Additions and updates to Dr. Mark Bee's review of SoundRuler 0.936

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Abstract

SoundRuler is a free program for acoustical analysis that was recently reviewed by Dr. Mark Bee in the journal Bioacoustics. The review describes the program in detail, indicates its main strengths and weaknesses, and tests its precision of measurement. This article adds to and updates the review to the latest version of the program (0.9.4). Besides the program, SoundRuler is a long term project that aims at producing an open toolbox of example code for applications in bioacoustics. One main interest is the identification and coding of mechanisms of sound detection, recognition and measurement. Past and current development focused on measurement capabilities. The next stage should emphasize the analysis of the measurements. The enhancement of automatic and interactive processes of sound measurement such as the ones offered by SoundRuler should provide good alternatives to procedures that are affected by subjectivity. SoundRuler also has modules and documentation for use as a teaching tool and it has been widely used in courses on Bioacoustics and Animal Behavior.

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Introduction

SoundRuler is a free tool for acoustical analysis, graphing and teaching that recently became available on the internet and is growing quickly in popularity (Gridi-Papp 2003). It interactively recognizes and measures 35 temporal and spectral properties of each sound in a file. It also features several measurement, graphing and didactic modules.

Bioacoustics, the International Journal of Animal Sound and its Recording, recently published a review of SoundRuler by Dr. Mark Bee, from the Institute for Biology of the Carl von Ossietzky Universität in Oldemburg, Germany (Bee 2004). The review starts by depicting the program's license, development, platforms and documentation. It then describes SoundRuler's main features, identifying its strengths and weaknesses. The author then does an experimental evaluation of SoundRuler's interactive analysis procedures, and ends by providing general recommendations to the users.

Bee's (2004) review is an invaluable resource for people interested in using SoundRuler for research, as it provides a very complete view of the program from a perspective that is independent of that of the developers. It does a superb work at revealing features that are unique to SoundRuler and that can speed up and improve the objectivity of the analysis, and also warning about weaknesses that might cause reduction in speed or precision of the analysis.

This article aims at complementing Bee's review with comments by the developer and with updates from the latest version of SoundRuler (0.940).

The project

Besides being a program for bioacoustics, SoundRuler is also a long term project, with the aim of producing an open, versatile and free tool box for bioacoustics. In the field of automatic analysis, for example, the aim is to identify the criteria that humans and other animals use when recognizing and measuring sounds, then to incorporate such criteria as facultative algorithms in the program to allow for quick and objective measurement. The process of identifying the criteria and building efficient algorithms can help to appropriately formulate questions and test hypothesis about sound recognition and discrimination by animals in several contexts.

SoundRuler as a toolbox

Writing a little program to implement a new idea for measurement in bioacoustics is frequently not trivial. One has to immediately deal with sound file input and output in addition to text, produce graphs, frequently with Fourier transforms, deal with allocation of memory and actually play the sounds. This causes many good ideas to be put aside untested, for lack of time.

SoundRuler, as a toolbox, offers a basic working structure for a wide set of procedures that can greatly facilitate the implementation and testing of new methods involving acoustical analysis. About 75% of the development time has been placed in visual features, user interface and documentation. The implementation of new analysis is now greatly facilitated by the body of acoustics code that is already available in the program to be reused or adapted. The code can be run and modified in Matlab or Octave (without the GUI) as a set of scripts for quick development.

Teaching

One of the most immediate uses that SoundRuler has received has been in courses of Bioacoustics and Animal Behavior. As the license is free, the program can be used in computer labs with any number of machines at no cost. It can also be installed in the students' personal computers for homework and studying for exams. SoundRuler has a fairly extensive and illustrated documentation in English and Portuguese, with guides, examples, explanations of how it works and frequently asked questions. The next versions should extend the documentation including bibliography and activities tailored to use in courses. SoundRuler also includes didactic modules such as SoundMath, which allows the students to explore the mathematical relations among acoustic variables in a hypothetic scenario. Such module is being expanded with the inclusion of visual and auditive tools and with an increased variety of scenarios.

Usage statistics

Since its first release in March 2004, SoundRuler received 20,348 visits to its website at SourceForge and it was downloaded 3,489 times. Registered users are mostly researchers and teachers at academic institutions in North, Central and South America, Europe, Oceania and Africa. Researchers are using it to study the sounds of mammals, birds, frogs, insects and even machines and to teach Animal Communication and Bioacoustics.

Navigation of sound files

Bee (2004) points out that it would be nice to be able to “freely scroll to any place across the file”, instead of navigating in sections. Such improvement is perfectly feasible and should be included in the next releases.

Graph editing

The reviewer asks for more editing options and “drag and drop” plot editing. The latest release of SoundRuler (0.940) addresses the first request, adding a large number of controls for editing plots. Future releases should add more options and smarter controls for quick editing. The “drag and drop” feature actually depends on the development of Matlab Compiler's (Mathworks, Inc.) graphical libraries, which SoundRuler uses. It is already incorporated into the main Matlab program and should be available in the compiler's libraries in the next version of Matlab. When it is released and SoundRuler's code is migrated to the new version of Matlab, then “drag and drop” should become available in SoundRuler.

Manual tools

With the initial emphasis on interactive analysis of repetitive sounds, some obvious features for manual examination and measurement were not included in the program. The latest release of SoundRuler (0.940) improved the manual control on how the program recognizes and delineates pulses, but a whole new set of features for manual analysis should be implemented soon. It should include two-click calculation of differences in time, frequency and amplitude, one-click generation of power spectra for any point in the file, comparison of power spectra, and more control over mouse logging.

Call recognition

The reviewer obtained effective and precise recognition of the calls of the European treefrog *Hyla arborea* (Hylidae) but had difficulties with setting automatic recognition for the calls of the North American bullfrog *Rana catesbeiana* (Ranidae). The structure of the calls produced by the second species requires higher levels of complexity from the recognition algorithm to efficiently process natural recordings. Good results can be reached with SoundRuler for these calls with the new detection features introduced in the latest release (0.9.4), after the review. The implementation and documentation of the sound detection algorithms still need to be improved, however, both to make more complex structures measurable and to make the usage intuitive.

Being able to precisely recognize complex acoustic structures in field recordings is a feature that might require endless development, as more difficult tasks can always be devised. As recognition becomes more difficult, the recognition algorithm tends to become more complex. For the program to be usable, complex algorithms require careful documentation and accessory tools to help users to reach the best settings. SoundRuler has become useful for a wide range of natural sounds and types of analysis, and it should keep improving its precision and general applicability for the recognition of sounds.

The digitized sound is a time series of voltage measurements. The computer has access to all the information that it displays for the user on the screen, but with higher precision and speed than the user. It is, therefore, a matter of developing the right code to reach superior call recognition to what humans can do visually. SoundRuler has open code and it is developed as a script to make development accessible to most researchers, so that the code can quickly evolve to its best.

Signal, noise and precision of measurement

Bee (2004) elegantly evaluated the precision of the measurements taken with SoundRuler, by generating artificial frog calls and measuring them with the program. When the calls were embedded with the noise of conspecifics, the precision of the temporal measurements was lower and the variance was higher than what one might hope to obtain. Those numbers could be improved to a certain degree with refinements of the measurement code. But to some extent, they are the result of masking the calls with a noise that is very difficult to deal with: a chorus of conspecific calls.

Sounds produced by conspecific individuals usually have similar temporal and spectral structure. When they form a chorus in the background, they add overlapping energy to the focal sound, distorting its amplitude envelope. Sounds overlapping with the edges of the focal call will distort its duration measurements, while sounds that are completely overlapped by the focal call will interact with its waveform, altering its peak and RMS amplitude. When humans analyze oscillograms visually, they tend to observe the smoothness of the amplitude decay at the edges of isolated sounds, and use that standard shape to decide “where to cut” the edges of calls overlapped by noise. This process is frequently unconscious and gives the person an impression of higher precision in human-made measurements. The problem is that when the edges are hidden in noise that can not be filtered out, it is unknown what their shape would have been in isolation. If one assumes repeatedly that the edges have the shape found in an ideal call, the errors in the estimates will bias the means and alter the variance of the measurements.

When automatic or interactive analysis of noisy recordings do not produce the precision that one wants, it might be because the algorithms are incorrect or too simplistic, in which case the software should be improved or replaced. Analyzing the same calls manually should introduce subjective decisions about the edges of the calls, which can produce biased data and a false impression of precision. Solutions to the problem might be reached by obtaining cleaner recordings, or by restricting the analysis to the portion of the calls that contain amplitude higher than 10% or 50% of the peak (see Littlejohn 2001).

Credibility

As most open code programs, SoundRuler is distributed with no guarantees of any kind (http://www.gnu.org). This is a necessary condition for it to be distributed freely. The developers do the initial testing of all new procedures, but the large number of end users test it under an uncountable number of situations, and send bug reports to the development team. Open code projects tend to openly document bugs and promptly produce new releases with the fix. This process has allowed several types of open software (web servers, databases, encryption) to become leaders in their market and be used in mission-critical applications.

Stability

The developers and testers have had a very hard time producing program or machine crashes with SoundRuler in any of the platforms. This is mostly due to the highly tested foundation provided by Matlab's mathematical and graphic libraries, at the core of SoundRuler. The review by Bee is our second report of repeated program crashes. While becoming familiarized with a new feature, users can produce situations that are unlikely to be encountered during normal analysis. Bugs that appear in those conditions are difficult to eliminate because they are rarely reported.

Feedback on any crashes is very important for the development of open software. Even if the user can not remember the exact procedure under which it happened, the output in the message screen (the black screen that opens at the beginning) might identify the error in the code. More information on how to report a bug can be found in the program's documentation.

Future plans for development

In the last months, development of SoundRuler has been focused in releasing Linux and Mac versions. This phase is almost completed, and general feature development should be resumed soon, addressing the points described earlier in this article. In the next months, SoundRuler should receive many modifications with the main goal of making it a good tool for measuring sounds. The main focus should then change to making SoundRuler a good tool for detailed analysis of the data that it currently produces. As a scientific toolbox, the development of new analyses and didactic modules will follow the requirements of research and teaching.

References

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