Rhythm 1.1 GUI user guide

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# Getting Started

Be sure that you have Matlab version 2017 or greater.

Download Rhythm 1.1 to your project directory from GitHub via link: https://github.com/optocardiography/Rhythm-1.2

Open rhythm.m with Matlab and go to Home -> Set Path. Add your project directory via “Add with Subfolders …”, then “Save” and “Close”.

Run rhythm.m.

# GUI

Main window of Rhythm consists of 3 parts (see figure 1):

1. Toolbars on the left
2. Four movie screens on the center
3. Signal windows on the right

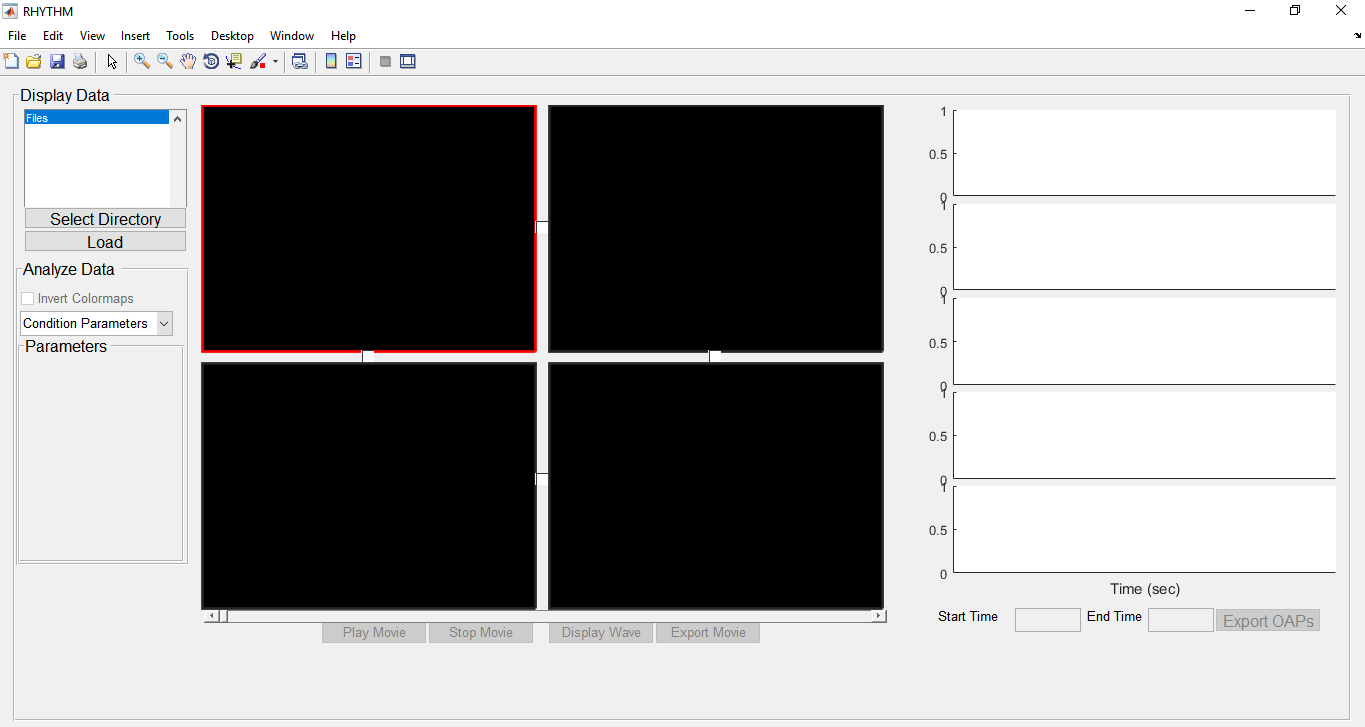


Figure 1. Start interface of Rhythm. Toolbars on the right, four movie screens on the center, signal screens on the right.

# Toolbars

Use button “Select Directory” on the top of toolbar menu to set path with your experimental data. You will see the list of available files in the current directory. Select an experiment and click “Load” to load experiment data and visualize it on the selected movie screen (with red boundaries). Reload data to any movie screen if it is necessary.

Menu “Analyze Data” on the bottom has popup menu containing add-ons for signal processing (Condition Parameters, Conduction Velocity, Activation Map, etc.). Once any data is loaded to movie screen(s) you can select signal processing method, that you interested in. After that you will see parameters for selected processing method. See several examples on figure 2.

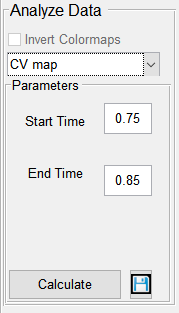
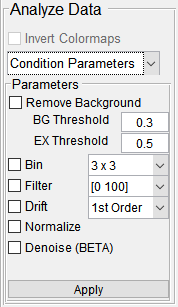
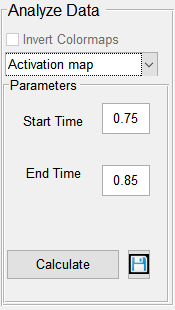


Figure 2. Examples of “Analyze Data” menu.

# Movie screens

Four movie screens allow to upload several experiments independently. One can select a screen by a single-click. The selected screen has red boundaries. Double click may be used to zoom in the selected screen.

Note that different experiments may contain different camera frames number, but all loaded data must have a common frame rate.

Once any data is loaded, buttons Play Movie, Stop Movie, Display Wave and Export Movie become unfrozen. Play movie and Stop Movie is used to play signal data with the respect to time. Time is shown on the movie slider.

Use “Display Wave” button to set marker on desirable point of loaded data. You can set up to 5 different markers. After setting 5 markers, new Display Wave calls will overwrite old markers. Each movie screen contains its own markers. Figure 3 shows three datasets with 3, 2 and 4 markers correspondingly. Signals waves are shown for a selected movie screen. Markers can be grabbed by single-click and dragged to different position of its movie screen.

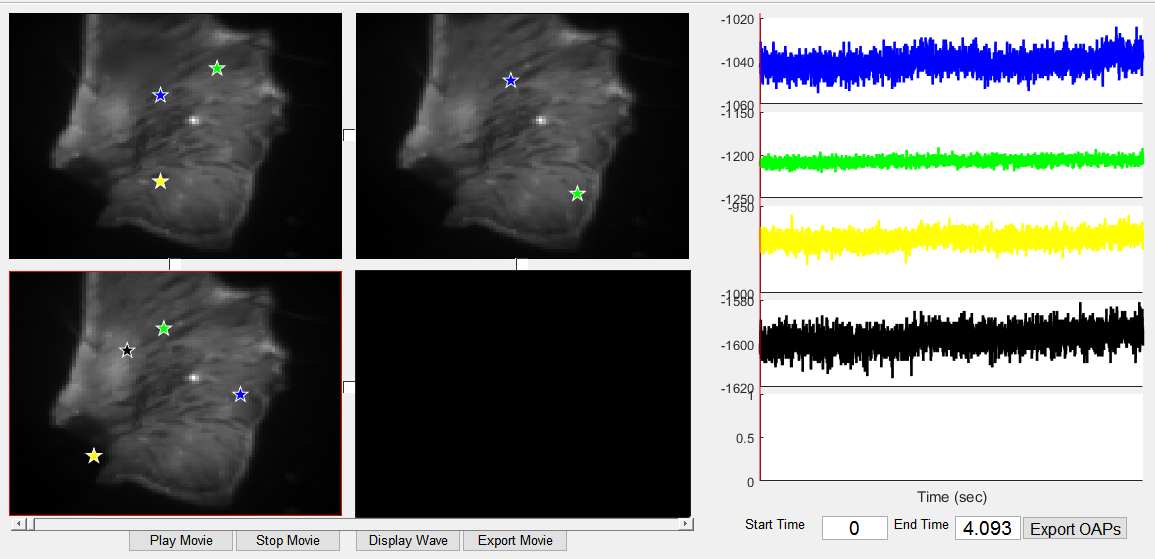


Figure 3. Several markers are set on different screens. Signal waves in marker points are shown on the signal screens for selected screen.

Screen synchronization

Several experiment files obtained with the same camera position may be synchronized. User can synchronize uploaded data with setting checkboxes between the movie screens. Once several movie screens are synchronized, they share group markers. Marker placed on one of synchronized screens, applied to all the screens from that group. Group markers can be dragged to a different position as usual. Figure 4 shows two synchronized movie screens 1 and 2, and one separate screen 3. Screens 1 and 2 have two group markers, while screen 3 has its own markers. Signal waves are drawn for a selected group of synchronized screens or for a selected screen if it is not in any synchronized group.

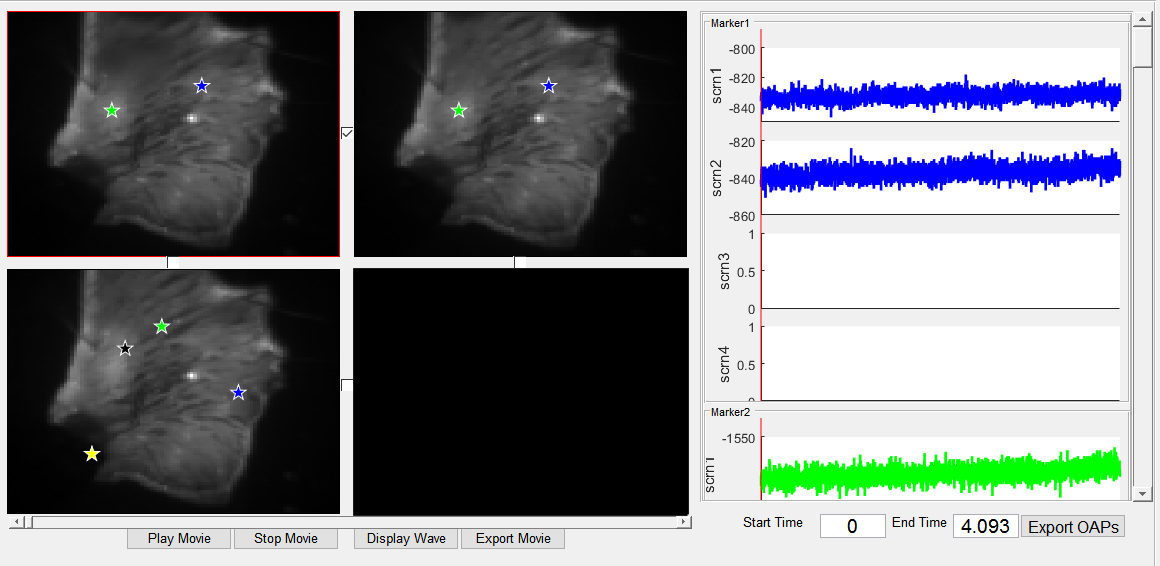


Figure 4. Example of the two synchronized movie screens and one screen with no group. Signals on the right are shown for the screen group, that contains the selected screen.

# Signal screens

Signal screens on the right show time-dependent signal waves, probed in the position of markers. Signal waves have the same colors as their markers.

Signal screens display signal waves in two modes: waves of a signal screen and waves of all the screens in one synchronized group. In the first case (see figure 3) there are 5 signal screens for each marker. In the second case (see figure 4) there are 5 signal groups for each group marker. A signal group is a four signal screens for each movie screen. Since a number of screens in the group mode is large, one can use vertical slider to see all signals.

Red vertical line represents the current time. User can zoom in/out in time, specifying “Start Time” and “End time”. Note that start time is non-negative value.

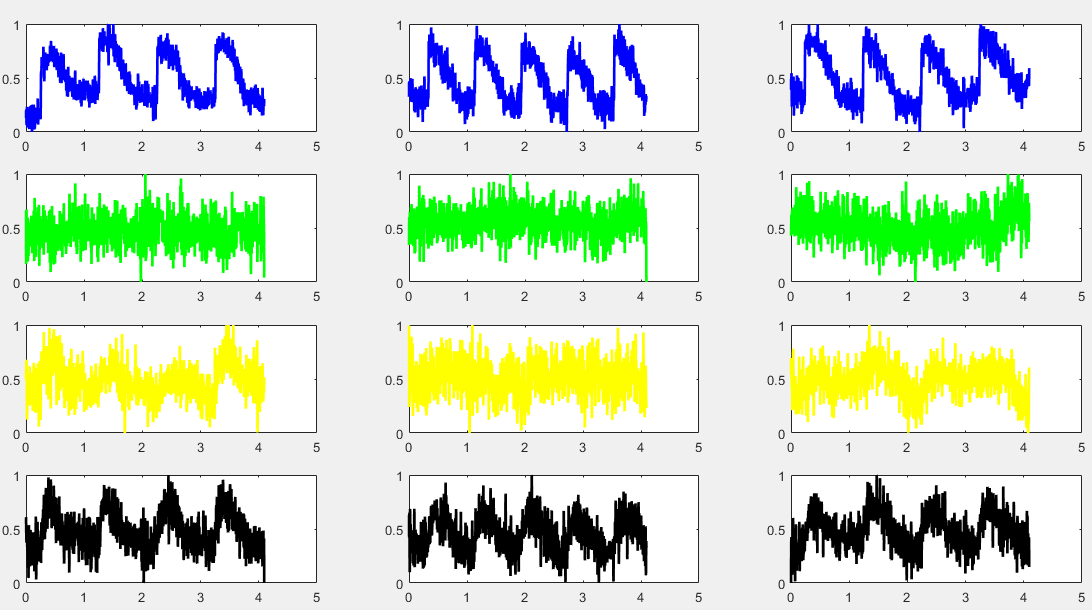
Button “Export OAPS” exports signal waves to a new window that can be used to save data as image. In synchronized movie screen mode, the new window organized as follows: columns stand for screens, rows for markers (see figure 5). 

Figure 5. Export OAPs window. Example for 3 linked movie screens with 4 markers on them.

# How to use separate functions

### Activation map

Edit start and end times of OAP part to define the time interval which you want to see the signal propagation. This interval is reflected by green sweep bars in the signal Screens. To visualize this map, click button “Calculate”, the map appears on the selected screen. The color of each pixel indicates the time at which the maximum derivative occurs. To save this map, click icon “Save”.

### Conduction Velocity map

This function calculates the rate of electrical impulses for a single action potential upstroke described by one pixel. It calculates the maximum upstroke derivative for each pixel.

Edit start and end times of OAP part to define the time interval. This interval is reflected by blue sweep bars in the signal Screens.

After clicking “Calculate”, select a rectangular region of interest on the selected screen with the cursor.

The image indicates the largest connected region of processed signal with vectors represented by superimposed red arrows. The direction and magnitude of the arrows indicates the path and rate at which the tissue is being activated. The color of each pixel indicates the time at which the maximum derivative occurs.

To save this map, click icon “Save”.

Upon completion of the CV map, five variables are displayed in the Command Window. These variable report the median conduction velocity (medV), standard deviation of the CV (stdV), median vector angle (medAng), standard deviation of the vector angle (stdAng) and the total number of vector (num\_vectors) described in the region of interest of CV map.

### New Conduction Velocity map

This function calculates the rate of electrical impulses for a single action potential upstroke described by one pixel. It calculates the maximum upstroke derivative for each pixel.

Edit start and end times of OAP part to define the time interval. This interval is reflected by blue sweep bars in the signal Screens.

After clicking “Generate Vec.Map”, select a rectangular region of interest on the selected screen with the cursor.

The image indicates the largest connected region of processed signal with vectors represented by superimposed red arrows. The direction and magnitude of the arrows indicates the path and rate at which the tissue is being activated. The color of each pixel indicates the time at which the maximum derivative occurs.

To save this map, click icon “Save”.

Upon completion of the CV map, five variables are displayed in the Command Window. These variable report the median conduction velocity (medV), standard deviation of the CV (stdV), median vector angle (medAng), standard deviation of the vector angle (stdAng) and the total number of vectors (num\_vectors) described in the region of interest of CV map.

If you want to select the arrow direction only along one line, you should click “Draw Line” and point the end dots of line. After it click double. The direction is selected.

Then click “Calculate CV”. The result of this program are five numbers in Statistics panel. There are median conduction velocity, mean conduction velocity, standard deviation of the CV, the total number of vectors and mean vector angle.

### Action Potential Duration Map

The Start Time and End Time entries restrict the data into a specific time interval, reflected by sweep bars in the Signal Screen.

The Min APD and Max APD entries allow the user to control the range of action potential duration in milliseconds, based on the data being analyzed. The entries must be numeric values greater than zero.

The %APD button allows control over analysis of the time duration, from the maximum upstroke velocity to the first point that is a specified percentage of the maximum value after the peak.

Upon selection of the “Mapping” button APD map appears on the selected screen. Also figure is a histogram reflecting the frequency of signals displayed in the map.

To save this map, click icon “Save”.

Upon clicking “Regional APD” select rectangular region of interest on the selected screen with the cursor. Two variables are displayed in the Command Window and in the Statistics panel. There are APD mean(apd\_mean) and the standard deviation of the action potential (apd\_std).