The Mathematics of Sound and Music

Introductory seminar. February 15, 2007. Konstantin Tretyakov.

Why math & music?

- First of all, the combination sells. Many people have heard that there are common points in these two very different areas and some are often eager to philosophize on the subject (go google and see for yourself).
- There are some obvious connections indeed. For example:
  - Both math and music consist of a certain logical and an aesthetical component (however, the logical part of music does not lend itself to analysis too easily and is thus often overlooked. Also, the importance of aesthetics in maths is not obvious to people not involved).
  - Both employ an internationally accepted notation.
  - By further examination one may descend deeper and deeper into metascience and find more and more intricate relations, in an attempt to somehow *unify* these two notions. However, in no event is *this* what we shall be doing here.
- We shall not *relate* music to mathematics or vice versa. Let music stay music - a sound sensation pleasing to a human's ear, and let mathematics stay mathematics - an analysis tool and language for the description of natural and abstract phenomena. These *are* very different things with different purposes. What this seminar is about, is trying to *use* the mathematical notions to *understand* something about sound & music.
- Understanding means here obtaining some *useful knowledge*. Knowledge, that one might later use to automate certain tasks related to musical data or maybe discover something new in the area.

What is it that one might try to understand about music?

The questions that would interest me are, for example:
- What is sound and how is it perceived?
- What is common and what is different in the sound "A#" of a violin, wood pipe, drum? Why?
- Why is an octave or a fifth "more harmonious" than a prime or a second.
- Why do we split an octave in 12 half-tones?
- Why is the sound in a concert hall different from the one in a church, in the speakers, in your headphones?
- How can we represent and store sound and music, trading size for quality in the most efficient way.
- How can we automatically convert among representations? MP3-to-midi, say?
- How can we generate natural sounds artificially?
- Given a melody, how do you add accompaniment?
- .. or how do you continue it?
- Or maybe it is even possible to generate melody from scratch?
- Is it possible to automatically discern Beethoven from Debussy from Michael Jackson from random noise?
- How-to of speech recognition or synthesis, although not directly a musical topic, sticks close.
- .. and there's probably more for you to add.

As you see many of the questions require your interest in music, maths, statistics, physics, computer science and data analysis. That's what makes the whole thing exciting, to my mind.

What might this seminar give to you?

- Answers to at least some of the questions, directions for further research, ideas.
- Practice of public presentation. DO IT WELL, no excuses! I'll try to organize a camera, and a feedback questionnaire.
- With proper attitude, you should get an enjoyable experience.

What should you give to the seminar?

- Try to keep yourself interested. It's *you* who chose to come here.
- Keep yourself up-to-date. The seminar will only highlight the most important parts of each topic. Some peculiar details may be omitted. Try to browse through the appropriate material both *before* and *after* its presentation.
- Ask a lot of "what", "how" and "why" questions. DON'T BE SHY, the most stupid questions are often the most enlightening.
- PREPARE A GOOD TALK!
  o PREPARE GOOD SLIDES! (pictures, sounds or stupid jokes are completely welcome).
- I'll do my best to help you, but remember that I'm not a specialist on the subject, and I am just as new to it as you are. Hence, we're on equal footing. I put hopes on you doing a good job. Let's try to keep this seminar from becoming a yet-another-very-boring-bad-quality-seminar. At least not too boring, OK?

Course requirements

- Attend seminars and be interested.

- Prepare a good lecture, or implement a project assignment and make a demonstration. A brief written summary is required in both cases.

Course information

- Seminars: Thursdays 16:15, Liivi 2-315

- Website: http://courses.cs.ut.ee/2007/music

- Mailing list: ati.music@lists.ut.ee

- Questions: kt@ut.ee (or the mailing list)