

Tutorial for RASCHlab-0.3.0

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Chapter 1. Introduction

RASCHlab is a program based on libRASCH (<http://www.librasch.org>), which allows the user to access time-series data. Additionally the user can process the signals (e.g. perform a beat detection in ECG's) and perform calculations based on the signals (e.g. calculate heart rate variability parameters from an ECG).

The program provides access to different file formats (e.g. EDF(+), MIT/AHA) and displays the informations which are included in a signal. For example comments/annotations in an EDF+ file is shown and the user can edit a comment or add a new one. Or when ECG's contain informations about the position and types of the heart beats, RASCHlab will show the positions and the user can edit/delete/insert the beat positions.

This tutorial will show you the fundamental usage of RASCHlab. All examples are shown on ECG's but generally it can be used for every kind of signal.

At the moment libRASCH (the basis of RASCHlab) supports best signals used in cardiology (e.g. ECG, continuous blood pressure) by special plugins for displaying and processing these signals. If you have experience with signal processing in other fields and some ideas what would be nice to have in libRASCH/RASCHlab, please send me an email (rasch@med1.med.tum.de) with your ideas and/or source code.

Chapter 2. Terminology

This section gives a short description of the terminology used in this tutorial.

Measurement

A measurement is the topmost object in libRASCH. Measurements consists of one or more sessions, information about the measurement object (e.g. name, forename and birthday if the measurement object is a person) and zero or more evaluations.

Session

A Session is a recording for a specific time interval without any interruptions during this time interval. In a measurement can be more than one session, but the layout of the recording (see below) must not be changed.

Recording

A recording contains the measured data (e.g. ECG leads V1-V6). A recording has one or more channels or two or more sub-recordings. Sub-recordings are used if more than one recording device is used. For example when one Analog/Digital converter-system records 3 ECG leads and one bloodpressure channel and another system records 12 EEG leads, the measurement consists of one top recording with two sub-recordings. The first sub-recording contains 4 channels (3 ECG and 1 bloodpressure channel) and the second sub-recording contains 12 channels (12 EEG channels).

Evaluation

The results of an analysis (e.g. positions of heart beats in an ECG) are stored in an evaluation. An evaluation contains zero or more discrete events (e.g. 'occurrence of a heart beat') and/or zero or more continuous events (e.g. 'recording period with noise'). In measurements handled by libRASCH, more than one evaluation can be available.

When an evaluation is added to the measurement by the original recording system (e.g. the evaluation performed by commercial long-term ECG systems), then this evaluation is called the *original* evaluation.

If only one evaluation is available, it is no problem to choose an evaluation when the user wants to process the evaluation. When more than one evaluation is stored in a measurement, one of these evaluations has to be the *default* evaluation, which is used when no specific evaluation is selected. In most cases the last added evaluation is set to the default evaluation.

Event

An event describes the occurrence of something in a recording (e.g. a heartbeat in an ECG). An event has one or more event-properties.

Event-Property

An event-property is a specific property of the event (e.g. the position of the event, the type of the event). A specific event-property is allowed only once in an evaluation, for example there can be not more than one 'qrs-position' property.

Event-Set

An event-set describes a group of event-properties. For example the event-set 'heartbeat' contains all properties which belongs to a heart beat (e.g. position of the heart beat, the RR interval, the type of the heart beat, systolic blood pressure).

Plugins

libRASCH makes heavy use of plugins. Plugins are small "programs" which are loaded when libRASCH is initialized. In the plugins the real work is done, the library-code "only" coordinates that the correct plugin is used and does some other administrative tasks. In libRASCH three principal types of plugins exist:

- access plugins
- view plugins
- process plugins

Access-Plugin

Access plugins handle the access to measurement files. They hide the differences of the various types of formats and offer an consistent interface to the measurements¹.

Process-Plugin

Process plugins perform a specific task on the measurement (e.g. the HRV-plugin calculates the Heart-Rate Variability parameters for an ECG or the detect plugin performs a simple beat detection in ECG's).

View-Plugin

View plugins allow to display the measurements on the screen. At the moment the following GUI's are supported:

- Qt from Trolltech (for Linux)
- MFC from Microsoft (for Windows)

Notes

1. The signal plugins can be compared with device drivers in operating systems.

Chapter 3. Installation

Please follow the instructions comming with the libRASCH distribution you downloaded.

Chapter 4. Open a Signal

After starting RASCHlab, an empty workspace is shown. In this workspace the signal and other information about the signal will be shown. Now the first step will be to open a signal. To do this, select the menu entry 'File/Open...' or press the open button on the toolbar (an opening folder; the first button from left). This will open the signal selection dialog box. Figure 4-1 shows the screen shot with the dialog box. The signal selection dialog box is similar to the file browser in Windows, on the left side you can select the folder. On the right side, the signals in the selected folder will be shown. (Only the signals which are supported by libRASCH are shown.)

Figure 4-1. Signal selection dialog box.

Now select the folder 'LIBRASCH_ROOT/examples/database' on Linux systems and 'LIBRASCH_INSTALL_ROOT\examples\database' on Windows systems on the left side¹. After selecting the folder, the available signals will be shown. Please select the signal named '100s'. This is a short ECG (one minute) from the PhysioNet database. To open the signal, you can double click on the signal-name or select the signal by clicking once on the signal-name and then click on the OK button. Then the signal will be shown in the signal window. Figure 4-2 shows RASCHlab with the signal window showing the ECG. The signal window is a libRASCH view-plugin.

Figure 4-2. Screen shot of RASCHlab showing the ECG 100s.

In the signal window, all channels of a measurement are shown. When the measurement contains more than one type of signal (e.g. ECG and arterial blood pressure) then each type of signal will be shown in their own signal window (for an example see Figure 6-1). To do this, libRASCH has to "detect" which signals are stored in a measurement. In general purpose file formats (e.g. file formats used by ADC systems), libRASCH tries to estimate the signal-type by the channel name. In file formats which have a fixed channel/signal-type relation, the signal type is set by the plugin supporting the file format.

Notes

1. LIBRASCH_ROOT is the directory of the libRASCH distribution on your system and LIBRASCH_INSTALL_ROOT is the directory selected while installing libRASCH

Chapter 5. Process a Signal

After opening the ecg in the previous chapter, we want now to find the positions of the beats in the ECG. libRASCH supports this by providing a process plugin ('detect-simple') which performs a beat detection. Additionally we want to group the found heart beats in similar looking groups (templates) and we want to calculate some ECG specific values (e.g. the intervals between each heart beat, called RR intervals). The later two steps will be done in the process plugins 'template' and 'ecg' respectively.

In RASCHlab, all the above mentioned steps will be performed when selecting the menu entry 'Detect->Detect'. After selecting the menu entry, the channel selection dialog box will be opened (Figure 5-1) and the user has to select the channels in which the heart beats should be searched. (At the moment all available channels will be selectable, but this will be changed in the future, showing only the channels which makes sense.) To select the channels, click on the channel-name on the left side and then click on the '->' button. This will move the channel-name to the right side. Figure 5-2 shows the dialog box after selecting both channels.

Figure 5-1. Channel selection dialog box.

Figure 5-2. Channel selection dialog box after selecting the channels.

After selecting the channels, press the 'OK' button. Now the beat detection, template grouping and the calculation of the ECG specific values will be done. For each processing step, a progress dialog will be shown. When all the processing is done, a window with ecg and the found beats and a window with the templates will be shown (Figure 5-3).

Note that the detection of heart beats are not limited to file formats which are used to store only ECG's. RASCHlab do not care which file format was used to store a signal. For example when you have an EDF file with ECG and EEG signals, you can perform the beat detection the same way as described above. As written above, at the moment the user has to be sure to select the correct channel containing an ECG recording.

Figure 5-3. ECG after beat detection performed.

RASCHlab allows you to correct the automatic evaluation of the ECG. A description how you can change an evaluation of an ECG is given in Section 9.1.

Evaluations created with RASCHlab are stored on disk at the same position where the signal data is stored. The data is stored in a file named using the name of the recording and for the file extension '.mte' is used. For example the evaluation created above is stored in the file '100s.mte'. The evaluation is stored using XML. The user can control with the menu entry 'General->Save ASCII eval-values' if array data (e.g. the positions of the heart beats) is stored as ASCII text (menu entry with check mark) or as binary

(menu entry without check mark). When storing the data as ASCII text, it can be used easily with other programs. On the other side, when a lot of events are in an evaluation (e.g. heart beats in a 24 hour ECG), loading and saving took a lot of time. For this type of signals, the binary format is recommended.

Chapter 6. Navigation

6.1. Navigation in the signal window

If there is more than one window in the signal window, then you have to select the signal window which should be used. To do this, click in the sub-window. Then a black frame in the sub-window will be shown and this sub-window has the input focus. Figure 6-1 shows an example of a measurement containing three ECG channels, one arterial blood pressure channel and one respiration channel. In the example the ecg-sub-window has the input focus (shown by the black frame around the ecg-sub-window).

Figure 6-1. Screen shot of a measurement with different kind of signal types.

To browse through the signal, you can use the horizontal slider on the bottom of the signal window or you can use the following keys:

- 'cursor left' (<-): 1/10th back in the signal
- 'cursor right' (->): 1/10th forward in the signal
- 'shift + cursor left' or 'page up': one page back in the signal
- 'shift + cursor right' or 'page down': one page forward in the signal

6.2. Selections

In the signal-view-plugins, libRASCH supports the concept of selections. Selections are a subset of events which have one common property. For example you can select all heart beats which belongs to the same template (i.e. all heart beats with similar morphology) or you can select all ventricular beats.

In these selections, you can step back and forth with the following keys:

- 'space bar': go to the next item in the selection
- 'b': go to the previous item in the selection

When a selection is "active", then the number of selected events and the current position in the selection is shown in the signal view in the lower right corner. The figure "12/456" means that you are currently at the 12th event from 456 selected events. For example the numbers inside the red circle in Figure 6-5.

Selections are implemented in the signal-specific view plugins. Therefore the type of selections will differ from signal to signal but the concept will be always the same independent of the signal type.

(Because at the moment there are not so much signal specific view plugins, the examples shown here are all for ECG's.)

Figure 6-2 shows the context menu which pops up when pressing the right mouse button inside an ecg view. The main context menu has three entries: (1) General Options, (2) Channel Options and (3) ecg. The first two entries are available in all view-plugins and will be described in Chapter 8. The third entry (ecg) is only available in ecg views. The ecg entry has two sub entries: (1) sort and (2) templates. Figure 6-2 shows the sub menu of the sort entry and Figure 6-3 shows the sub menu of the template entry.

Figure 6-2. Context menu for the selection of beat types (e.g. normal beats, ventricular beats).

Figure 6-3. Context menu for the selection of beats belonging to a specific template.

When you are interested in specific beat types (e.g. all ventricular beats or all artifacts) then you have to choose the wanted beat type from the sort menu. If you are interested in a specific template, then you have to choose the template from the template menu. After the selection of the selection criteria, the first beat in the selection is shown in the signal window. The selection is sorted chronologically.

6.3. Inter Plugin Communication

All plugins in libRASCH can communicate with each other. This communication allows the selection of a signal position or the selection of specific events through view-plugins which are not in the signal window. For example, you can select a position in the tachogram by clicking on it and the signal in the signal window will be positioned to this position. Figure 6-4 shows an example. In the tachogram the short RR Interval (which is followed by a longer RR interval) was selected (marked with a vertical bar). In the ecg-view, the beat with the short RR interval is shown in the middle of the window and is marked also with a vertical bar (the cursor).

Figure 6-4. Select position in tachogram.

If you are interested in a specific template, you can select the beats belonging to this template as described above. Another way is to double click on the wanted template in the template window (Figure 6-5). This has the same effect as selecting the template from the pop-up menu.

Figure 6-5. Select beats belonging to a specific template in the template window.

Chapter 7. Signal Comments

In RASCHlab comments/annotations to specific time-points or time-periods in a signal are supported. When a file format support annotations (e.g. EDF+ or MIT/AHA), RASCHlab can handle (edit and/or delete) these annotations. Additionally, RASCHlab can add new comments. The "RASCHlab" comment can be specific for one channel or can hold for all channels.

To insert a comment, select the position (click on the wanted position in the signal window) or mark an area (click and move the mouse while holding the left mouse button down) and then press the '.' (period) key. Then the comment dialog box opens (see Figure 7-1) where the comment can be given. If the comment should be for one specific channel, the channel can be selected in the drop-down menu at the top of the dialog box.

Figure 7-1. Add a comment.

Additionally to the comment text, you can set indicators. At the moment there are two possible indicators, "Noise" and "ignore data". These indicators can be used in programs which use libRASCH when the evaluation of the measurement is analyzed.

Figure 7-2 shows the ecg with 4 comments. If a comment describes a period of time, this period is marked by a horizontal line with little vertical lines at the beginning and at the end. If the comment is for one specific point in time, the position is marked by a small cross.

Figure 7-2. Screen shot of the signal showing four comments.

If you want to edit or delete a comment, you only need to double click on the comment text. Then the comment dialog box (Figure 7-1) appears. Here you can change the text of the comment or delete the comment ('Delete' button is on the lower left side in the dialog box).

Chapter 8. Change Settings

In RASCHlab you can set different options how the data is shown. The options are for all recording channels (Figure 8-1) or for a single channel (Figure 8-2). To open one of the both dialog boxes, you have to click with the right mouse button inside the view window. Then a popup menu appears and the first entry opens the general options dialog box and the second menu entry opens the channel options dialog box (see Figure 6-2).

The general options are:

- 'show statusline': show or hide the status line; the status line is the line at the bottom of the signal view(s), showing informations about the current positions and the current selection
- 'show channel info': show or hide the name and the unit of the channels on the left side of the signal view
- 'show grid': show or hide the grid in the signal view
- 'use fixed channel-height': With this option you can select if for each channel a fixed height (in pixel) should be used. The default behaviour is to give each channel the same space depending on the available space. Therefore the space changes when the size of the window is changed. When this option is enabled, the space for each channel is always the same independent of the current window size.
- 'speed [unit]': Here you can set the "writing speed" used to draw the recorded data. At the moment the unit is fixed to 'mm/second'.

Figure 8-1. Dialog box to set general options.

When drawing a recording channel, two modes are available: (1) draw the data centered around a specific niveau and use the given resolution to scale the amplitude or (2) scale the data in that way, that the min-value corresponds to the lower channel border and the max-value corresponds to the upper channel border. When using the second mode you have the option to set only the min-value and let the max-value be "controlled" by the resolution.

The niveau used for mode one is a percentage of the channel height. Typically you use 50%, this means the data is centered around the middle of the channel.

The first mode is used for data which is centered around a specific niveau. This is typical for ECG's. The second mode is used for data which are normally in a specific range. This mode is used for example for continues blood pressure recordings.

In the channel options dialog box you have to select first the channel for which the options should be set. The channel can be selected in the combo-box at the top of the dialog box ('select channel').

The channel options are:

- 'Position' - 'centered': draw the data centered around a specific niveau (see text above)
- 'Position' - 'min/max': scale the values to given min and max values (see text above)
- 'show channel': show or hide a channel
- 'invert channel': if selected, the channel is drawn inverted
- 'Resolution': Here you set the amplitude resolution used for drawing the channel.

Figure 8-2. Dialog box to set channel specific options.

Chapter 9. View-Plugin specific controls

This chapter will give a brief description of each available view-plugin and the key-strokes provided by the plugin.

9.1. ECG View-Plugin

The ecg view-plugin displays ECG and ECG related information (e.g. type of the heart beat, RR interval). The user can edit the evaluation of the ECG, he can insert or delete a beat or he can change the type of the beat. Additionally he can "create" ECG specific selections which can be helpful while inspecting/correcting an automatic evaluation.

If the user wants to edit a beat, the beat has to be selected first by clicking in the area around the position of the beat (marked by the beat annotation). The current selected beat is highlighted by a bold beat annotation and the cursor (vertical line) is on the position of the beat. After selecting a beat the following actions can be done:

- 'd': delete current selected beat
- 'n': mark current selected beat as normal
- 'v': mark current selected beat as ventricular
- 'x': mark current selected beat as artifact

If the user wants to insert a beat, the position has to be marked by the cursor by clicking at the wanted position. Then use one of the following keys to insert a beat:

- 'n': insert a normal beat
- 'v': insert a ventricular beat
- 'x': insert an artifact

The following ECG specific selections are available (press the key while the ecg view has the input focus):

- 'k': select all beats sorted with the shortest RR interval first
- 'l': select all beats sorted with the longest RR interval first

9.2. Blood Pressure View-Plugin

The blood pressure view-plugin displays continuous blood pressure signals and blood pressure related informations (e.g. systolic and diastolic blood pressure).

When the position of a blood pressure measurement point has to be corrected, the user have to click on the new position in the blood pressure view (the cursor marks the position) and then press one of the following keys:

- '1': the current position is choosen for the diastolic measurement point
- '2': the current position is choosen for the systolic measurement point

The user can change the position where the systolic and diastolic blood pressure is measured and can mark the blood pressure values as invalid when the pulse wave is distorted. To do this, first select the current pulse wave and then press the 'x' key. If you want to delete the mark, just press 'x' again.

Chapter 10. Information Dialog Boxes

RASCHlab provides the possibility to get informations about the loaded libRASCH plugins. To get the plugin info dialog box, select the menu entry 'General->Plugin infos...' and a dialog like the one shown in Figure 10-1 opens. In the upper half of the dialog, the loaded plugins are shown. The name, type and license of each plugin is listed. In the bottom half of the dialog, informations about the current select plugin is shown: the name and the version of the plugin, a short description, the location of the plugin on the system, if the plugin should be used and the time stamp when the plugin was build.

Figure 10-1. Dialog box for libRASCH plugin management.

When you are interested about the evaluations in a measurement, you can get informations about them by selecting the menu entry 'General->Evaluation infos...'. An evaluation dialog box like the one shown in Figure 10-2 is opened. In the upper half, a list of the evaluations in the current openend measurement is shown. You can delete the current selected evaluation by pressing the 'delete' button right to the list. In the bottom half, informations about the current selected evaluation is shown: a short description, if this is the default evaluation (see *Evaluation* in Chapter 2), if this is the original evaluation (again, see *Evaluation* in Chapter 2), when the evaluation was created, in which program, by which user and on which computer it was created and finally when was the last modification. The event properties of the current evaluation are shown in the event-property dialog box, which opens when the 'event-prop's' button is pressed.

Figure 10-2. Dialog box for evaluation management.

The event-properties dialog box (Figure 10-3) lists the event properties of an evaluation. In the upper half the available event properties are listed. If you (really) want to delete an event property, you can do it by pressing the 'delete' button. In the bottom half of the dialog box, informations about the current selected event property is shown: the name and how many events are stored in the property, a short description, the type of the value (e.g. long integer, double, string) and what type of event property it is (discrete like heart beats or continuous like periods of noise).

Figure 10-3. Dialog box showing the event-properties stored in an evaluation.