NAVIS Tool
User Manual

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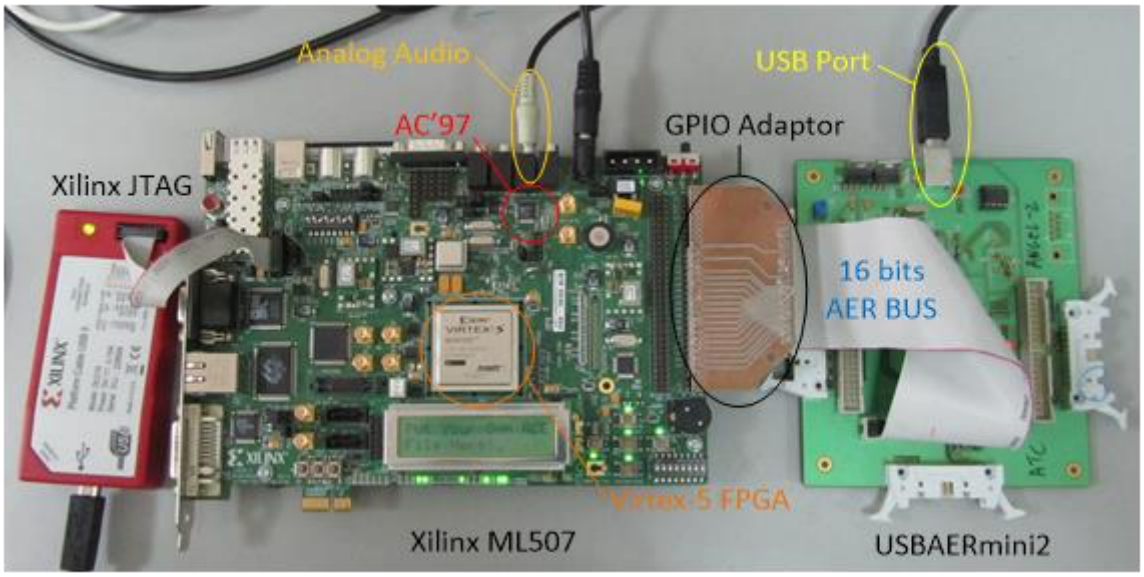
Introduction

Welcome to the Neuromorphic Auditory VISualizer Tool user manual.

This page will be useful for those who have not used NAVIS Tool yet and want to get introduced to it without getting lost. On the following sections you will find the diverse functionalities of this software and how to use them properly in the desktop software application.

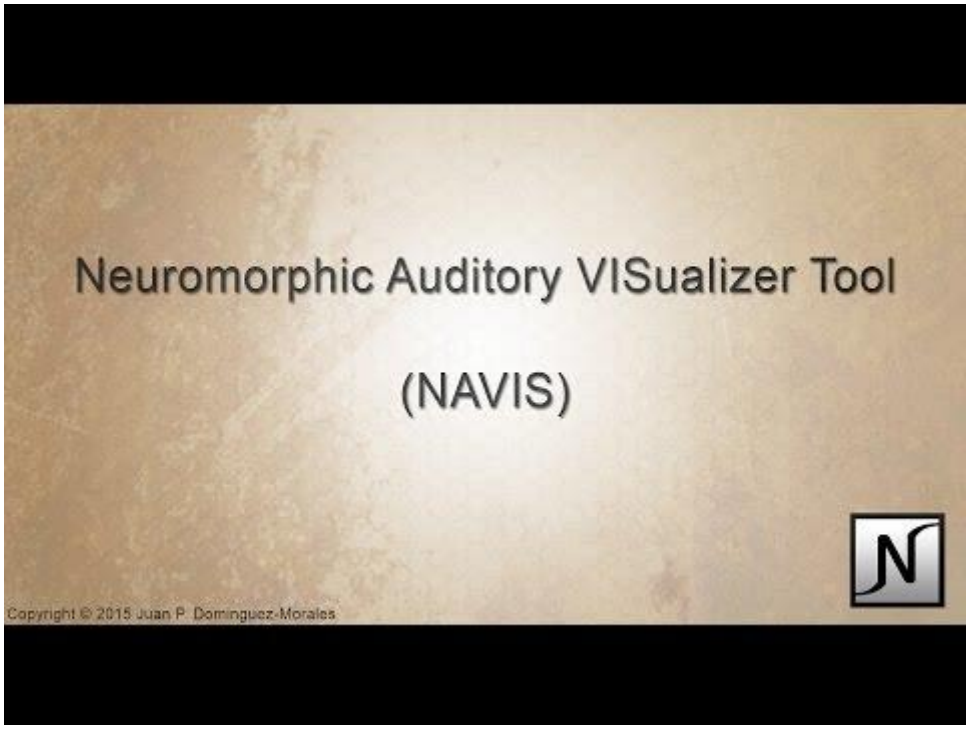
To demonstrate these software functionalities a 64-channel binaural Neuromorphic Auditory Sensor (NAS) for FPGA has been used together with an USB-AER interface, as it can be seen on the image bellow.



0. Getting started

This page will be useful for those who have not used NAVIS Tool yet and want to get introduced to it without getting lost. This step by step tutorial will guide you on how to install NAVIS, load your first file and start working with it. But first, let's take a look at the prerequisites needed before installing NAVIS.

The following step-by-step guide will show you how to download, install and start using NAVIS. If you prefer a more user-friendly tutorial, you can watch the NAVIS' Getting Started video by clicking on the next image.

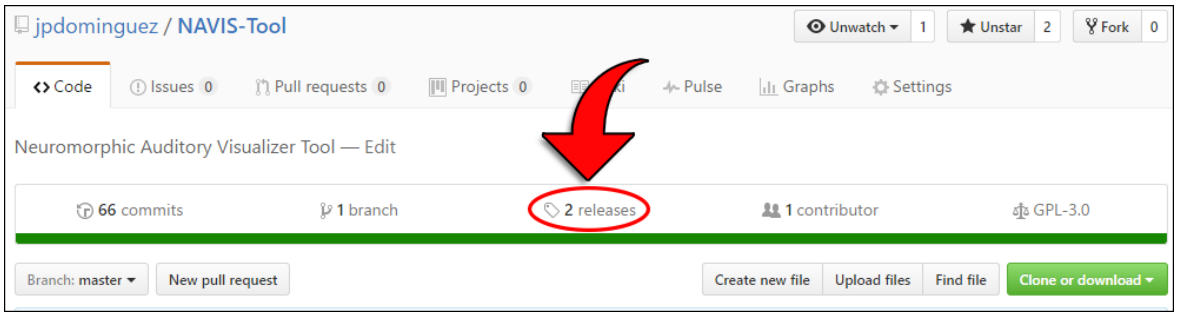


Prerequisites

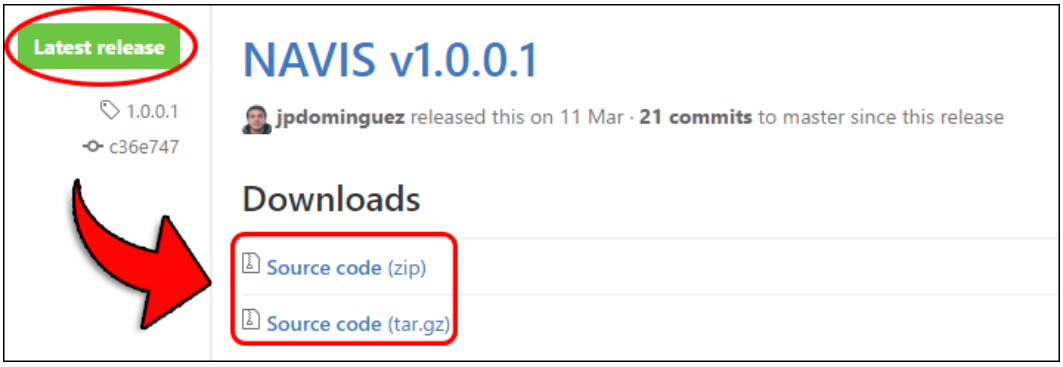
NAVIS requires Microsoft .NET Framework 4.5 or greater to be executed. The .NET Framework 4.5 and later versions are not supported on Windows XP, but on Windows Vista, Windows 7 and later versions of Windows.

Installation

To use NAVIS, first you need to download the latest release. This can be done by clicking on the "releases" button on the home page or just by cloning/downloading the repository.



Then, select the latest release (it has a green button next to it containing the text "Latest release") and click on the source code download link.



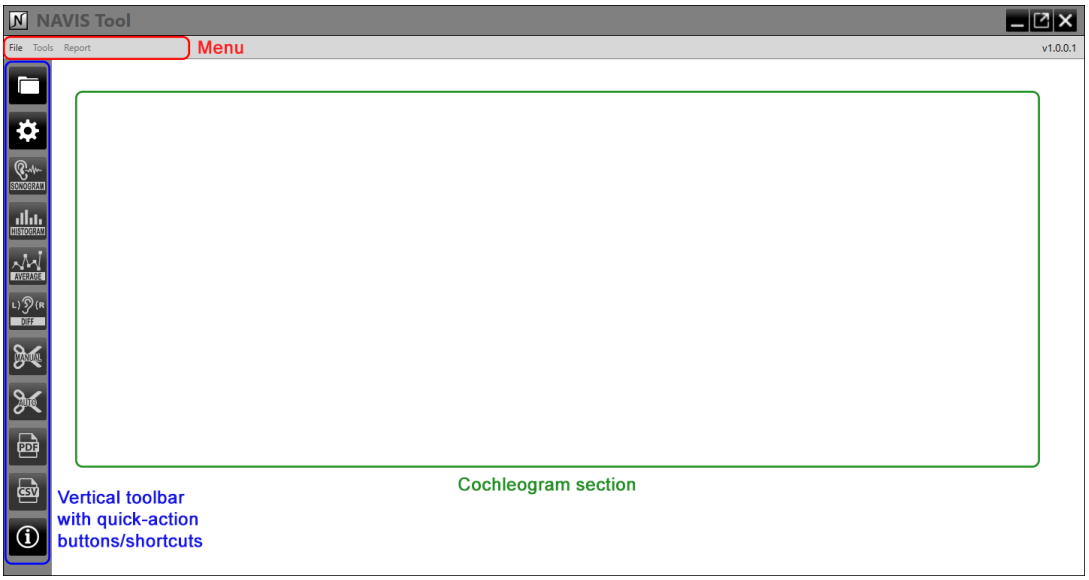
After the file has been downloaded, decompress it. NAVIS executable file (NAVIS.exe) is located at the "NAVIS_LatestBuild" folder. Place this folder wherever you prefer and double-click NAVIS.exe to run this tool. If you get an error when trying to execute NAVIS, please check that the folder from which it is being run contains each of the files that are inside the "NAVIS_LatestBuild" folder (no file has been deleted or moved to another folder) and that your have already installed Microsoft .NET Framework 4.5 or greater in your computer. If the problem persist, please send me an email explaining the situation.

Usage

Double-click on the NAVIS.exe file to run it. Three main sections can be seen when the main window is opened: the menu, the toolbar and the cochleogram section:

- The menu is located at the upper side of the window. It allows the user to access each of the NAVIS's functionalities.
- The toolbar is located at the left side of the application. It has some quick buttons (shortcuts) for the most-common NAVIS's utilities. All of these buttons are shown by default when using NAVIS for the first time. Although, the user can select which of them should appear or not, based on his /her interests. This can be done in the settings, which are deeply explained in the NAVIS wiki.
- The cochleogram section is the big empty space that can be seen after opening NAVIS. This will be used to display the cochleogram of the audio file (in .aedat format) after we load it.

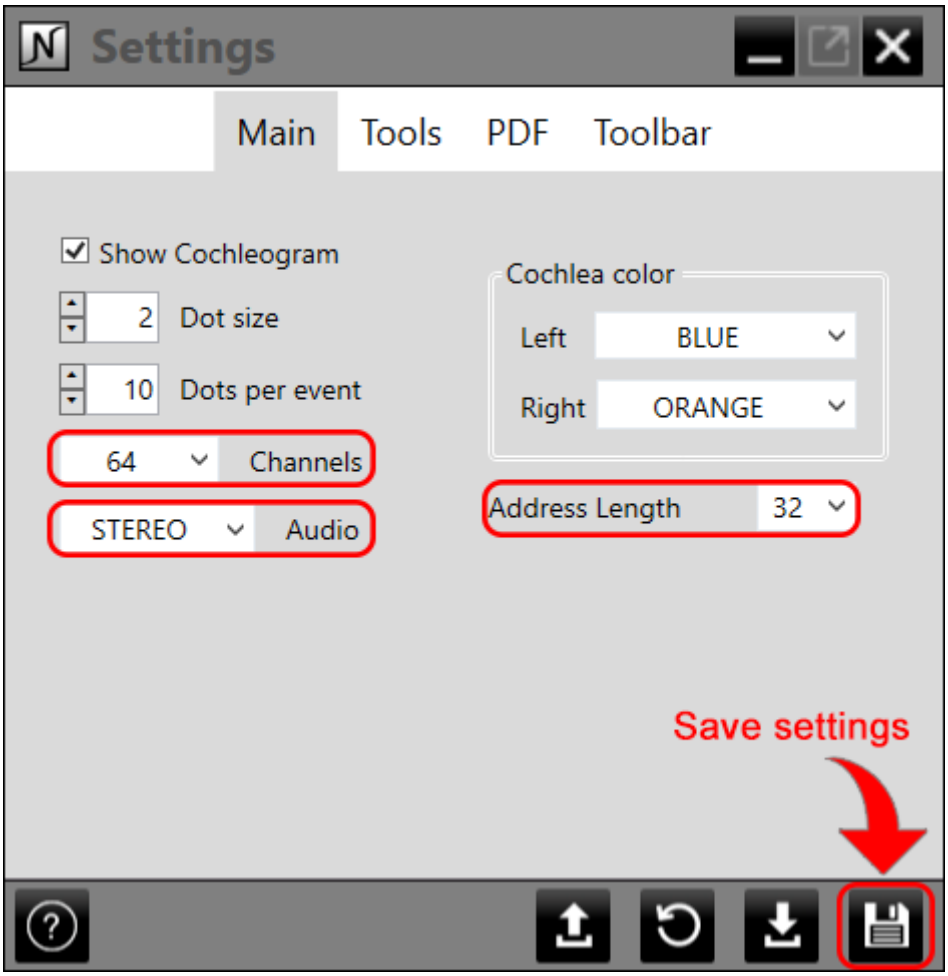
The following picture shows the main window that you should be seeing after running the application.



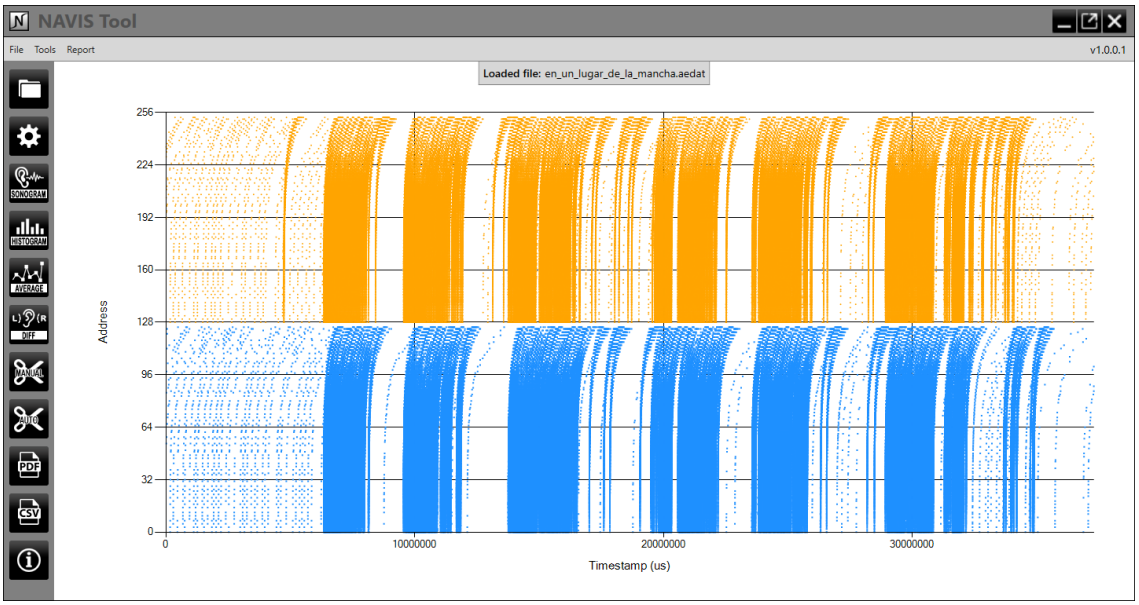
The folder “AedatSampleFiles” contains several aedat files that can be used to test the application and its functionalities. These files have been captured using jAER, the USBAERmini2 platform and a NAS (with different configurations: mono, stereo, 32-channel and 64-channel).

In this step-by-step tutorial we will be using an aedat file that was captured using 64-channel bianural NAS: “en_un_lugar_de_la_mancha_aedat”, which contains a stream of events that correspond to a young woman reading the first sentence of the famous Spanish novel The Ingenious Gentleman Don Quixote of La Mancha: “En un lugar de La Mancha”.

Before loading this file, we need to configure NAVIS first. Click on File->Settings in the menu or on the button with the gear symbol in the toolbar. This will open the settings window, which is organized into different tabs. Each of the parameters that appear on every tab of the settings window is explained on the “Settings” page on the Wiki. For loading a file we only need to focus on the “Main” tab, specifically on three values: “Channels”, “Audio” and “Address Length”. The file that we will use in this tutorial is captured using a 64-channel bianural NAS and jAER; hence, we will select: “64” as “Channels”, “STEREO” as “Audio” and “32” as “Address Length” (jAER use 32 bits for storing the event’s address information). After this settings have been selected, click on the “Save as default settings” button.



After the settings have been modified and saved, we are now ready to load our first aedat file. Click on File->"Load Aedat" or on the button with the folder symbol in the left toolbar. Navigate to the folder where the file is and select it (this aedat can be found in the "Stereo->32-bit address length" folder from the AedatSampleFiles folder of the GitHub project). The loading process will now begin. Take into account that the file will take longer to load depending on its size and length. After the file is loaded correctly, its cochleogram will be shown in the cochleogram section that we mentioned before.



Now that the file is loaded, you can use any of the functionalities that NAVIS provides: sonogram, histogram, average activity, disparity between left and right cochleae, etc. This software also allows to split the original file into different single aedat files both manually and automatically based on the channel's average activity.

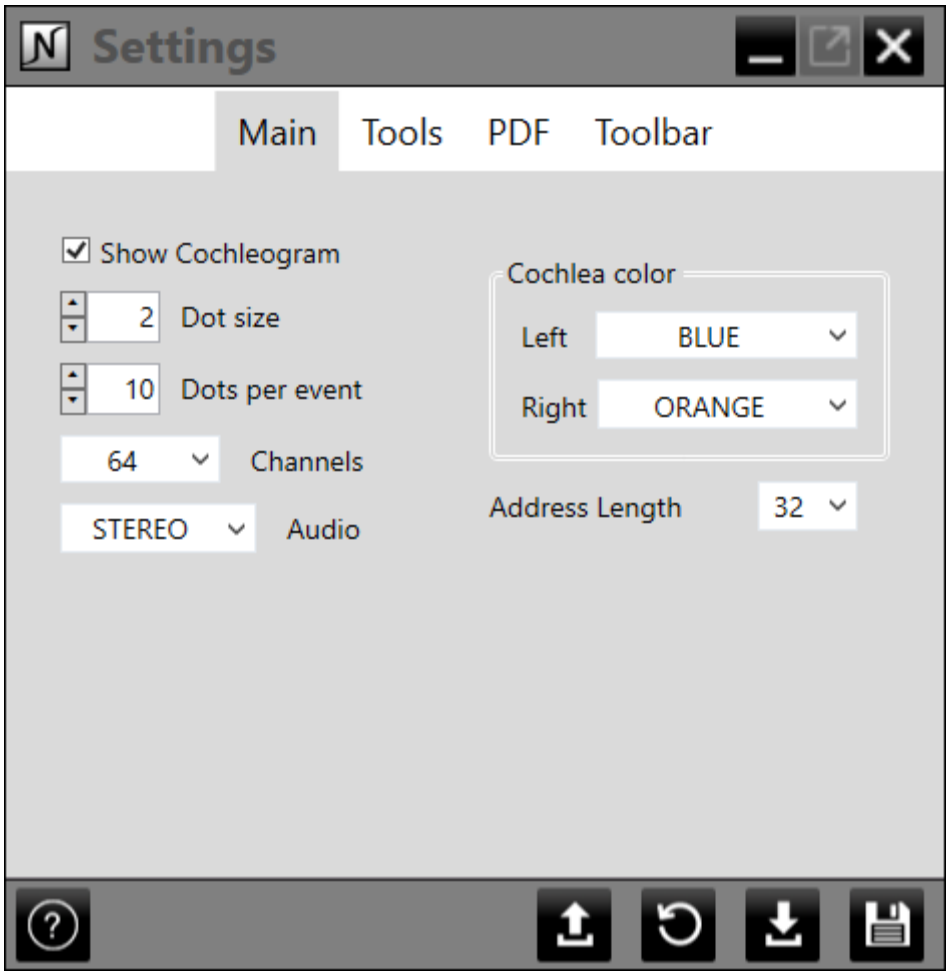
In this tutorial we have introduced you on how to install, configure and start using NAVIS. We have shown how to load aedat files and the basics for further processing of the information using the tools that this software provides. A more detailed explanation of the main NAVIS' functionalities (sonogram, histogram, average activity, disparity between cochleae, Manual Aedat Splitter and Automatic Aedat Splitter) and how to use them can be found in the next sections of this wiki:

- Sonogram
- Histogram
- Average activity
- Disparity between both cochleae
- Manual Aedat Splitter
- Automatic Aedat Splitter
- Other functionalities

But first, take a look at the settings section, which contain an in-depth description of every parameter that can be configured in NAVIS (some of them will be useful for the functionalities that have been presented before).

1. Settings

Configuring NAVIS Tool is an important step before loading your first file. You can modify the settings in the settings window, which can be opened if you click on the button with the gear symbol on the left sidebar menu or clicking in File>Settings on the top menu. The following window will open up:



As can be seen, there are four different tabs in the settings window, which will be explained one by one next. The buttons located on the bottom of the window allows the user to load a settings file, save the current configuration to a file, save the current configuration as default and restart the configuration to default values, in addition to display some information about the window.

1.1. Main

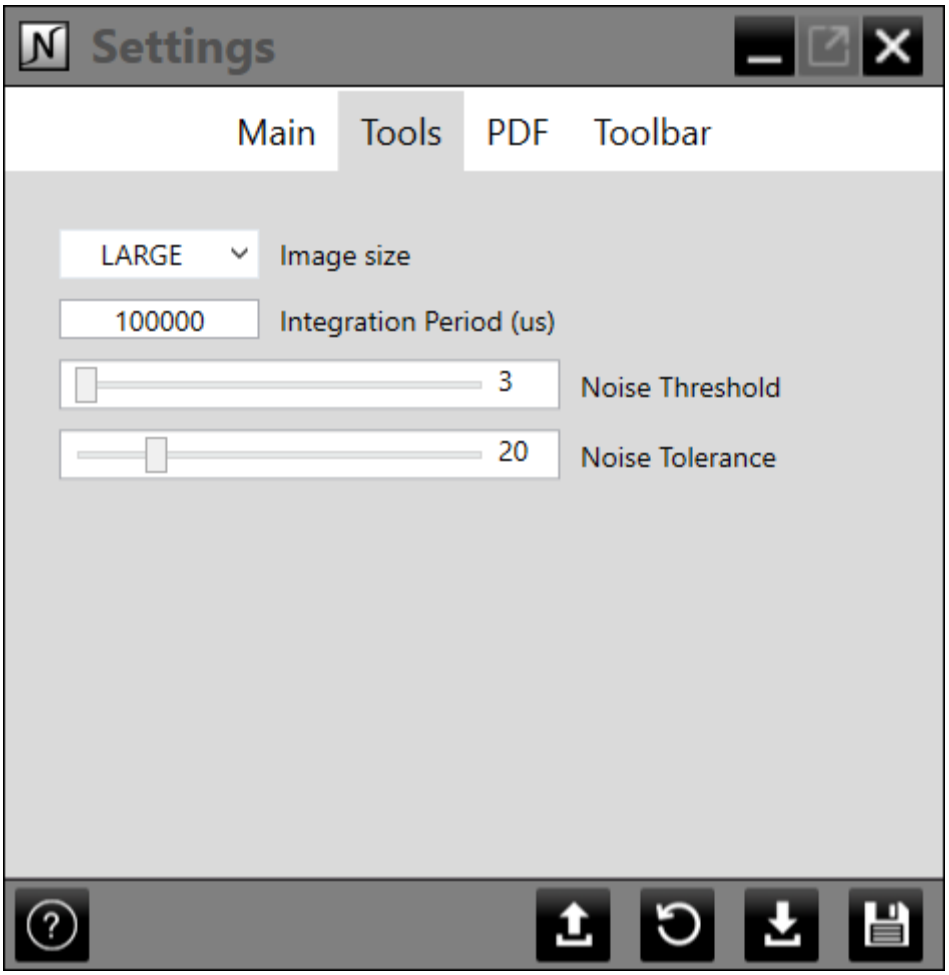
Main is the first of them and it contains settings about the cochlea specification and about the cochleogram that will be displayed in the main window.

- If **Show Cochleogram** is checked, the cochleogram for the loaded file will be generated and displayed on load.
- Each event is represented as a dot in the cochleogram. **Dot size** lets the user choose the size of it.
- Aedat files can contain a huge quantity of firing information. Displaying every event in the cochleogram could slow down the application and the user experience. **Dots per event** lets the user set how many events will be represented with one dot on the cochleogram. Higher values will reduce load times.
- **Channels** determines the number of channels of the cochlea that you are working with.
- jAER captures events information with 32 bit for the address and 32 bit for the timestamp. If you are capturing this firing information with a different tool, timestamp may have 16 bits instead of 32. You can select the number of timestamp bits for your file in **Address Length**.
- **Audio** lets the user choose between a stereo or a mono cochlea.
- **Cochlea color** sets the color for the cochleogram chart, dividing the left cochlea and the right cochlea information in two different colors that can be selected using the comboboxes. If you are working with a mono cochlea, you should only modify the left color.

1.2. Tools

Tools allows to configure some parameters that are used by a set of functionalities in NAVIS Tool.

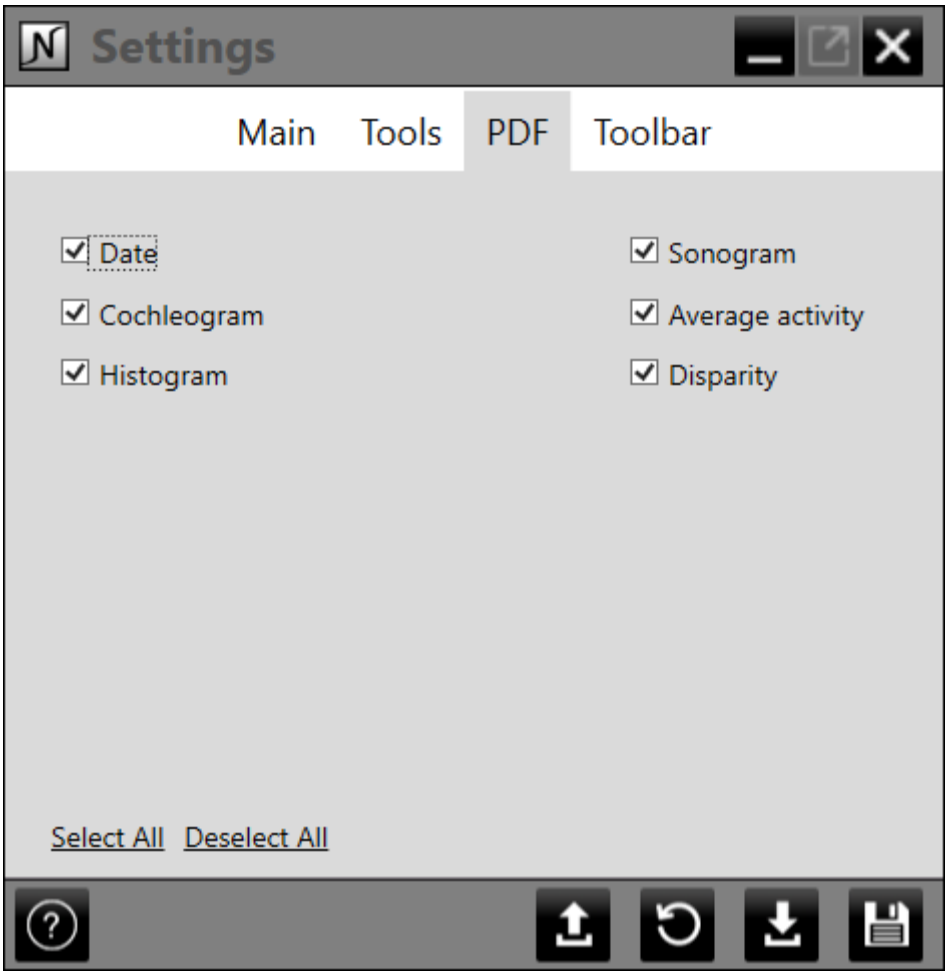
- **Image size** lets you choose between four different sizes, which will be used to generate both Sonogram and Disparity between both cochleae tools.
- As we are working with files with a huge amount of data, the functionalities implemented cannot iterate through the entire event list looking for the events that fired in a specific timestamp. **Integration period** is the smallest time period that this software works with.
- **Noise threshold** and **Noise tolerance** are used for the **Automatic Aedat Splitter tool**. Head to that section of the user manual to know more about them. These parameters are not essential to set right now, they can be modified later after loading the file.



1.3. PDF

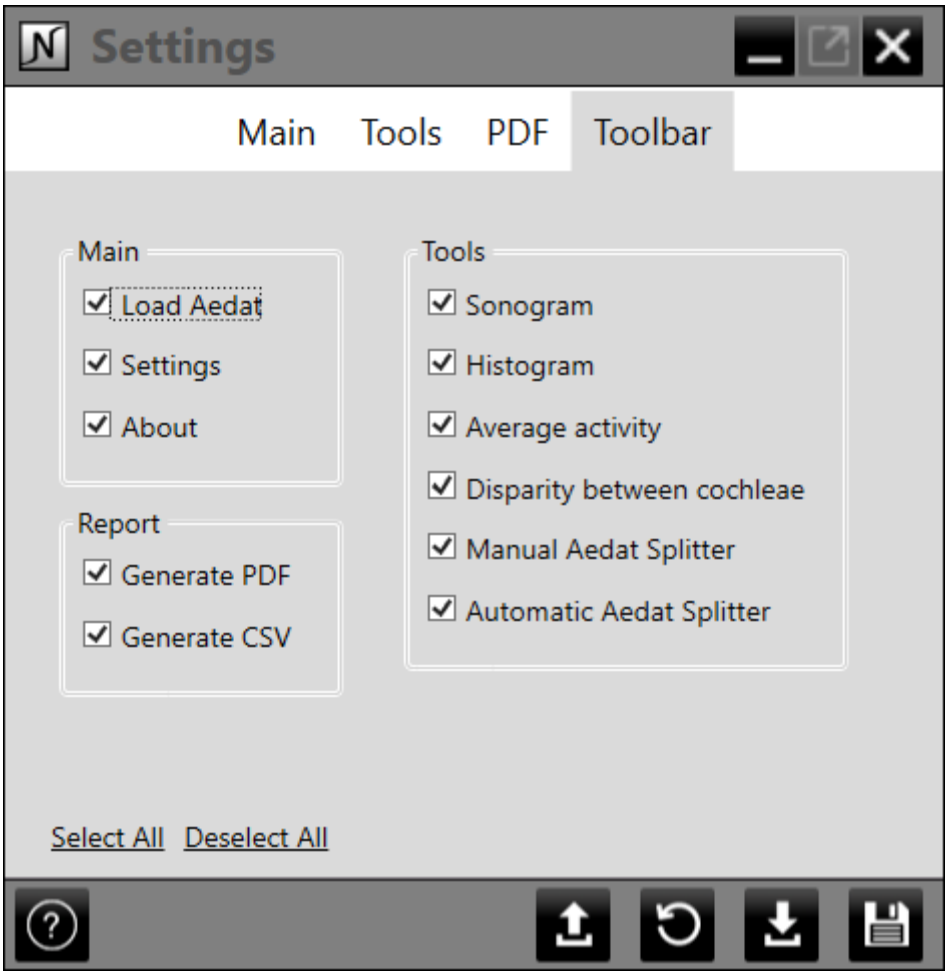
NAVIS Tool has a function that generates a report or summary of the loaded file in a PDF. This window allows to check or uncheck which functionalities will appear on that PDF.

- **Date** when the PDF was generated
- **Cochleogram**
- **Histogram**
- **Sonogram**
- **Average activity**
- **Disparity** between the left and the right cochleae (only if working with an stereo cochlea)



1.4. Toolbar

As we told in the Getting started section of this manual, NAVIS Tool has two menus: the left sidebar menu and the top menu. This window allows the user to select what buttons will appear on the left sidebar menu. If none is checked, the menu will not appear.

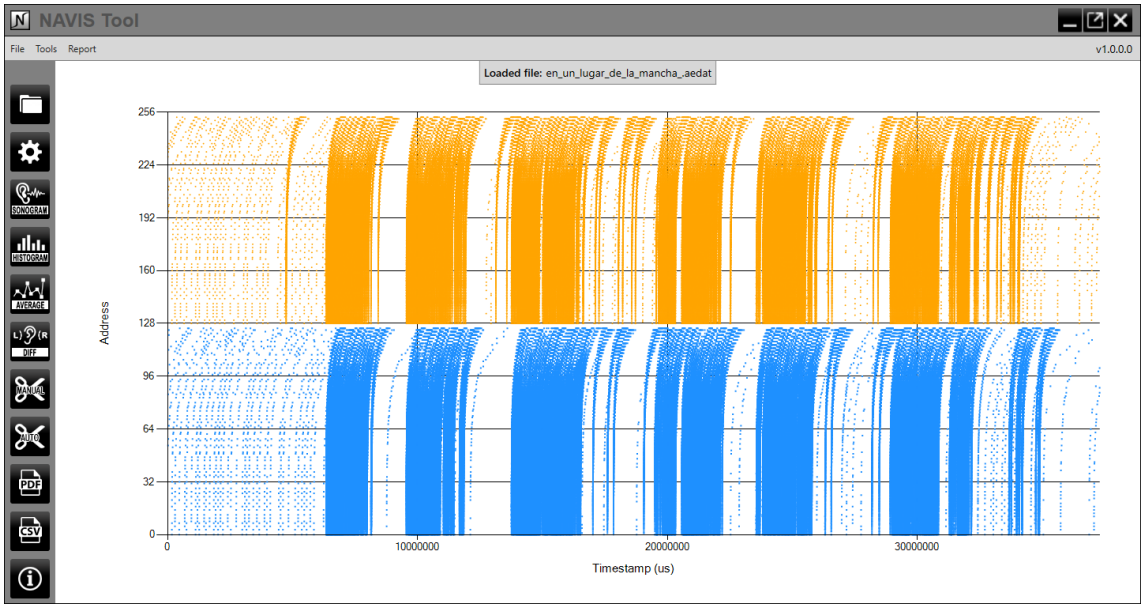


Now, after the NAVIS Tool configuration, you are ready to load your first file. Click on the folder symbol button on the left toolbar or in File>Load Aedat on the top menu. You can also load a CSV file with File>Load CSV; this file should have a different line for each event fired. Each line should have the timestamp and the address values separated with a semicolon.

After loading a file, the rest of the functionalities will be accessible.

2. Cochleogram

After choosing the file to be loaded, the internal data storage process and the subsequent cochleogram calculation and representation in the main window are launched. The output can be seen in the next image, where the X axis represents time (µs) and, the Y axis, the AER address for each cochlea channel. Each dot is an event that has been fired in a particular AER address at a specific time. The picture shows the AER events fired for both cochleae: the left one at the bottom and the right one on top. Focusing on one cochlea, lower addresses belong to the events of higher frequency channels.



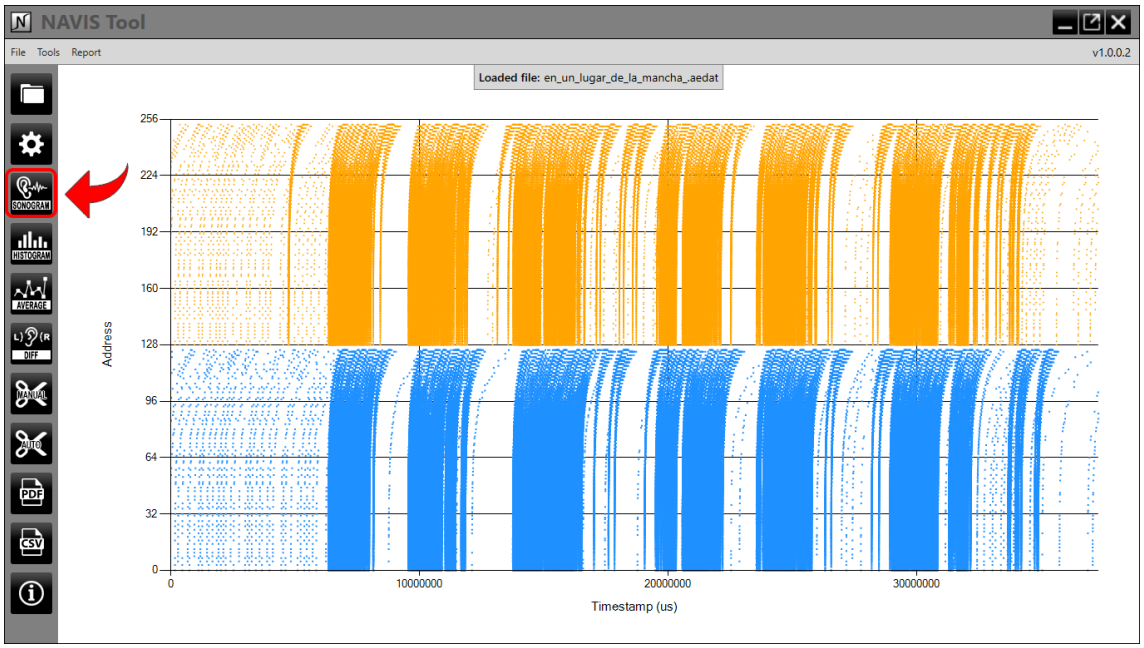
The pseudocode of this functionality is shown in the image below.

Cochleogram

```
for each(event in EventList):
    chart[event_timestamp][event_addr]
```

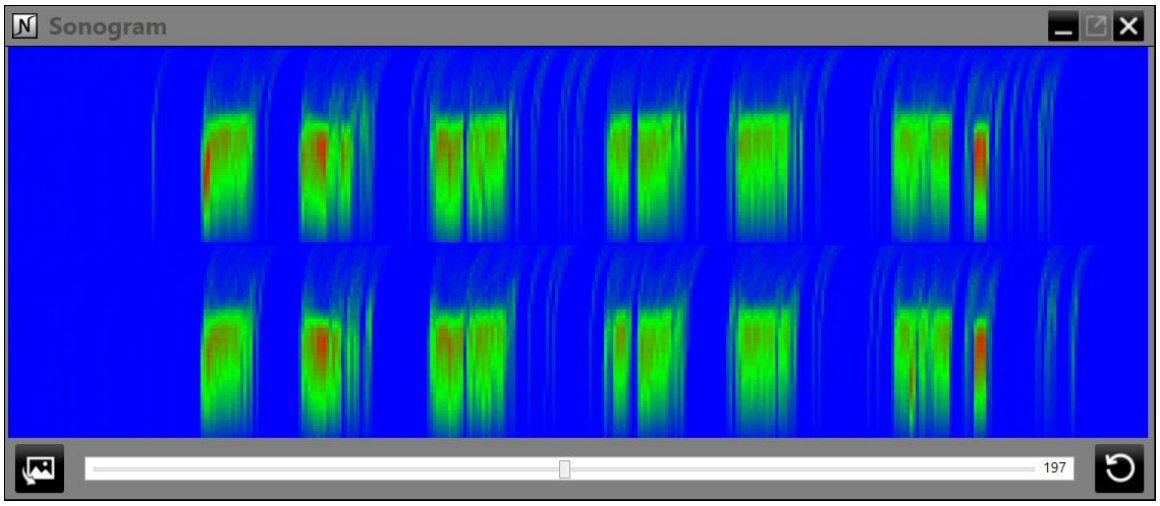
3. Sonogram

To generate the sonogram of the loaded aedat file, click on Tools->Sonogram or on the button of the vertical toolbar that can be seen in the next image.



A new window with the output of the sonogram will open. This output can be seen in the next image. The image represents the spike rate of both left and right cochlea in a color map, where X axis is time, Y axis is the cochlea channel, and the color is the spike rate of the channel in a particular time period (Integration period, which can be set in the settings).

Red represents the highest spike rate and blue the lowest one, green being in the middle. Although the highest spike rate is a value that cannot be changed (197 in the image), the scrollbar gives the user the opportunity to swap the maximum value set as red to a different one. The user can also save the image to a PNG file or reset the scrollbar to its default value.



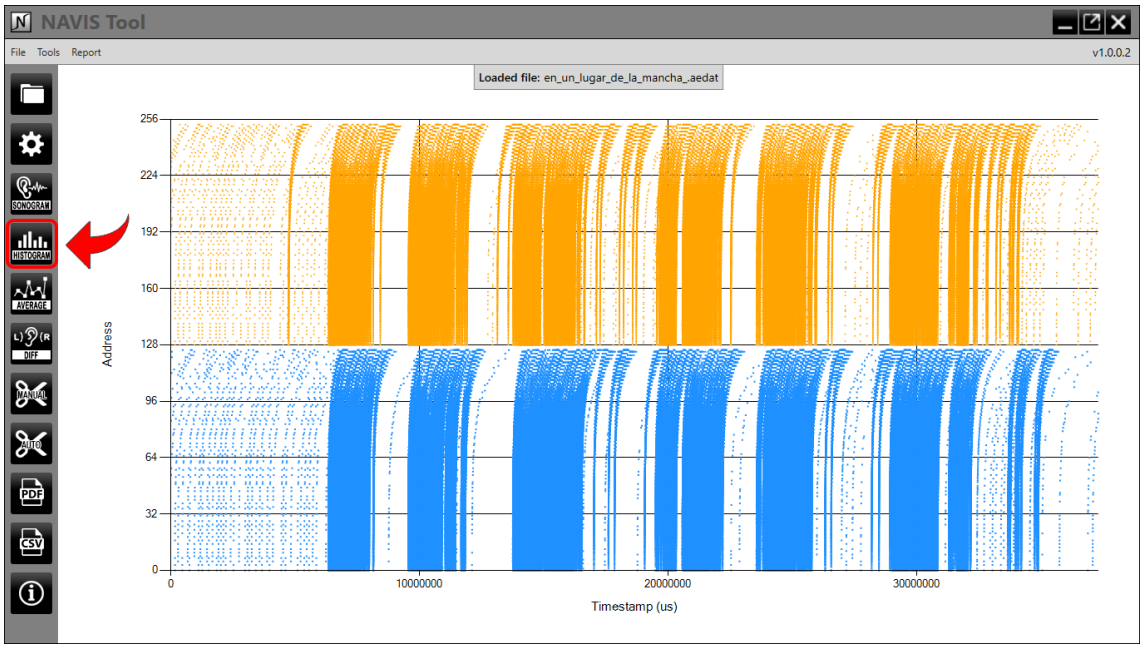
The pseudocode of this functionality is shown in the image below.

Sonogram

```
Ts = integrationPeriod
N_timeSlices = max(Ts)/integrationPeriod
m = matrix(N_timeSlices,  numChannels/2)
for each(event in EventList):
      k = floor(event_timestamp / Ts)
      m(k, addr/2)++
max_value = max(m)
m = m ./ max_value
```

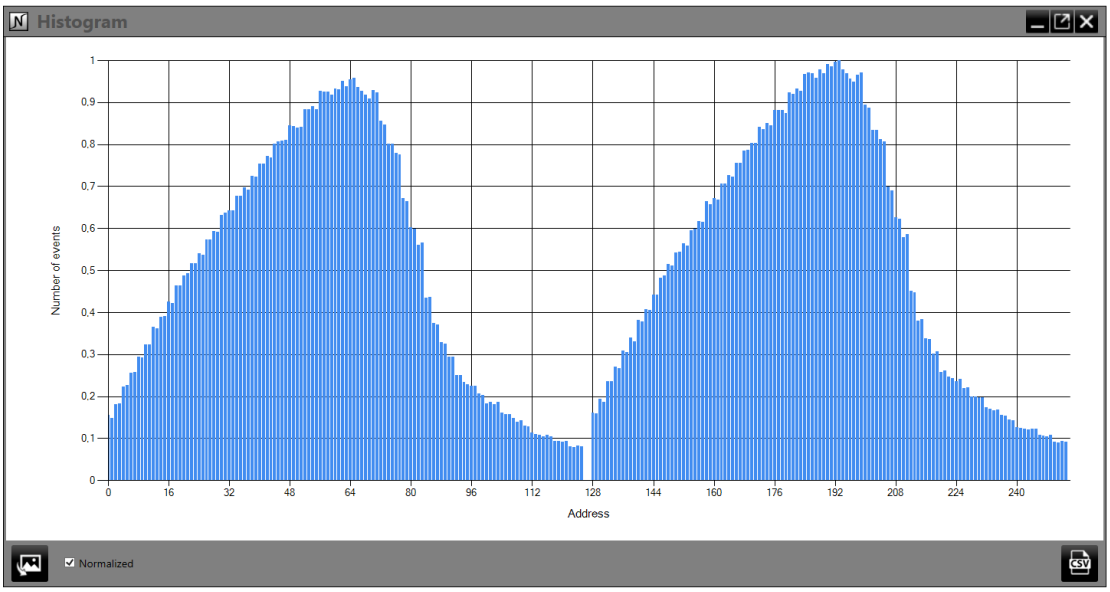
4. Histogram

To generate the histogram of the loaded aedat file, click on Tools->Histogram or on the button of the vertical toolbar that can be seen in the next image.



For certain applications it is important to know which cochlea channels are the ones that fire more events. The histogram is the appropriate chart to measure this information. The image shows the result of the histogram for the aedat file that we have been using in this manual. The X axis represents the 256 possible addresses, while the Y axis is the number of events fired.

The checkbox with the label "**Normalized**" allows the user to choose if the histogram is normalized or not, this is, in a percentage value of the highest number of fired events on the Y axis. The user can also save the image as a PNG file or save the histogram information (number of events fired for each address) in a CSV file.



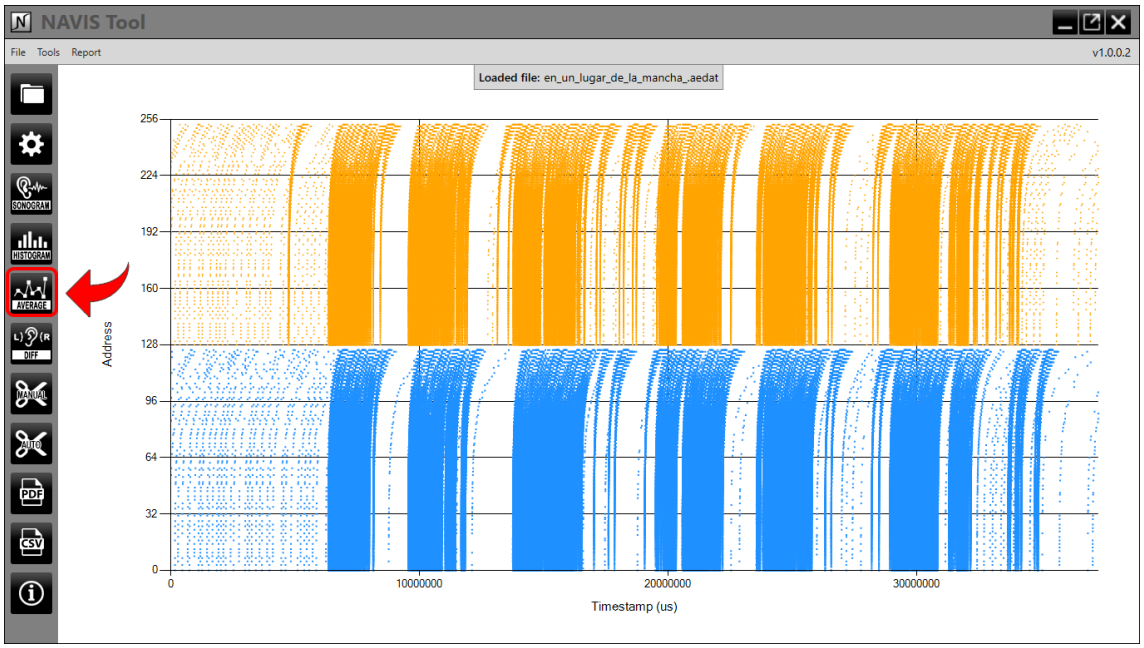
The pseudocode of this functionality is shown in the image below.

Histogram

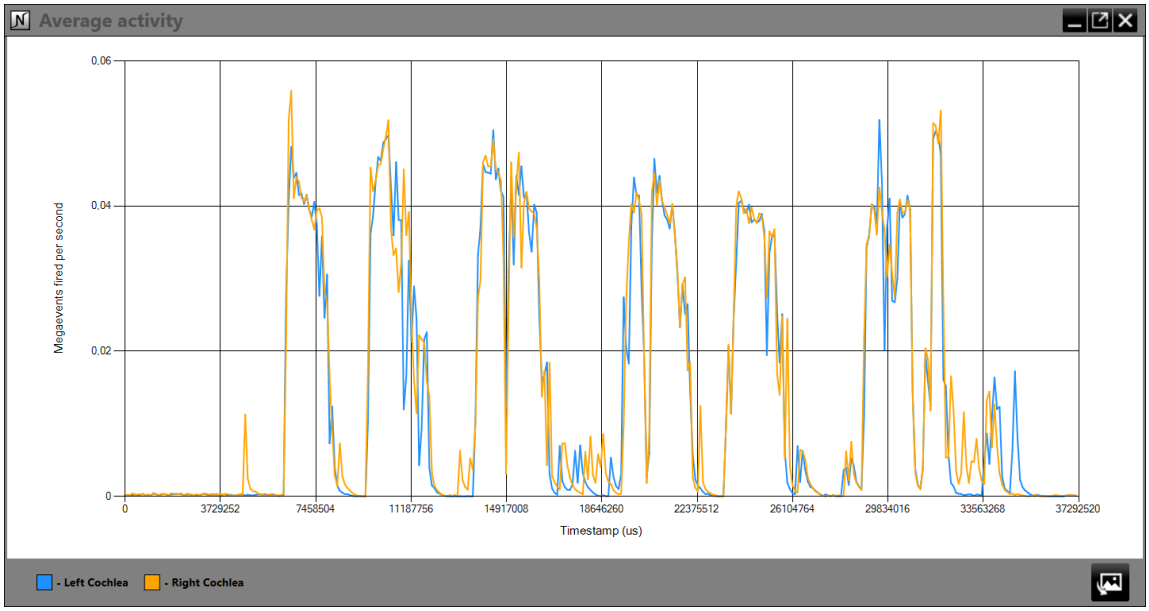
```
for each (event in EventList):
    histogram[event_addr]++
```

5. Average activity of the cochleae

To obtain the average activity of the loaded aedat file, click on Tools->"Average Activity" or on the button of the vertical toolbar that can be seen in the next image.



It is really important to know the activity of the cochleae in terms of number of AER events fired per second in a particular time period. This tool provides this functionality, generating a 2-axis chart that can be seen in the image below, where the X axis represents time (timestamp, µs) and the Y axis is the number of megaevents (10^6 events) fired per second. The user can also save the image as a PNG file.



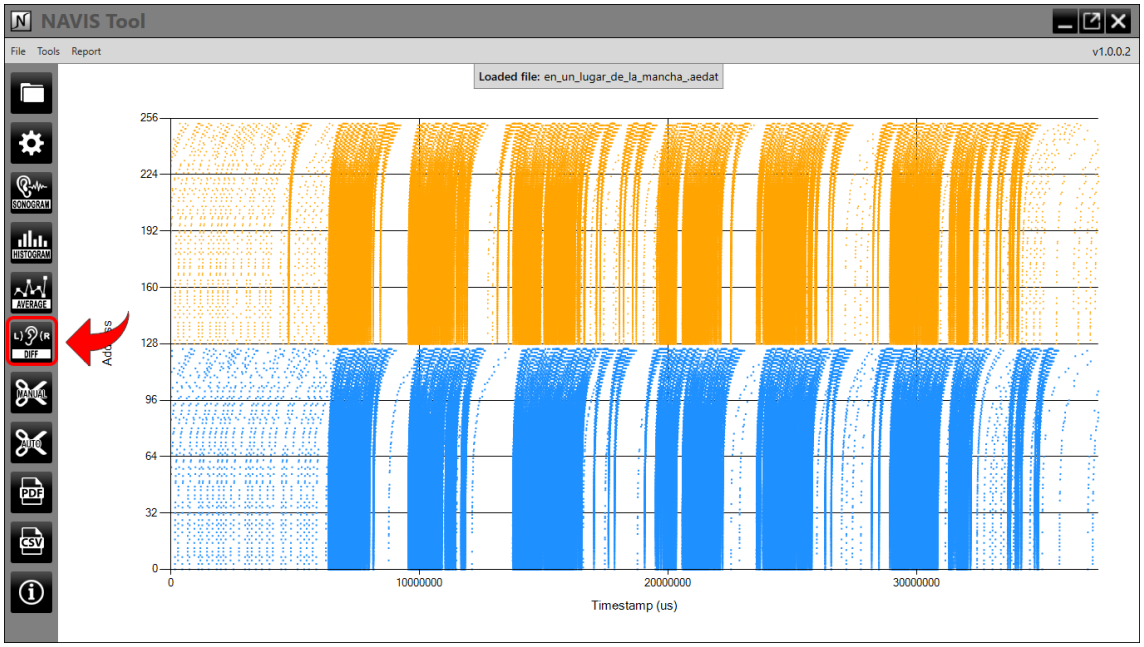
The pseudocode of this functionality is shown in the image below.

Average activity of both channels

```
average = array(N_timeSlices)
for each (slice in N_timeSlices):
    average[slice]= |EventList with event_timestamp ∈ [slice*i,..., slice*(i+integrationPeriod))|/integrationPeriod
```

6. Disparity between both cochleae

To obtain the disparity between both cochleae of the loaded aedat file, click on Tools->"Disparity between cochleae" or on the button of the vertical toolbar that can be seen in the next image.

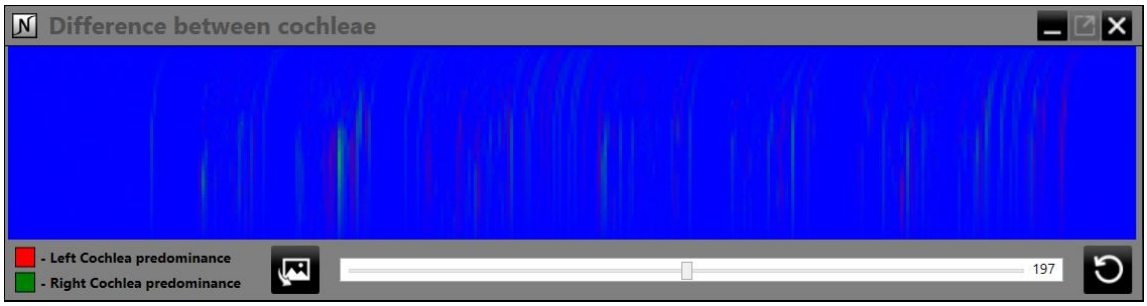


NAVIS Tool allows the user to know the difference between the left and the right cochleae, so that the predominant one in a particular time period can be identified. This will be extremely useful in echolocation tasks because it will give us information about from where the sound is coming.

Blue represents the lowest spike rate. Red represents the right cochlea predominance, while green represents the left cochlea predominance, both measured in spike rate difference. Full green or red values represents the highest spike rate. Although the highest spike rate is a value that cannot be changed (197 in the image), the scrollbar gives the user the opportunity to swap the maximum value to a different one

The user can also save the image to a PNG file or reset the scrollbar to its default value.

This tool will only be accessible if the loaded file corresponds to a stereo cochlea.



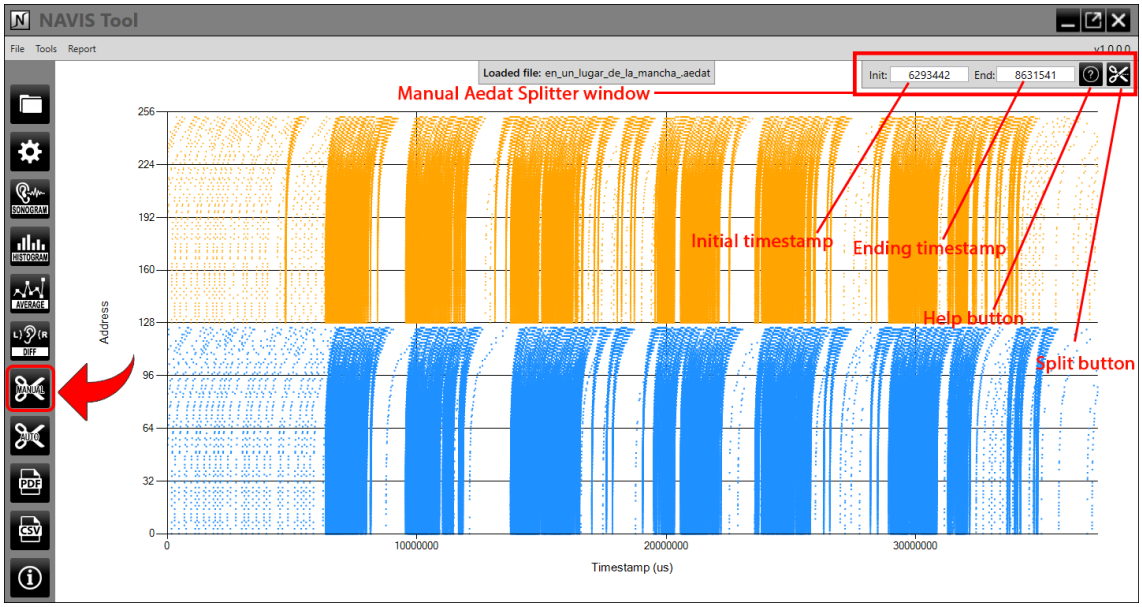
The pseudocode of this functionality is shown in the image below.

Disparity between left and right channels

```
m = matrix(N_timeSlices, numChannels/2)
for each (slice in N_timeSlices):
    for each (ch in max(numAddr)):
        m[slice][ch] = sonogram[slice][ch] – sonogram[slice][ch+numChannels/2]
```

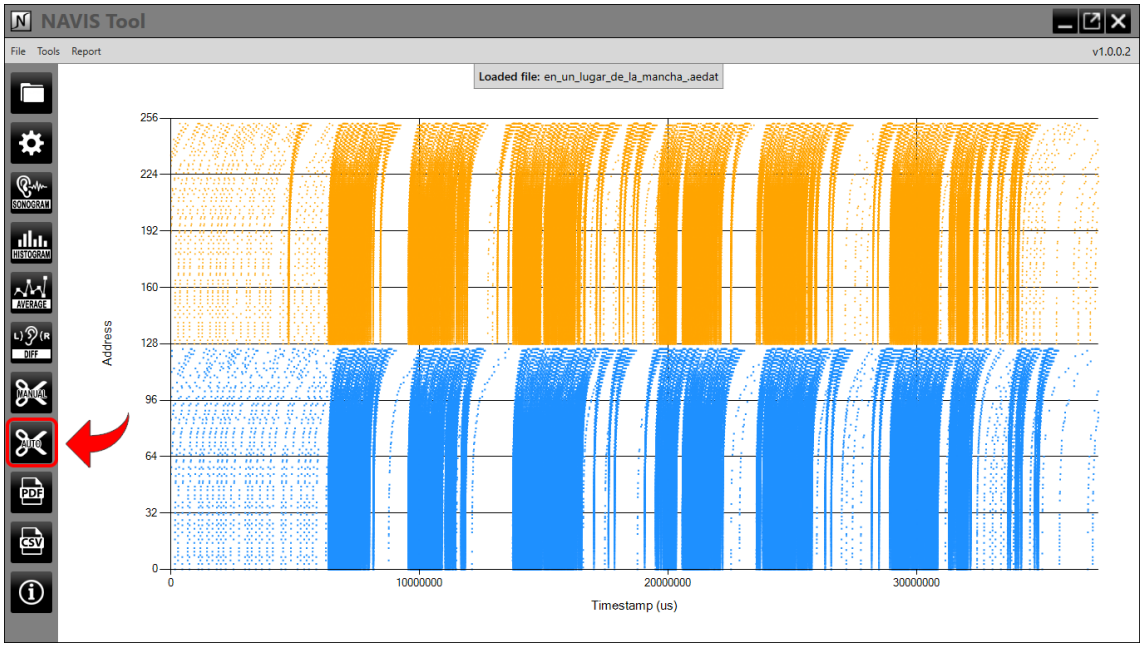
7. Manual Aedat Splitter

Manual Aedat Splitter is a tool that allows us to manually extract a specific section of the original aedat file and save it as a separate. A tab with two textboxes will open up in the main window, letting us choose the range of time that we want to take from the original aedat file. The first and last timestamp can be specified manually in the textboxes or just by clicking on the cochleogram (double-click with the left mouse button to select the initial timestamp and double-click with the right mouse button to select the ending timestamp). Once these two values are chosen correctly press the split button to save it.

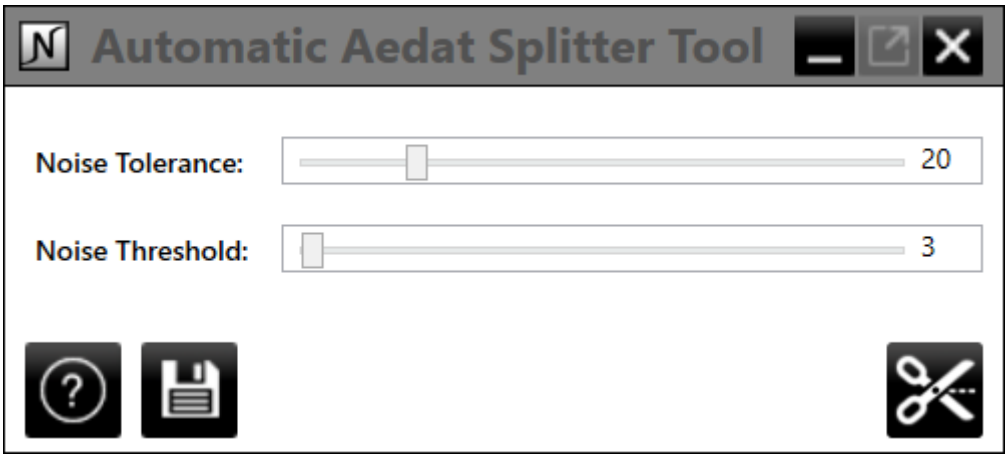


8. Automatic Aedat Splitter

In addition to being able to split the aedat file manually (Manual Aedat Splitter), NAVIS Tool has another function that allows to split the file automatically based on the activity level of the cochleae. This tool can be accessed by clicking on Tools->"Automatic Aedat Splitter" or on the button of the vertical toolbar that is highlighted on the next image.

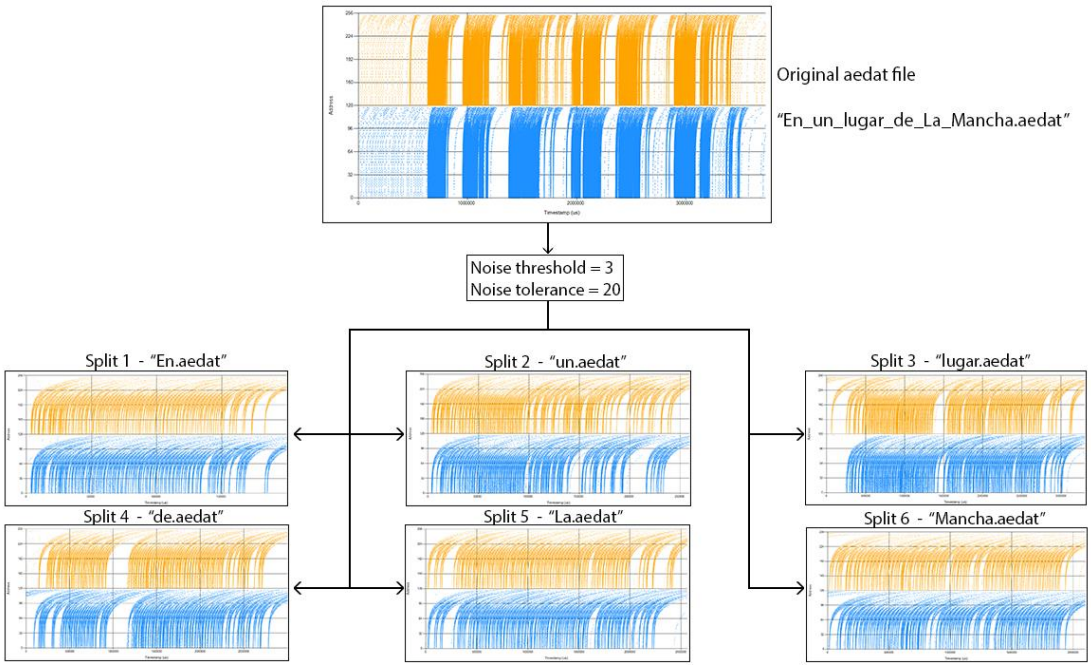


Two new parameters are needed for this purpose. These can be modified before executing the process and will add some control over it. The first one is called **Noise Threshold** and it's the percentage value from the total number of events fired in the aedat file that an integration period needs to have to be considered as sound instead of noise from the transition between two words. The **Noise Tolerance** tells for how many consecutive integration periods it is needed to detect a higher number of events than the percentage from the total (Noise Threshold) to be considered as a real sound instead of noise. Then, when a time period with not enough firing rate is detected, if the process has previously passed through Noise Tolerance consecutive times or more detecting sound, a new split is created, otherwise this information will be taken as noise and will be omitted in the results of this function.



These two parameters can be configured in the Tools tab on the settings window or in the window that shows up when clicking on the Automatic Aedat Splitter window.

The image shows the output of this function for the aedat file that we have been using in this manual.



The pseudocode of this functionality is shown in the image below.

Automatic Aedat Splitter

```
indexSplit = 0, consecutiveIntegrationPeriods = 0, i=0
while i < maxTimestamp
    eventsFired = EventList with event_timestamp ∈ [i,..., i+integrationPeriod)
    n_eventsFired = |eventsFired|
    if (n_eventsFired >= (noiseThreshold /100) * |eventList|):
        splits[indexSplit] = splits[indexSplit] ∪ eventsFired
        consecutiveIntegrationPeriods++
    else if (consecutiveIntegrationPeriods < noiseTolerance):
        splits[indexSplit] = ∅
    else:
        indexSplit++
        consecutiveIntegrationPeriods = 0
i += integrationPeriod
```

9. Other functionalities

9.1. Generate PDF

This tool allows to generate a PDF with a report or summary of the loaded file. It includes charts and information about the cochleogram, histogram, sonogram, disparity between cochleae and average activity. These five outputs can be either selected to appear in the PDF or not in the PDF tab on the settings window.

9.2. Generate CSV

Generates a CSV with the aedat information (a list with the timestamp and address for each event). This file has a different line for each event fired. Each line shows the timestamp and the address values separated with a semicolon. An example can be seen in the next image:

```
Timestamp;Address
0;235
2278;191
9101;204
9103;229
12518;54
15170;85
15932;192
15934;195
21240;98
21242;127
22001;58
22755;209
27309;232
```

9.3. Stereo to mono

After loading a stereo aedat file, you can convert it to a mono aedat file using this function, saving this information in a different file. It only saves the information of the left cochlea.

About

This software was created by Juan P. Dominguez-Morales under a GPL license.

Email: jpdominguez@atc.us.es

NAVIS Tool GitHub page: https://github.com/jpdominguez/NAVIS-Tool

You can find aedat sample files in https://github.com/jpdominguez/NAVIS-Tool/tree/master/NAVIS/AedatSampleFiles