SignAPROS
User manual

SignAPROS: Signals Acquisition Protocols System

https://github.com/SaidS11/SignAPROS

CONTENT

Key words

Firstly, we want to define some words that this manual includes throughout the entire document for you to be familiar with them and make this manual easier to read.

- **End user/final user**: if you are reading this, probably you are the end user. SignAPROS is designed to be used by students, researchers, teachers, and someone who wants to acquire bio-signals and keep the records in their system. These people are the end or final users.
- **Subject**: they are the people that participate in the acquisition, the people from whom the signals are acquired.
- **Protocol**: we call a protocol to all the steps and instructions involved during the acquisition, which means, a protocol contains a configuration, an experiment, subjects, etc. I
- **Experiment**: this is a process to be carried out following some instructions related to the purpose of the protocol. An experiment includes the actions to be done by the subject in order to obtain the bio-signals.
- **Configuration**: this is a set up needed for every experiment that details the hardware needed for it. It's mandatory to have a configuration before setting up an experiment.
- **Module**: to every option in the main SignAPROS menu (see next topic) we call it a module. Ex. Protocol, Subject, AI Analysis.
- **Section**: within every module, you have different options to select, any of those options are called a section. Ex. Create configuration, Tune Algorithm, etc.

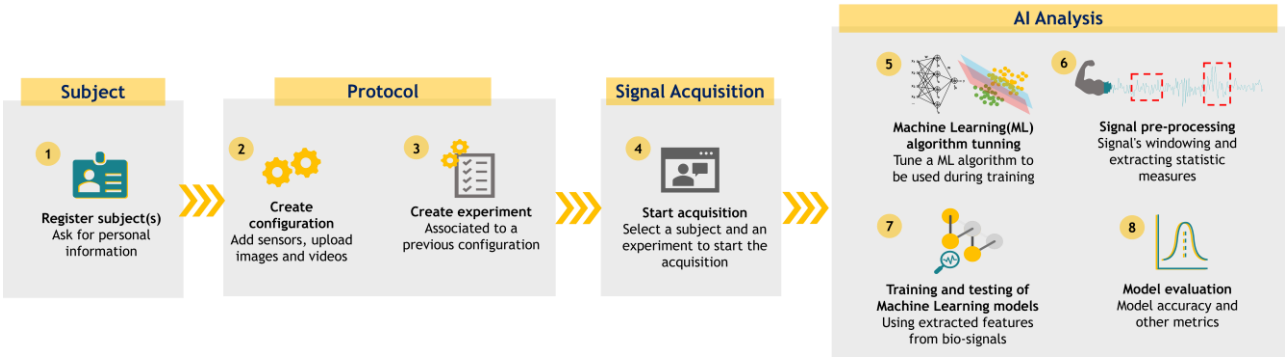
SignAPROS menu

The image below shows the available options in the menu of the SignAPROS app. The end user can select any of those to carry out a specific task. In the next parts every module and section will be explained in detail.

Recommended path

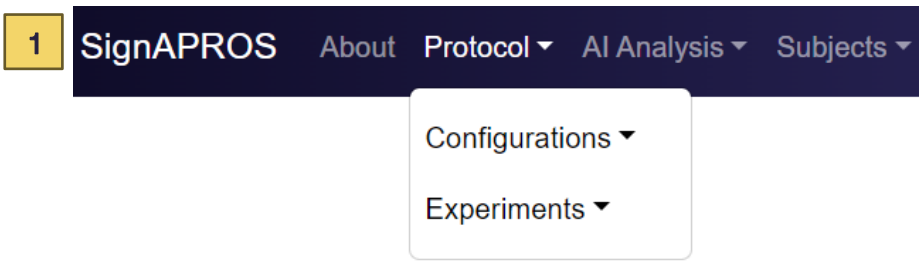
The next image represents the path that we encourage to follow if you want to do the whole process from registering a subject to analyze data with Machine Learning algorithms. Points 6, 7 and 8 can be made in Prediction or in Training and characterization sections. As an

example, if you already have registered all subjects or already have defined a Machine Learning algorithm, you can skip those steps.



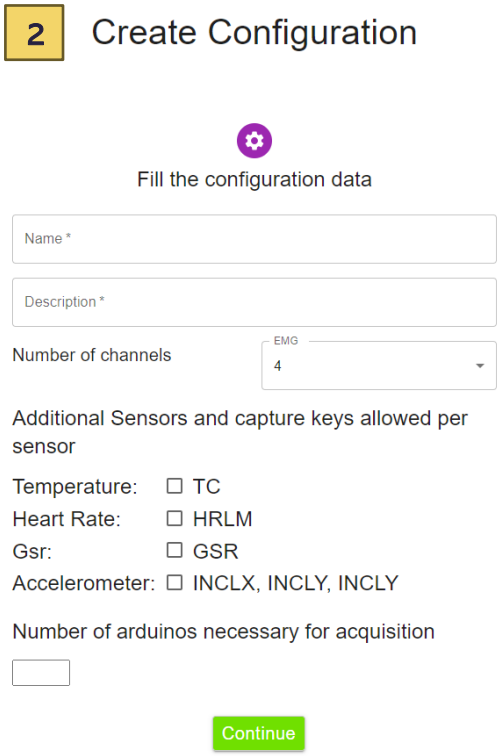
Protocol

Within this section are available two options: Configurations and Experiments, as you can see in image 1. To be able to create and define an experiment it is mandatory to have set a configuration before, which is possible to do in these protocol's sections.



Configuration

If the end user selects this option, two additional tasks can be performed from there: create a configuration or/and view the configurations already created.



As can be seen in image 2, to **create a configuration** it's mandatory to fill out some data in the form. Specifically, the name of the configuration which, along with the description, should provide some relevant information regarding a specific protocol.

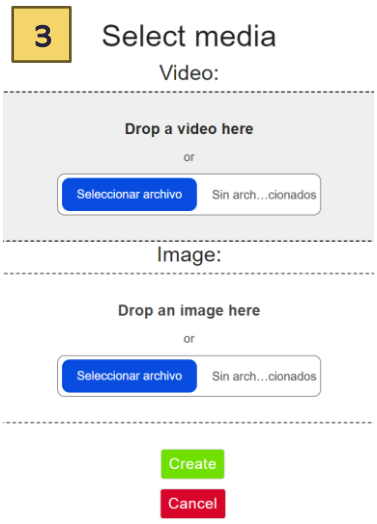
The number of EMG channels can be set from 1 to 4, depending on the needs of the experiment.

Additionally, the end user can select one or more of the accessible sensors, such as: Temperature, Heart rate, GSR and Accelerometer. These are optional, not mandatory to select.

The number of Arduinos needed for an experiment must be given, in case the experiment does not need any, it's necessary to fill this field with the value of 0.

Once the form is completed, please click on Continue and a new view will appear as it shows in image 3. There you need to upload (dragging and dropping) a video and an image or look for the files in your system.

The time of the acquisition will be the same as the duration of the video, that's why the video should include the instructions or the steps to be followed by the participant of the experiment at the time they have all sensors placed where is needed. The location of the sensors should be indicated in the image loaded, which could be a photograph of a real person, or it could be an illustration as well; the importance here is to show where every sensor needs to be in the subject's skin or in a part of the body. This image should be a resource for the end user to take it as a reference for the procedure during the experiment.

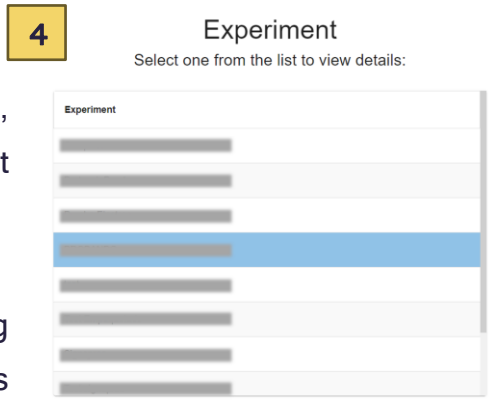


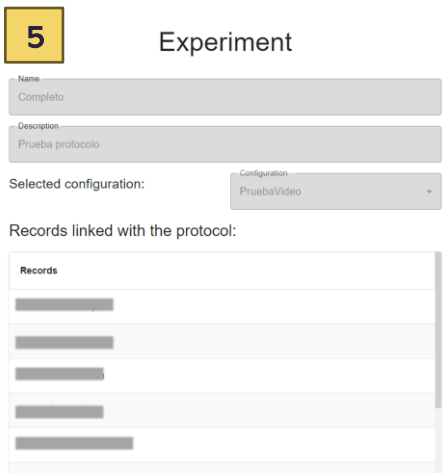
Once the video and the image are loaded, please click on create and a list of all existing configurations will appear on the screen. You can click on any of them and automatically the details of it will appear as well on the screen; they are not editable, just readable. This view is the same as if you click on View Configurations at the Protocol-Configurations menu.

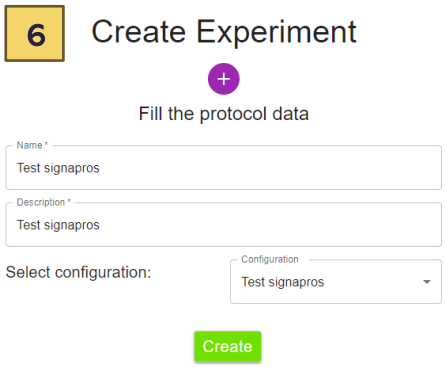
Experiments

Within this section, as well as in the configuration section, the end user can select two options: create an experiment and view all the experiments.

If you select View experiments, a list of all the existing experiments is showed as in image 4 (private data is hidden) and if you click on any of the elements of the list, another view with all the details of the experiment will appear, describing name, description, configuration related to that specific experiment (you can have different experiments with the same configuration, but not otherwise) and an internal list with all the records registered during an acquisition for the selected experiment, as shown in image 5.





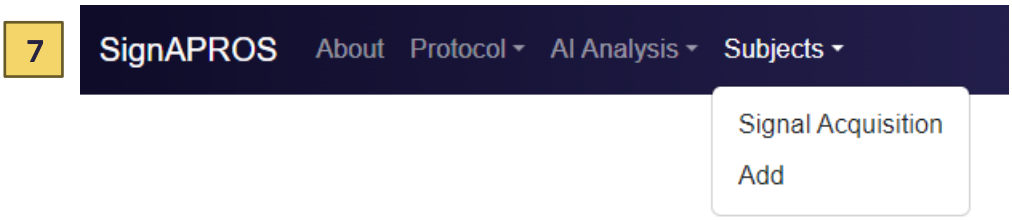


If you select the option **Create experiment** a new screen will appear with a form to be filled where all the fields are mandatory, see image 6. The name of the experiment and the description should be filled in typing, and the configuration for that experiment needs to be selected from a Select field that contains a list of all the previously created Configurations.

Once you have filled in the form, please click on Create. SignAPROS automatically will direct you to the View Experiments screen explained early.

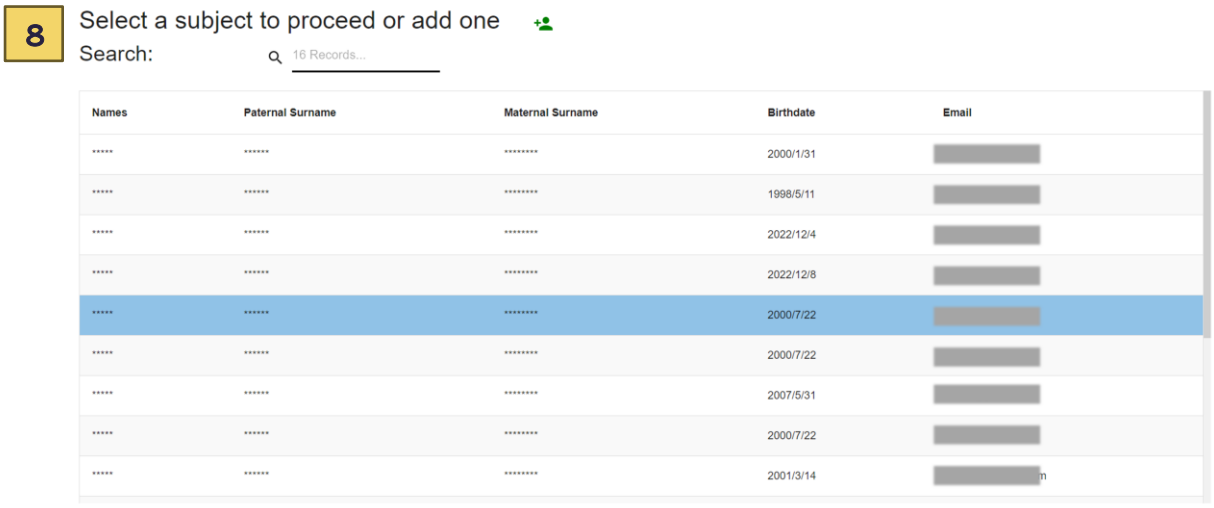
Subjects

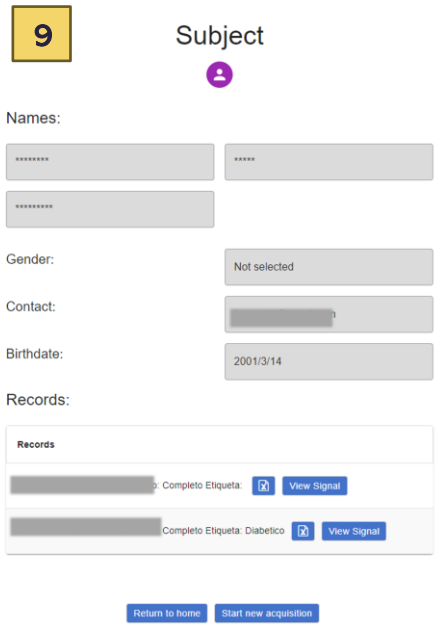
Inside this module there are two available options: Signal Acquisition, which allows to carry out an experiment, and Add, which helps to add a new subject, as shown in image 7. Every section is described below.



Signal acquisition

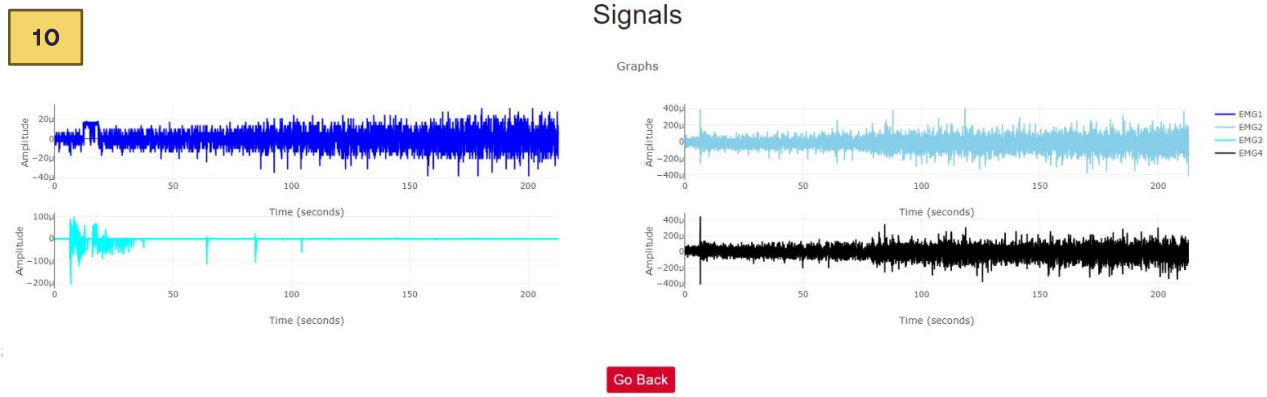
Within this section, a list with all the registered subjects is shown as in image 8. You can scroll down in case you cannot see the subject you are looking for; you can find them as well from the search tab at the top of the screen where you can type any details regarding the fields related to the subject (such as the name or the email) and the list will update itself automatically with the matching results. Once you have found the one that you need to start an acquisition, you can click on any part of the row corresponding to the subject and a new view will appear.

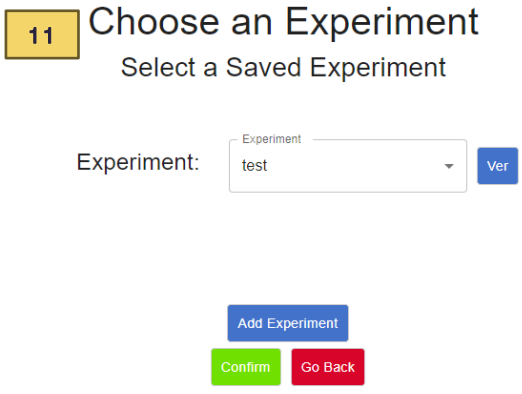




This new view shows all the data corresponding to the subject, see image 9; at the end of the screen, you can see a list as well of the previously acquired records of any of the existing protocols where the subject has participated. From here you can see the acquired signals if exist (image 10) or download the signals data in a .csv file.

There are two buttons at the bottom of the screen, one to go back home screen of SignAPROS and the other one to Start a new acquisition for the selected subject. To do so, please click on the button to select the experiment to follow.





A new view of SignAPROS will appear where you need to select a previously set Experiment (which already has a Configuration) or to create a new one from scratch, see image 11. We highly recommend to first create the experiment and then go to this module to Start a new acquisition. Once you have selected the experiment, please click on Confirm.

A new screen will appear showing the image already uploaded in the Configuration section where the location of the electrodes/sensors appears. Image 12 is an example of the EMG electrodes position for an experiment of several flexions/extensions of the arm. The image is a helpful resource for you to place the sensors correctly. This is the time where you locate

all available sensors before starting the acquisition, take all the time you need. Once you have all set up, please click on Confirm.

A new screen will appear; it contains the video uploaded before in the Configuration section, see image 13. You can click on play just to verify it works (audio and video-images). SignAPROS offers an option to test the sensors before starting the acquisition, you can click on the button Test Sensors and after a few seconds, a plot will appear with the signals acquired from the sensors selected in the Configuration. Please check them and verify if they are good, if so, you can start the acquisition by just clicking the Proceed to the acquisition button. This will automatically play the video and start the acquisition at the same time.

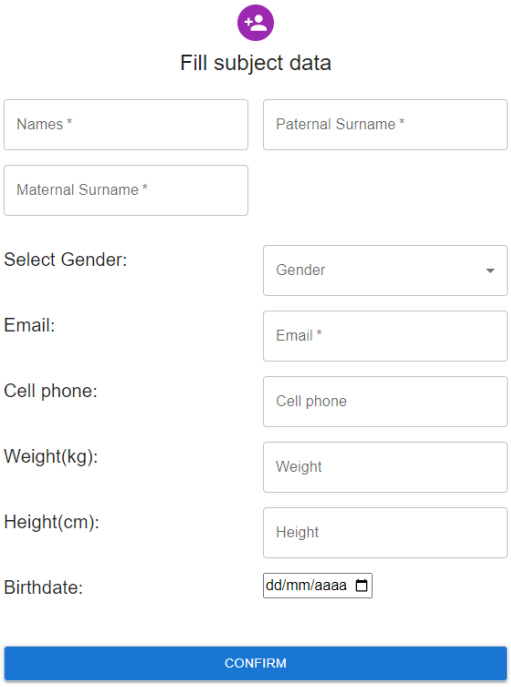
From that moment on please DO NOT move, click or close any window of the SignAPROS system. At the end of the video (and acquisition) the system will start plotting the results in a new screen, please wait until a view like in image 10 appears.

This means that the signals were acquired and can be consulted in the Subject section by selecting the subject that has just participated in the experiment.

Add subjects

You need to use this section to register a new subject in the system. Please fill out all the mandatory fields and optionally you could fill the remaining fields and click on Confirm to finish. Those marked with an * are mandatory (consider as mandatory the birth date as well). See image 14 to verify all the fields in the form.

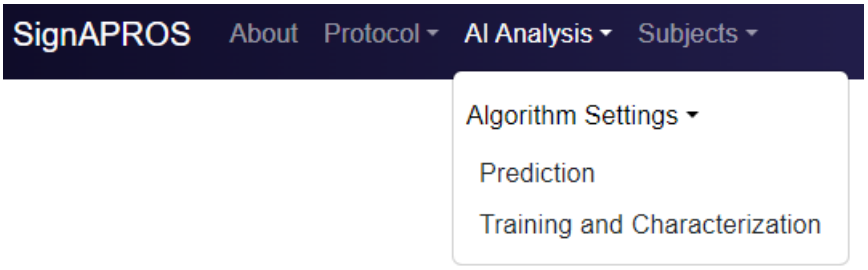
14 Add subject



AI Analysis

In this module, three different options are available, see image 15. The first one is the Algorithm settings where you can tune a Machine Learning algorithm or view all the existing ones. The next option is Prediction, here you can predict the label (for supervised learning) of a subject's record captured during an acquisition. The last option is Training and Characterization, here you can train a previously tunned algorithm with different manually extracted features (windowing) from the acquired signals of a specific protocol.

15



Algorithm Settings

The first step in this section is to Tune an algorithm. There are four Machine Learning algorithms to select: Decision Tree, K-Nearest Neighbor, Multilayer Perceptron, Support Vector Machine. Every algorithm has different parameters to fill out in the form as you can see in images 16 to 19; all parameters are mandatory. These algorithms, once tuned, will appear in a list that contains every configured algorithm, and you can access it from Algorithm Settings and then go to View Algorithms, see image 20.

16 Algorithm Implementation

Fill the Implementation data

Name *

Description *

Choose an Algorithm: Algorithm — Multi Layer Perceptron

Layers: Layers *

Activation Function: Function

Learning Rate: Learning Rate *

Create

17 Algorithm Implementation

Fill the Implementation data

Name *

Description *

Choose an Algorithm: Algorithm — Decision Tree

Depth: Depth *

Random State: State *

Create

18 Algorithm Implementation

Fill the Implementation data

Name *

Description *

Choose an Algorithm: Algorithm — K-Nearest Neighbor

Neighbor Number: Neighbors *

Create

19 Algorithm Implementation

Fill the Implementation data

Name *

Description *

Choose an Algorithm: Algorithm — Support Vector Machine

Kernel: Kernel

Create

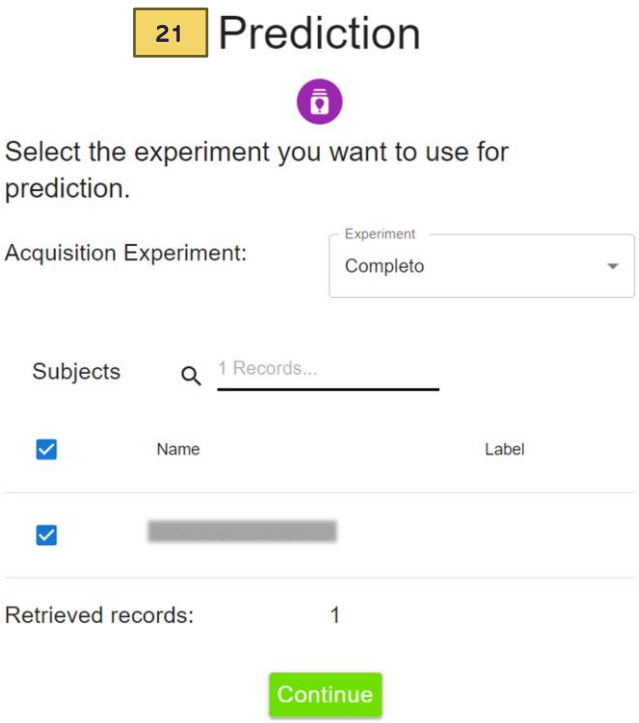
20 Implementations

Select one from the list to see details:

Implementations
Arbol 3
test
fds
Red Neruonal
test algorithm

Prediction

This section can be used to predict a label for a previously acquired record. This label is needed in the training and testing of supervised machine learning algorithms. The first step to achieve that is to select an acquisition experiment and a list of all the existing records for that experiment will appear on the screen. You can select all the records that you need; please click on Continue after you complete that step, see image 21.



The next step to get to the label prediction is windowing the signals of the selected subjects to extract features and calculate statistical measures to be able to define a class/label for the record; this is needed for the Training and Characterization section of the AI Analysis module.

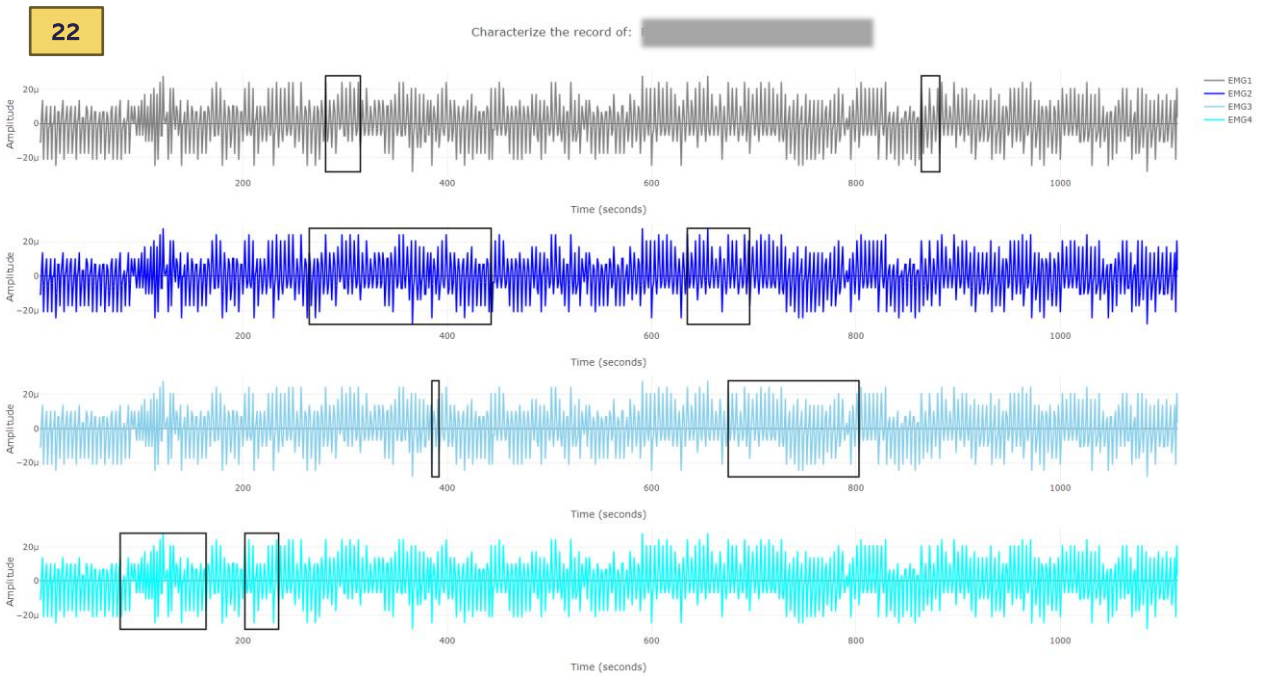
Windowing

If the record has EMG signals, they will appear on the screen. There, you need to start windowing all the signals, one by one, with a minimum of two windows per signal to continue to the next step. The process to select a window is first click (start of the window) and second click (end of the window). The intention of windowing is to extract several features in zones of interest where you could find more information regarding the nature of the acquired signals, see image 22.

The steps to follow for windowing the signals are described below:

- Click on the point of the signal where you want to create a window, this will be the position of the beginning of the window.
- Notice that nothing will happen on the screen, but your point is saved, do not worry.

- Click again on the signal but in the position where you want to end the window. After you do so, a black square will appear automatically showing the window you just created.
- Repeat this process until you have at least two windows per signal.



It's important for you to know that the same windows you create in the EMG signals will be replicated as well for all the other sensors. If you make a mistake and want to delete a window, please go to Discard Window section below. Once you finish the windowing, please click on the button with the legend "Process Selection".

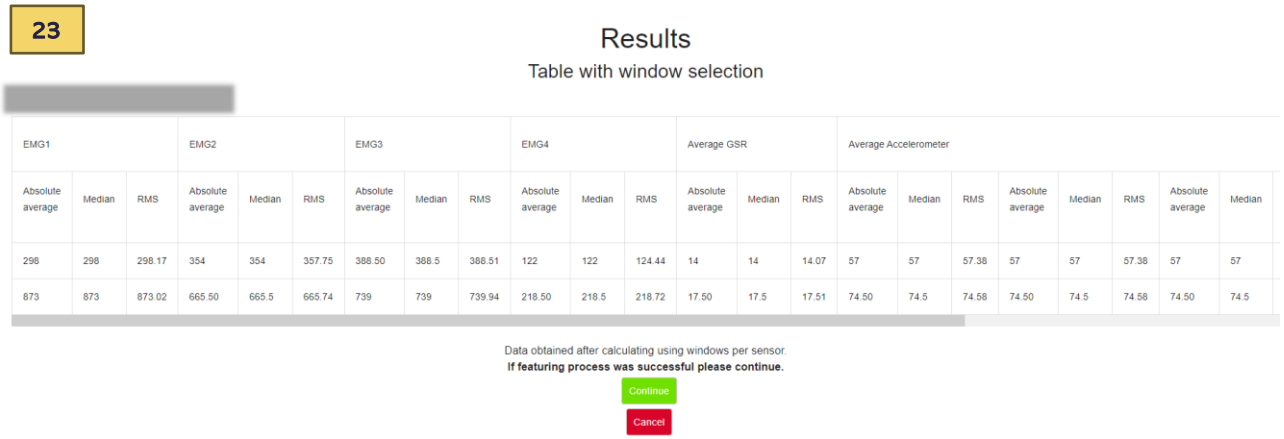
Discard window

If you made a mistake windowing and you want to undo it, you can click on the red button with the legend "Discard Last Window" and the last window will disappear from the screen. You need to be aware that you can only discard the last window you selected in any of the signals by pressing the button, but you can press the button all the times you need.

Extracted features

Once you have completed the windowing, a new screen with a table result will appear. These results present three different measures for every sensor available for the previously selected experiment: Absolute average, median and RMS. Within this screen you cannot do any action, it's just readable (see image 23). Please click on Continue to go to the last step in the Prediction section.

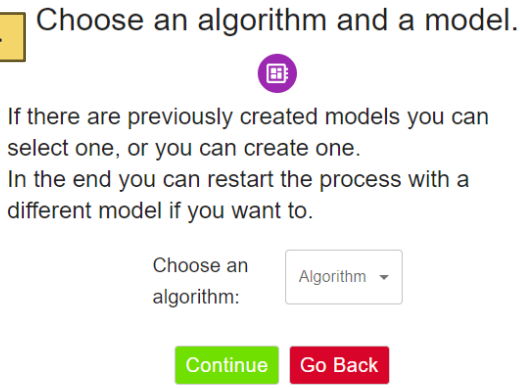
23



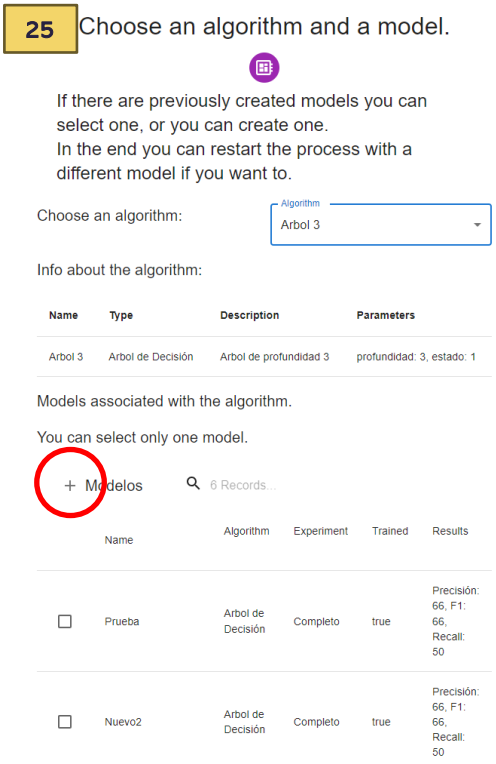
Machine learning algorithm and model selection

After you see the extracted measures, you need to select an algorithm (from the previously configured in the Algorithm Settings module) to be trained with the data you just got in the last step, see image 24.

24



25

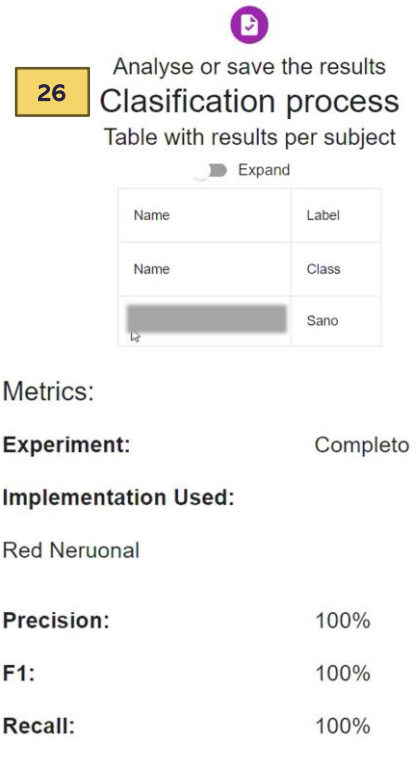


Select the preferred algorithm for your case and if the algorithms have been used before, automatically a list with the generated models for that algorithm will appear on the screen. From there, you can select any of the existing models to predict the label or you can just create a new one by clicking in the plus (+) symbol at the top of the list with the existing models, see the red circle in image 25.

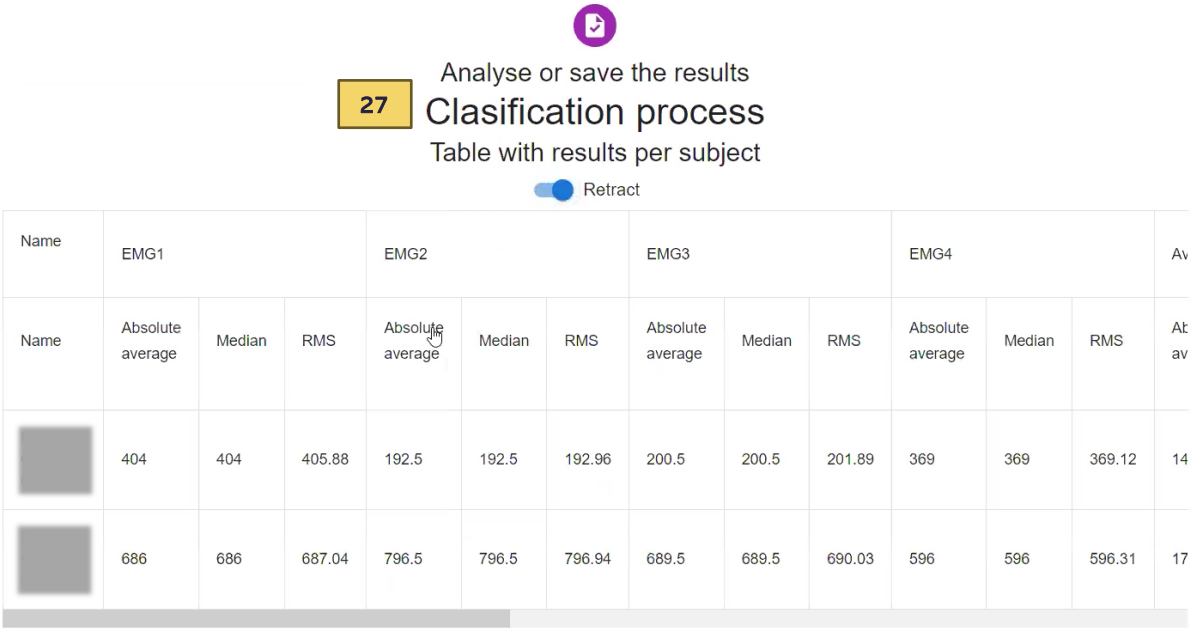
All the models shown in the list have the results with the Precision, Recall and F1 metrics, as well as the parameters chosen for them; pick the one that best fits for you. Once you select one, please click on Continue.

Results

After selecting the model, SignAPROS will run the algorithm with the data from the windows set before and will show a table with the predicted label for the records as well as other details like the name of the experiment, the name of the used algorithm and the metrics obtained during the running, see image 26.



If you click on Expand you can see a new table where the number of rows corresponds to the number of windows you selected for any signal, and at the end you can also see the predicted label, see image 27.



Name	EMG1			EMG2			EMG3			EMG4			Av
Name	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Ab av
	404	404	405.88	192.5	192.5	192.96	200.5	200.5	201.89	369	369	369.12	14
	686	686	687.04	796.5	796.5	796.94	689.5	689.5	690.03	596	596	596.31	17

You can get additional information regarding the labels, like a normalized confusion matrix. Click on the button “See More” to observe it; see image 28.

28 Metrics:

Experiment: Completo

Implementation Used:

Red Neruonal

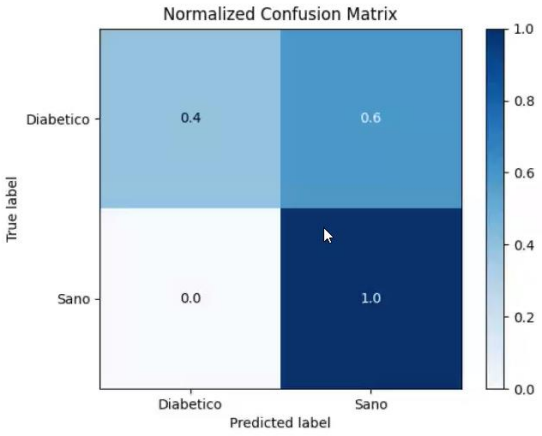
Precision: 100%

F1: 100%

Recall: 100%

See More

Cancel



Training and characterization

The first part in this section is to generate a model and train it with data from a specific experiment, see image 29 to check the required data in the form. Please select the experiment and set the values for K-folds (this represents the number of folds to be used in the k-fold cross validation technique for training and validation of the model) and the test split size percentage (with values from 1 to 100).

Once you have completed that, please select all the subjects that you want to include in the training of the model, see image 30 (please make sure you have enough records for training a model, at least two records per existing label) and then click on Continue.

29 Model Generation

Select the experiment you want to use for model generation.

Training Configuration

Acquisition Experiment:

Experiment

Completo

K(Folds):

Iterations *

Test split size (1-100):

Percentage *

Subject selection

Subjects

15 Records...

	Name	Label
☐	[redacted]	Diabetico
☐	[redacted]	Diabetico

30 Subject selection

Subjects

15 Records...

	Name	Label
☐	[redacted]	Diabetico
☐	[redacted]	Diabetico
☑	[redacted]	Diabetico
☑	[redacted]	Diabetico
☑	[redacted]	Sano
☑	[redacted]	Sano
☐	[redacted]	Sano

Retrieved records: 15

Continue

To extract some features from the signals, you will be asked to apply at least two windows per signal for every selected subject early. For more details on windowing, please go to the Windowing section. Once you have completed this process and have clicked on Continue, the next screen will show you several tables with all the extracted measures; every row represents the information from a window, see image 31. Please click on Continue after looking at the tables.

31

Results

Table with window selection

EMG1			EMG2			EMG3			EMG4			Average GSR			Average Accelerometer							
Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median
204.50	204.5	205.50	506	506	517.57	503.50	503.5	504.23	467	467	467.05	11	11	11.09	46	46	46.48	46	46	46.48	46	46
422.50	422.5	423.01	910.50	910.5	910.96	640	640	640.07	658	658	658.10	15	15	15.02	63	63	63.08	63	63	63.08	63	63

EMG1			EMG2			EMG3			EMG4			Average GSR			Average Accelerometer							
Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median	RMS	Absolute average	Median
417	417	417.22	510	510	511.23	548	548	549.78	489.50	489.5	490.28	14	14	14.07	57	57	57.38	57	57	57.38	57	57
578	578	578.08	730.50	730.5	730.59	732.50	732.5	732.81	621	621	621.10	17.50	17.5	17.51	74.50	74.5	74.58	74.50	74.5	74.58	74.50	74.5

EMG1		EMG2		EMG3		EMG4		Average GSR		Average Accelerometer	

The next screen will ask to choose an algorithm from the ones that you created in Tune Algorithm section, as well as you did in the Prediction section (see image 25 or 32). Please select the one that fits best for you and then, if you already had trained any model for that algorithm, they would appear in the list below; if you do not have any generated models, please type the name of the new model and click on Continue.

32 Choose an algorithm and a model.

If there are previously created models you can select one, or you can create one.
In the end you can restart the process with a different model if you want to.

Choose an algorithm: Algorithm: Red Neruonal

Info about the algorithm:

Name	Type	Description	Parameters
Red Neruonal	Red Neuronal	Red configurada	capas: 3, neuronas: 3,4,2, funcion: tanh, tasa: 0.3

There aren't any models associated to this algorithm

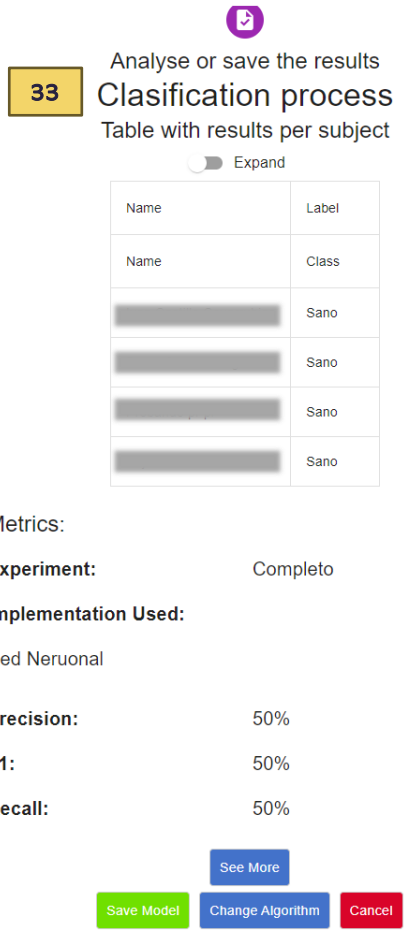
Choose .

Name *: new model

Continue Go Back

Automatically the system will run the training of the model and it will take some time to get the results, depending on the amount of data you have selected at the beginning of this process. Please be patient.

Finally, the results of the model training will appear on the screen showing the labels for every selected subject, the obtained metrics of evaluation for the model (see image 33).



If you click on Expand, a full table with all features and labels for every subject's signal will appear. The table is similar to what you get in image 27, but in image 34 appears more rows because the number of selected subjects were bigger in the train and characterization example. You can check the confusion matrix of the results as well if you click on the button "See more".

If you want to save the model for future running, please click on "Save model"; or if you want to run again the process but with a different algorithm, please click on "Change Algorithm" and you will be able to do so (see image 33).