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# SonoUno: a user-centred approach to sonification

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**Abstract.** Though there are a variety of astronomy sonification software packages, none of them shown high granularity evidence of having been designed with a user-centric focus. SonoUno is a sonification package created taking into account the user from the beginning, and incorporates end user contact feedback for continuous improvements to the software. In this contribution, SonoUno user cases are presented with the soft corresponding updates, as well as the first description of a recent web page development.

**Keywords.** methods: data analysis, instrumentation: miscellaneous

## 1. Introduction

Astrophysics tools are mostly visual, despite studies showing that multimodal approaches can enhance data analysis possibilities. In general, multimodal tools broaden accessibility to scientific data for those with varying performance, learning styles and disabilities. Several projects around the world attempt to make astronomy accessible only at educational aspect, motivating people to progress to aspects no related to the mainstream of astronomy research. These works present different sensorial inputs, like sense of touch, for example Planetariums for blind people, the vibrating universe (De Leo-Winkler *et al.* 2019), different 3D mockups and texts on braille.

Moreover, there are some sonification tools that allow to sonify specific data sets, as Sonification Sandbox (Davison and Walker 2007), MathTrax (https://prime.jsc.nasa.gov/mathtrax/), xSonify (Diaz-Merced *et al.* 2011), Sonifyer (Dombois *et al.* 2008), Sonipy (Worrall *et al.* 2007) (https://github.com/lockepatton/sonipy), Planethesizer (Riber 2018), StarSound (Cooke *et al.* 2017) and SonoUno (https://github.com/sonoUnoTeam/sonoUno). First four of them are outdated. Particularly, Sonifyer was design to sonify electroencephalography data, MathTrax have educational purpose and the other software present astronomical applications. About the graphic user interface (GUI), Sonipy don't have one and the others shown complex GUI with a lot of elements and in some cases present pop-up windows, forcing end users to change between windows. In general, these software are centred on the data set, the common software frameworks or programmer experience, leading the end user needs out of the loop until the end of the development. In contrast, sonoUno has been designed to be User Centred (UC), its

development has been motivated by the desire to bring multimodal access to astrophysical data to all people and aspects of expertise, irrespective of their performance styles or functional diversity. This digital interface may allow people with different learning styles and multiplicity of disabilities to succeed in their transitions through performance aspects. This tool allows to import data, plot, sonify and mark points of interest, with several options available on the sound parameters and plot styles. Moreover, the software allows to script mathematical states avoiding pop-ups. Starting from sonoUno software theoretical framework and ISO standard 9241-171:2008, we present in this contribution some user case studies and the consequent software updates.

## 2. Methodology

On April 2019 a focus group (FG) sessions were conducted at Southampton University; during that session participants made suggestions and comments about what they need and what they propose to change in the soft. Participants were contacted directly by the recruiter/facilitator through email or through Southampton Sight. Southampton Sight is an award-winning charity organisation in Hampshire County, UK, supporting blind and partially sighted people since its inception in 1899.

About the groups, Group A: four people, two visually impaired and two with low vision (no expertise); Group B: one person with no sensorial or physical disabilities (computing specialist); Group C: one professional astronomer with low vision; Group D: three professional astronomers with no disabilities. The iterations were voice recorded after previous consent approved by the ethics committee at Southampton University, and the audio recordings and consent forms were kept in a password protected file during a year at the Universidad de Mendoza in Argentina. Both audio recordings and consents were erased after a year.

In addition, a group of specialists related to astronomy in a diversity of aspects, were contacted by email to install different version of sonoUno. They used the soft on their own, with their own data, carrying data analysis activities characteristic of their daily practices; and shared with us feedback about its use and recommendations. The next section presents some end users recommendations, collected from all the contacts, and the analysis for the implementation of modifications, taking into account the sonoUno framework and main goals.

## 3. Result

### 3.1. *End users recommendations*

During the FG sessions, the participants make some suggestions to improve the software according to their needs and expectations, for example: "put the play and pause on the same button" (Group A and C); "some of the continuous decreasing data use the same note" (All groups); "one of the panel wasn't on the panel section" (Group B); "the slider should show the real data point, not the position" (Group D); "why do the software only shown the first ten rows of the data set?" (Group D); "to change the instrument they have to press stop and play again" (All groups). During the email exchange with specialist in astronomy and astrophysics some suggestions were focused on the time between notes, to match the points distance (for variability); the mark point button, to show the mark when it is pressed; a loop function; to plot and sonify two or three columns against x at same time; and a line command interaction. The discussion and implementation of changes according the suggestions, were based on accessibility. A screenshot of the software and all updates are available on GitHub web page (https://github.com/sonoUnoTeam/sonoUno).

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### 3.2. *SonoUno updates*

As a first step, the recommendations were divided in 3 groups: "graphic", "sound" and "complex implementation". A complex implementation may be, data operations and graphic changes that would require to implement aspects in the internal structure of the algorithm that may affect several functionalities of the software. The graphic modifications selected for implementation lacked that complexity and were fully implemented. For example, play and pause is now on the same button, the panel 'Data Parameter' was changed to the panels section on the menu to follow a good tasks linearization, when the mark button is pressed the mark line appear above the position line and all the elements on the interface display a textual description when the mouse is hoover over them.

About the sound recommendations, the first was a bug discovered during the focus group session, now sound parameters can be changed without pressing any additional button. Another was based on the sound resolution, with a previous library using MIDI notes (in our context of use and when using python 2, MIDI restricts the number of notes, only around 70 notes on Piano instrument for example), as a preliminary approach and in parallel to Python 3 update the library Pygame was used to generate and play sound modifying sound parameters directly on its waveform. Temporarily the resolution problem was solved, but the way to include MIDI sounds stay on agenda. About the problem of the reproduction time, the limitation is based on the minimum tempo that the graphic user interface allows, this time can't be modified. Instead, is proposed to reduce the number of dataset elements averaging the closest values, this update has to be tested in the next contact with end users. The last one was that time between notes must match the points distance, according to do that the space between notes was measured and the program take in consideration each gap of silence between notes.

Ultimately, in the complex implementations group, the sliders bars were modified to show the real dataset value and not the position on the array. Then, the possibility of write the desired value above the slider was reached. About the data-grid that in the past only shown the first ten values, a way to show all the dataset without freezing the graphic user interface was addressed, right now the dataset was shown in pages of 100 values and it has to be tested in future end users exchanges.

Afterward, some recommendations present potential but require changes on the interface framework, instead of that was decided to address those by first implementing these updates with the command line element on the interface and test it before to include any change in the graphic user interface. This approach allows not only to ensure that the functionality is useful, but also perform user exchanges to decide the optimum way to include it in the graphic user interface maintaining the user centred concept. These final updates incorporate a loop function (because some datasets like light curves were best represented with that functionality) and to display and sonify more than one column in the same or different plots. The recommendation to generate several audio files with one command from different data sets (not related to data analysis) seems to be very useful, but didn't correspond with the sonoUno main goal: 'Creation of a human-computer interface suitable for the access, collection, sonification and analysis of astrophysical data centred on the user from the beginning'. This software is mainly centred on data analysis, the creation of audio files is a consequent for portability and exchange with colleagues.

### 3.3. *Web Page development*

Addressing other recommendation and a wide and global use of the software, a Web Page development was initiated at the beginning of 2020 (Developed under the Project REINFORCE-GA 872859 with the support of the EC Research Innovation Action under

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the H2020 Program SwafS-2019-1the REINFORCE). Installing a full application with all its dependencies may be too much work for some users that don't require complex functionalities or are occasional users of the software. It was decided that a web interface, with fewer functionalities that the Python base program, would help overcoming these limitations.

A web interface implies the use of HTML, JavaScript and CSS to do the programming, which results in different code bases for the native and web versions, which requires extra programming effort. Additionally, web access is also achieved through a web browser, which introduces an intermediate software layer, especially when it comes to user interface, with its own rules and standards. The implementation can be divided in front-end and back-end. The front-end is the most fundamental part, as it provides the actual data presentation and sound functions and is being currently implemented with many functions already working. This section provides the interactive part of the experience, which is also the most appealing for the users, has a high contrast design that can be customized through CSS and also takes advantage of the ARIA features of modern web browsers that allow to customize the screen reader workflow. Some of the limitations of the web interface will come from the slower processing speeds on the web browser and some limitations of producing sound. On the other hand, back-end part has been planned to take jobs that depend on more complex software capabilities so the user would not need to install such large and complex software packages locally, but probably transferring data from the local device to the back-end server makes it inconvenient for large data sets.

## 4. Conclusion

We can conclude that the proposed development has the potential to enhances the actual scientific work bringing other sensorial styles to data analysis. Also, sonoUno makes possible to analyse data by people with functional diversity, permitting to explore data and make decisions by themselves. This method shows the importance of a user centered approach influencing over computational science, engineering and software design, among others, to take into account the end user with high granularity from the beginning, making the tools more usable, efficient and useful, taking into account the accessibility.

Finally, it is very important to address the cause of inequity to remove it or find an alternative way. There are a lot of cases where remove barriers is easy if a user centred approach with a good design was made from the beginning.

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