical performance (the means); why this is done (the goals), and for explaining the sometimes surprisingly large differences between professionals' interpretations of one and the same piece.

Research on music performance has been performed in a number of EU projects with partners in different European countries, in particular Italy. Most of these projects ran to completion in 2003.

In *MEGA* ("Multisensory Expressive Gesture Control"), the aim is to extract, synthesize and map expressive features in dance, musicians' gestures, and music performance. The importance of the musician's gestures in music communication has been clearly illustrated in a study of a marimba player. The player was asked to perform the same piece in different intended emotions (happiness, sadness, anger, fear). Subjects had in general no difficulties in identifying the intended emotions only by viewing video clips of selected parts of the body, without sound tracks. The results illustrate the visual power of the body language in the performance. As instrumentalists produce the sounds and the music by movements of the fingers, hands, arms, and body, the characteristics of the body language will automatically be reflected in the sounding performance.

A novel application of results obtained within MEGA is the *Groove Machine*, by which a dancing disc jockey controls how the music is performed. A video camera records the dancer's motion. Body movement cues are extracted on the fly by real-time vision analysis and used to control the emotional character of a repeated rhythmic loop ('groove'). This technology was applied in a large-scale gesture controlled game application, *Ghost in the Cave*, produced as a major proof-of-concept prototype in the MEGA project. The new game, in which two teams control avatars on large screens by their movements, was premiered at SMAC03 and repeated later in the autumn, receiving a great deal of media coverage. A key feature of the game is that it recognizes the basic emotional character of the team members' movements (sad, happy, angry), and use it as a control parameter.

The interactive gesture-controlled game "Ghost in the Cave" was premiered at SMAC 03.

In *SOb* ("The Sounding Object") the aim is to develop sound models which can be connected to various objects in a virtual reality world. An overall goal of this research is to develop control facilities for physical models which are intuitively easy to use by musicians.

In *FeelMe* ("Feedback Learning in Musical Performance"), a project directed by the Department of Psychology, Uppsala University, the aim is to apply results from music performance research in a training program, teaching students to play expressively. At basic levels of music training, the playing technique with all its practical and motorical difficulties, is often put in focus at the expense of the emotional expression. The strategy in FeelMe is to extract some of the most important parameters in the sounding performance which carry emotional content ('cues'), and to use these cues for estimating how pronouncedly the student performed a particular emotion. The program gives cognitive feedback, with the aim to help the student to improve on the aspects in the performance which did not communicate the intended emotion convincingly. For example, a fast tempo in an intended sad performance gives a contradictory signal to the listener.

Other projects within music performance research deal with studies of the perception of drift in tempo, the influence of auditory delay on the performance of drummers, and physical modeling of 'scratching'. Scratching can be viewed as a novel musical instrument. The sound is produced by turning a vinyl disk back and forth with the pick-up resting on the disk. Like all successful musical instruments it can be precisely controlled by the skilled player, and not the least, many different versions of what is basically the same sound can be generated.