Music in the interpretation of scientific data: an experience aimed to evaluate racehorse gait spacing from spectral music to microtonality

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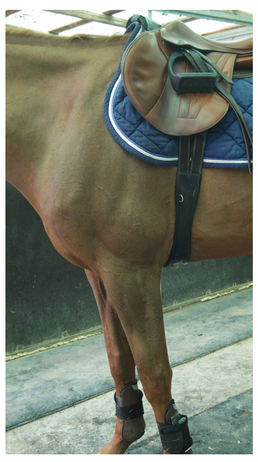
The thought that music in addition to the known role of art and subsidiary support of the speculative thinking had quite an effect on the development of science as an autonomous conceptual force has now been accepted, even though with a certain reservation [1], *similarities have also been demonstrated between music forms and some subjects of scientific studies as in genetics* [2] *and it is also a fact that some scientific investigation domains, as acoustic physics and vibrational mechanics, are at the base of the study of what music is made of, and that they owe their early stage development to music.*

Along these lines, in this paper aimed to characterize methods for the evaluation of regularity of racing horse gait, we used statistics and harmonic analysis by Fast Fourier Transform by means of similar methodologies such as those used for the study of periodic signals and in particular for musical sound. Finally, we implemented a digital music instrumentation able to represent biomechanical statistic data by means of musical sounds.



The subjects under examination trotted for about 20 seconds and were equipped with a 3-axis accelerometer positioned at withers, close to the saddle *(Figure 1)*

Figure 1 - Horse equipped with 3-axis accelerometers at withers and legs for biomechanical studies. In this study we collected data from the saddle-positioned accelerometer.

The collected vibrational data were noise-filtered and analyzed in the time and frequency domains *(Figure 2, Figure 3)* by means of GASF (Gait Spectro-analysis Facility), a specific software that we developed in SCILAB [3] programming language, that uses auto adaptive algorithms to calculate stride's statistics relative to intensity, RMS, duration, peeks timing as well as symmetry/balancing indexes, [4] overtone–undertone harmonic analysis, spectral lines fitting by Levembert-Marquard method, spectral entropy, probability density function and Tait-Bryan angles.

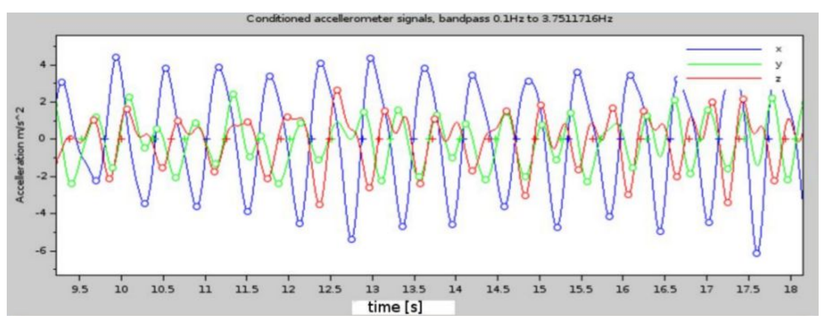


Figure 2 - GASF Time-domain analysis plot example with peeks detection

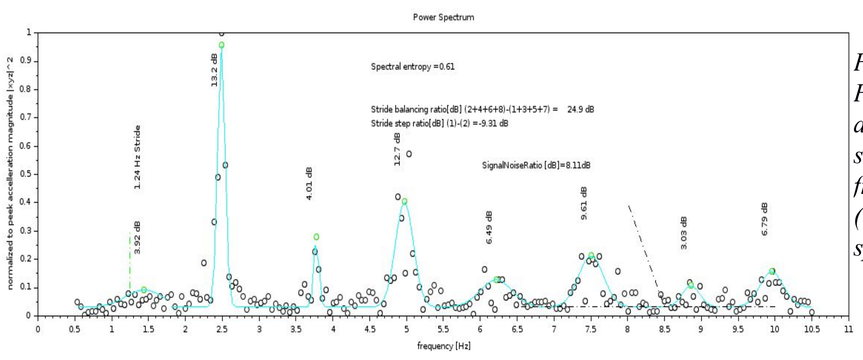


Figure 3 - GASF Frequency-domain analysis plot of a trotting subject: fundamental frequency, undertone (1.24 Hz) and overtone spectral lines.

Data chosen from the previous analysis fed the electronic-music instrumentation, consisting of two listening subsystems.

The first was implemented as a GASF build-in function that produces a kind of spectral music consisting of white noise amplitude-modulated by the vibration signals without any information loss (*Figure 4*). In this way the horse's stride inaudible vibration spectrum (about 0.5 to 10 Hz range) was transposed in the 20 to 20000 Hz range that can be heard by humans.

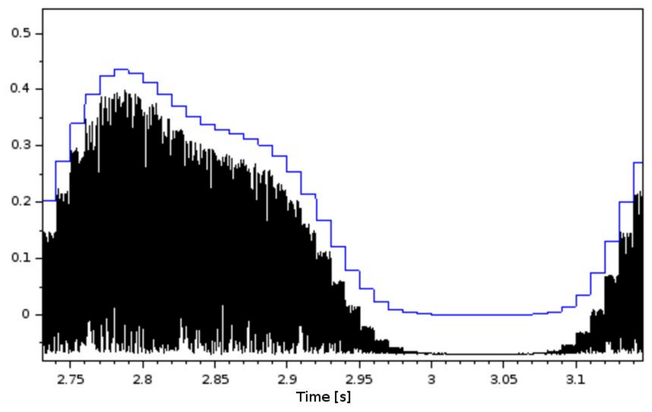


Figure 4 - Audible sounds at 22050 sample/second (black) and the original accelerometer's signal (blue)

The second *(Figure 5),* consisting of an autonomous subsystem, was based on an *arbitrary* transliteration of time domain processed numerical data into a musical form in such a way that some significative features of each horse stride became a parameter of a note in MIDI standard coding [5] using 19-equal temperament [6].

In the adopted outline, microtonal scale tuning was proportional to the stride's time duration gap with respect to the statistic mean stride duration time, dynamic was proportional to the stride's Root-Mean-Square intensity and the sound beat corresponded exactly to each stride timing [7]. The note sequence was then reproduced by a software sound synthesizer [8] adapted to 19-TET by acting on pitch-bend.

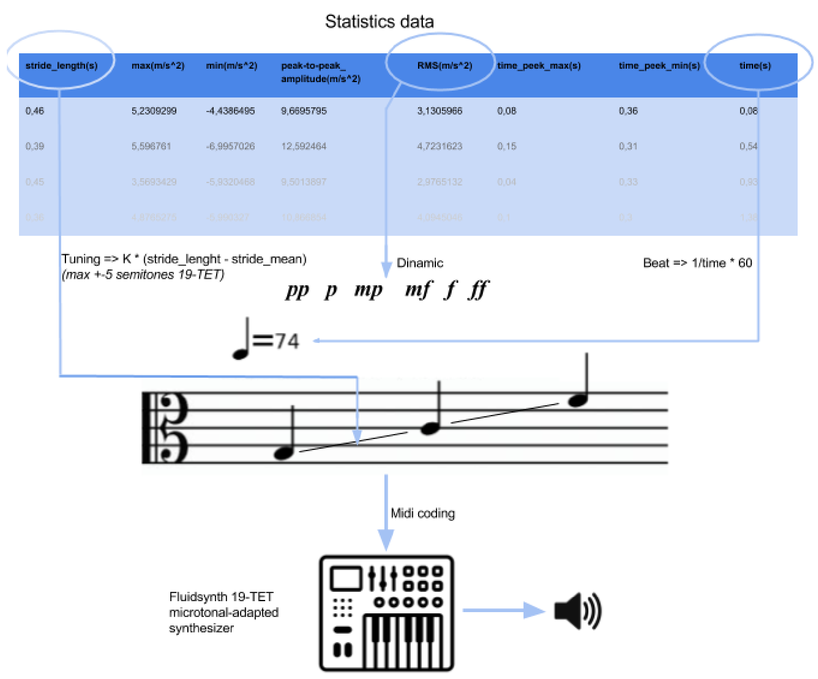


Figure 5 - Stride statistics transposed to a microtonal music sequence.

It was found that gait's accelerometer collected data and stride statistics can be converted as sound sequences that provide the veterinary surgeon with a reference for the subject under evaluation in conjunction with the analysis software. It also appears that the data representation by means of the second system, based on the microtonal musical sequence, is more comprehensible and better reproduce the subject's regularity and hesitations than the first one.

Both systems can easily be adapted to perform audible readout of scientific and statistical data in other contexts.

download spectral sequence

download microtonal sequence

references

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8. FluidSynth: *A SoundFont Synthesizer* - http://www.fluidsynth.org