

WPI - T1.2: Automated assessment of injurious behaviours on farm

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DI.3 : On-farm activity detection monitoring demonstrator and its user guide

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This is a deliverable of the PigWatch project. The project aims to combine the 'eye of the stockman' and precision farming techniques to improve pig welfare. PigWatch is funded through the ANIHWA ERA net.

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I. On-farm activity detection monitoring system conception

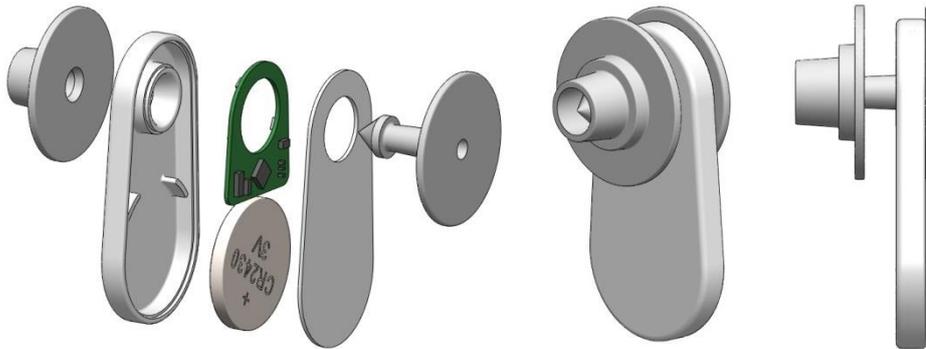
The on-farm activity detection monitoring system developed in the PIGWATCH project consists in a sensor and its electronics embedded in an eartag device, a smartphone with the PIGWATCH App for data acquisition from sensors, including a machine learning algorithm able to automatically recognize different predefined pig's behaviours and send an alert to the farmer when the target behaviour is detected, namely injurious behaviours in this project.

I.1 Sensor and its electronics

Requirements specification for this sensor included:

- Water proof
- Resistant to chewing
- Light, adaptable to RFID pin and easy to install (compatibility with the plier used to install the RFID pin)
- Tri axial accelerometer
- Micro-controller
- Bluetooth Low Energy communication
- Power supply (battery) for 2 months of use
- Power switch (to save battery when the device is not used)

The technical solution proposed to use the male and female part of the RFID pin and to insert between them a third piece containing the accelerometer, the associated electronics and the battery.



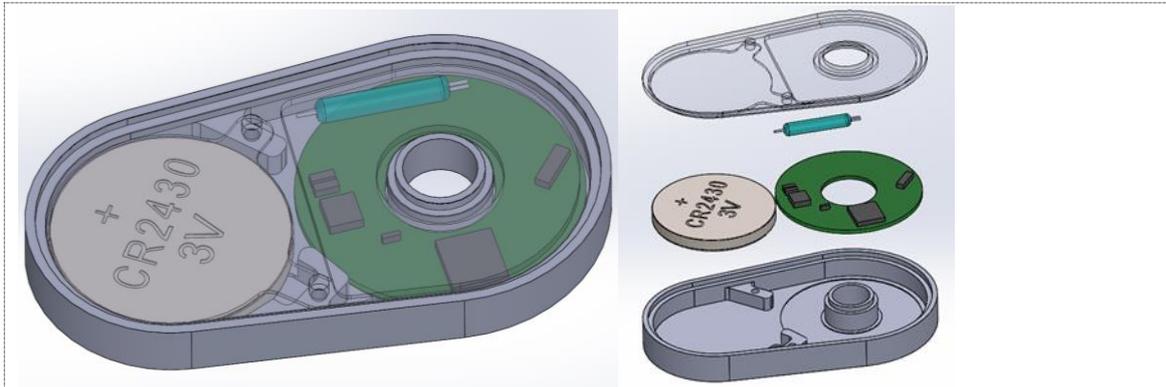


Figure 1: Diagram of the CAO mechanical solution to integrate all electronics components and battery.

This solution was advantageous as the installation of the RFID pin and the ear tag remained easy for the farmer.

1.2 Firmware

Associated to the electronics, the firmware required to initialize the sensor, the Bluetooth communication and the low energy mode have been developed and embedded in the micro controller. This firmware also stores raw data in a structure before sending those to the Android smartphone via the Bluetooth low energy communication. Data transfer is done in connected mode.

1.3 Android App

Android App manages the connection to the sensors and the data writing in binary files which are stored in the smartphone memory. This Android App includes a Graphical User Interface displaying a status on sensors connection and the list of connected sensors. If one sensor is disconnected, the App will automatically scan sensors for connecting again the sensor.

Additionally, Android App also manages the data processing in real time in order to automatically estimate the pig behaviour among 9 different classes of behaviours and with respect the settings (selection of which behaviour has to trigger an alert), alert the farmer when the target behaviour is detected (for a detailed description, see below the user manual).

1.4 First pilot test

In a first pilot experiment done at INRA in Rennes (France), four animals were fitted with ear tags containing the wireless accelerometer. This first experiment aimed at testing if the device was well suited to its use in farm on animals and its acceptance by animals. Based on this first step, water proof and mechanical robustness have been improved: electronics and battery are now fitted in resin and the system housing has been made in polycarbonate, a more robust material. Android App has been also upgraded in order to get more stable connection to sensors.

1.5 Second experiment: database collection

In a second experiment on February 2017 at INRA in Rennes (France), twelve animals were fitted with the new ear tags and were observed by video cameras. The animals were subjected to a food restriction period during 4 days and to a mixing period to provoke aggression during the last two weeks (from middle to end of April 2017). This second experiment was dedicated to collect the database required for algorithm development.

PigWatch database consists in two data types: accelerometer measures and manual annotations of pig behavior based on video recordings. This video annotation was done with the software The Observer XT[®] from Noldus company and was based on predefined ethogram, e.g. a set of postures, locomotion and behaviours which have been defined by experts at INRA.

Annotated behaviours are summarized for each pig and each day with notably the start time (time at which experimenter started annotation) and the relative time (with respect to start time).

1.6 Machine learning algorithm

Behaviour records obtained through video were synchronized to the sensor data, allowing algorithms to link sensor data and pig behaviours to be developed. As the cameras and the smartphone collecting sensors data were not clocked wise, this synchronization was based on visual checking of concordance between salient pig behaviour such as ear shocking or fighting and accelerometer signals. This step is crucial for machine learning algorithms as the algorithm training will be based on these annotated signals.

Supervised Machine learning algorithm requires at first to extract and select features describing the data and able to discriminate the different states (classes in the machine learning language) that we want to detect. Several features have been extracted from data and then, used for learning a model to recognize annotated pig behaviours. Several machine learning models have been tested and their performances have been evaluated. The final model is a hierarchical model based on several successive binary models.

To summarize results obtained with the hierarchical model to date, the figure below displays the model performance (true positive/true + false positive) in percentage at each node of the model. So, to date, the model is able to detect that a pig is active in 84% of the cases (N1). Similarly, the model is able to detect combative pig behaviours in 44% of cases.

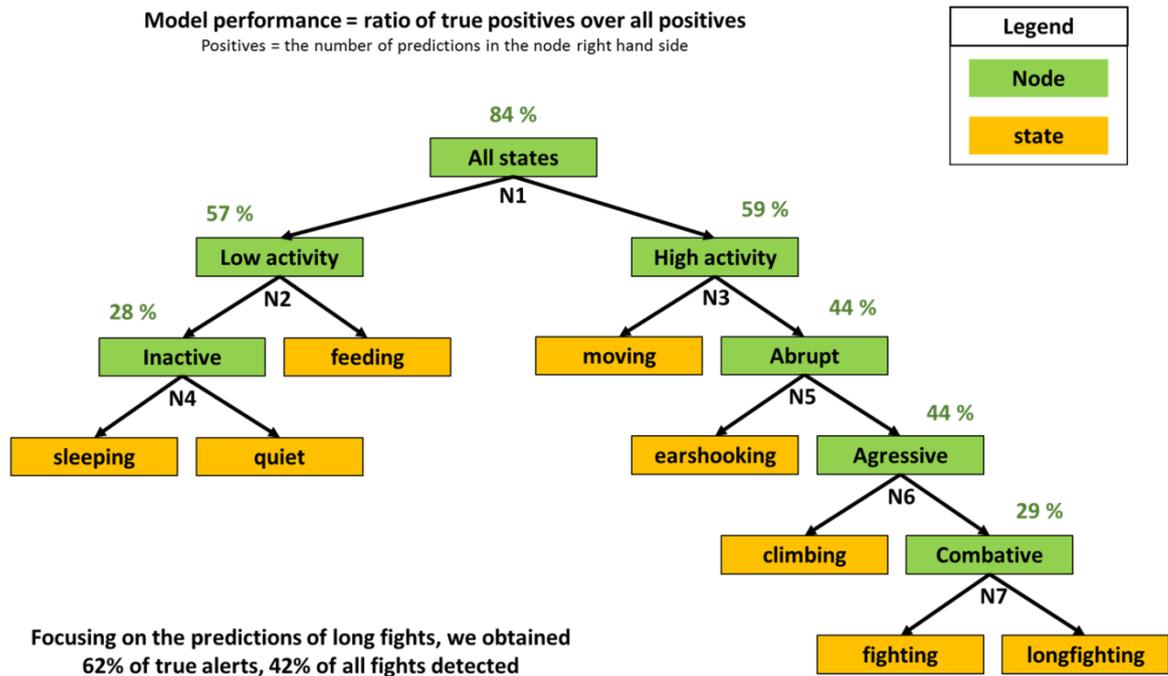


Figure 2: model performance (true positive/true + false positive) in percentage at each node of the model

Focusing only on the predictions of long fights, 62% of true alerts were obtained and 42% of all fights events are detected.

1.7 Third experiment: pre-test of the final demonstrator

Three animals have been equipped with an eartag and one smartphone with PIGWATCH App was deployed at INRA experimental barn. The experiment lasted one month during which the system has been evaluated: connection between sensors and the smartphone, settings parameters to tune the number of alerts, feedbacks on the PIGWATCH App.

Following this pre-test phase of the final demonstrator, based on INRA feedbacks, few improvements in the Android App have been done:

- writing of a trigger and its time occurrence in data files when a QR code was generated by the user for further synchronization with the video
- improvement of the SMS management system in order to write in a log file the SMS sending event times and SMS sending failures time
- option to reset the database
- add a “Help” menu for an access to the user manual directly from PIGWATCH App on the smartphone

Several connection failures between the sensors and the smartphone were also reported. By switching off/on the smartphone, sensors connection was recovered. However, only one sensor worked all the pre-test phase duration. One sensor only worked 10 days and the other one around 3 weeks. INRA concluded that one weak point of the system was the sensors connection to the smartphone and recommended a regular check of the system in order to ensure the best running.

2. PIGWATCH App User Manual

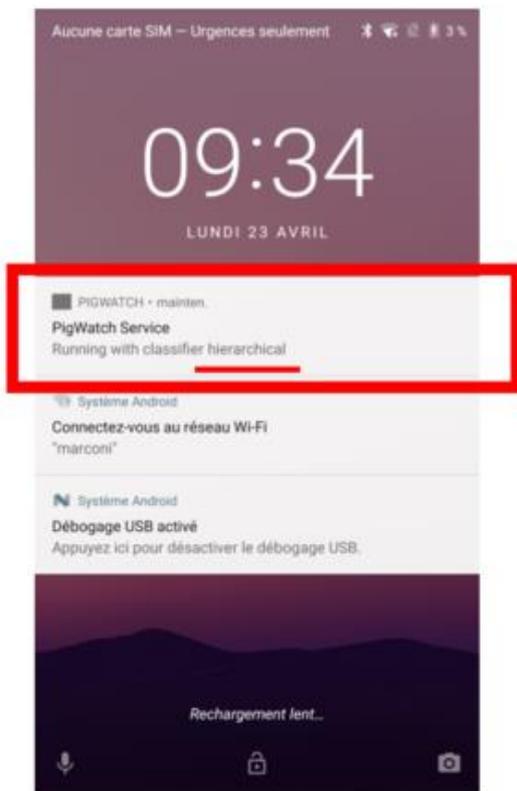
2.1 PigService

The "Pigservice" service starts automatically when the phone is started. It works in the background and without human-machine interface.

This program without interface is the heart of the system.

- Sensors communication
- Save data in logFile and data base.
- Calculate pig activity
- Monitor a « dangerous » bahavior (activity) and send SMS when this activity appears

It's possible to verify if this program is running in notification windows :



2.1.1 Pig sensors communication

The [\Nexus 5X\Espace de stockage interne partagé]\CEA\PIGWATCH\sensorList.txt file describes the different sensors connected to the phone. (pigName, sensorAdress).

Exemple :

```

PIG-17 DE:84:3E:B1:27:E6
PIG-18 CE:D8:22:71:75:9D
PIG-3  FF:BE:06:E0:FE:EE

```

Each phone has its own configuration file. These files must be modified at each sensor change.



BE CAREFUL : don't associated the same sensor at different phones.

2.1.2 Save data on log file and database

The application is primarily a dataLogger, it allows to save the raw data from the sensors and data from the classifier in csv text files of all pigs connected to the phone. These files

make it possible to carry out a post-processing. These files are saved in [\ Nexus 5X \ Shared Internal Storage Space] \ CEA \ PIGWATCH \ [year] \ [month] \ [date]

For example: \ Nexus 5X \ Shared Internal Storage \ CEA \ PIGWATCH \ 2018 \ Apr \ 8 \

The rawData file:

The naming rule for raw data files is:

[pigName] _ [date] _ [time]_ACCEL.csv

2018-04-24_14:33:48.600	0	1,5246E+12	80.0	99.0	400.0
2018-04-24_14:33:48.600	0	1,5246E+12	80.0	99.0	400.0
2018-04-24_14:33:48.735	1	1,5246E+12	51.0	25.0	328.0

The classifier file :

The naming rule for raw data files is: [pigName] _ [date] _ [time]_CLASSIFIER.csv

2.1.3 Calculate pig's activity (classifier)

The service embeds 3 different "classifiers" algorithms:

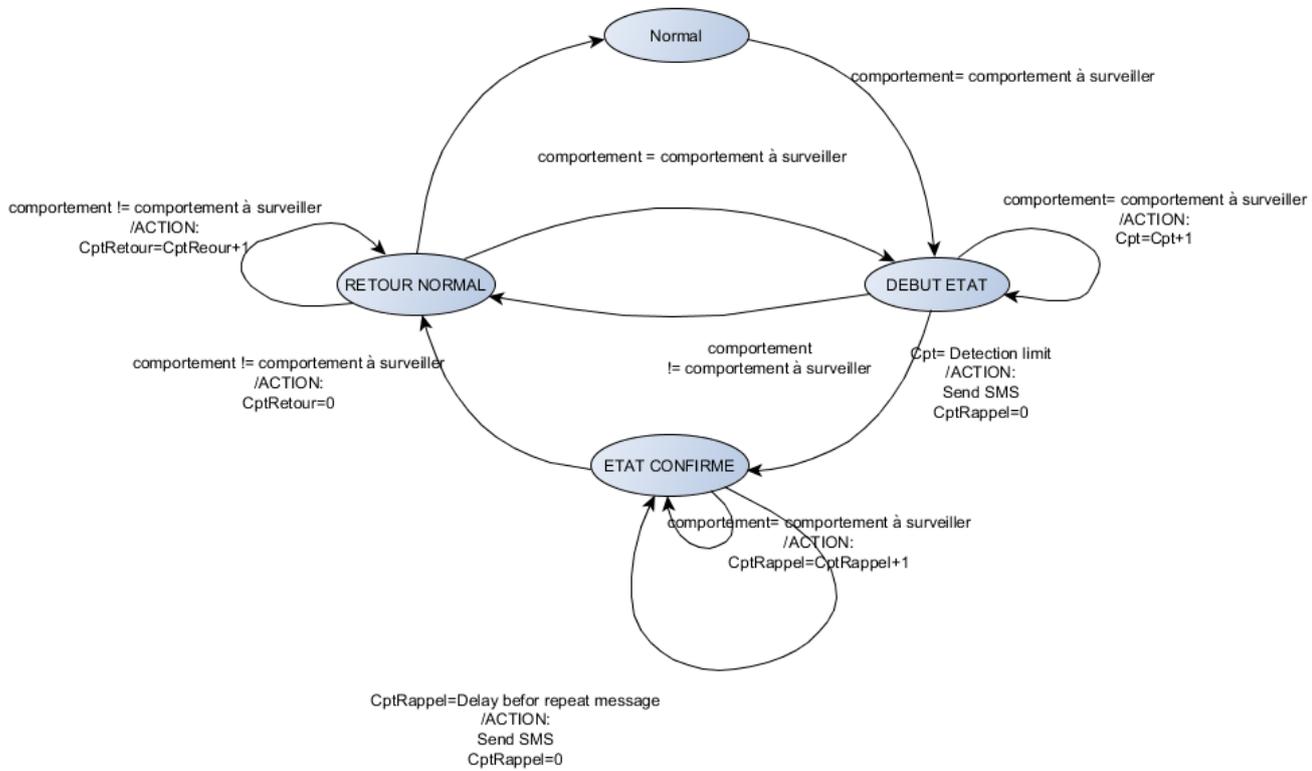
- « Hierarchical » (default classifier) who will detect the different behaviors of the pig:
Climbing, earshooking, feeding, fighting, longfighting, moving, quiet, sleeping
- « fight_vs_all » classifier binary with 2 states : « fighting » ou « no fighting »
- " multi-class"

The classifier defined in the default settings is used. (See the "setting" section of the HMI section for more information on how to change the default settings).

The classifier processes data on 10 seconds windows. But the classifier is called every second. Thus, a behaviour is identified every second.

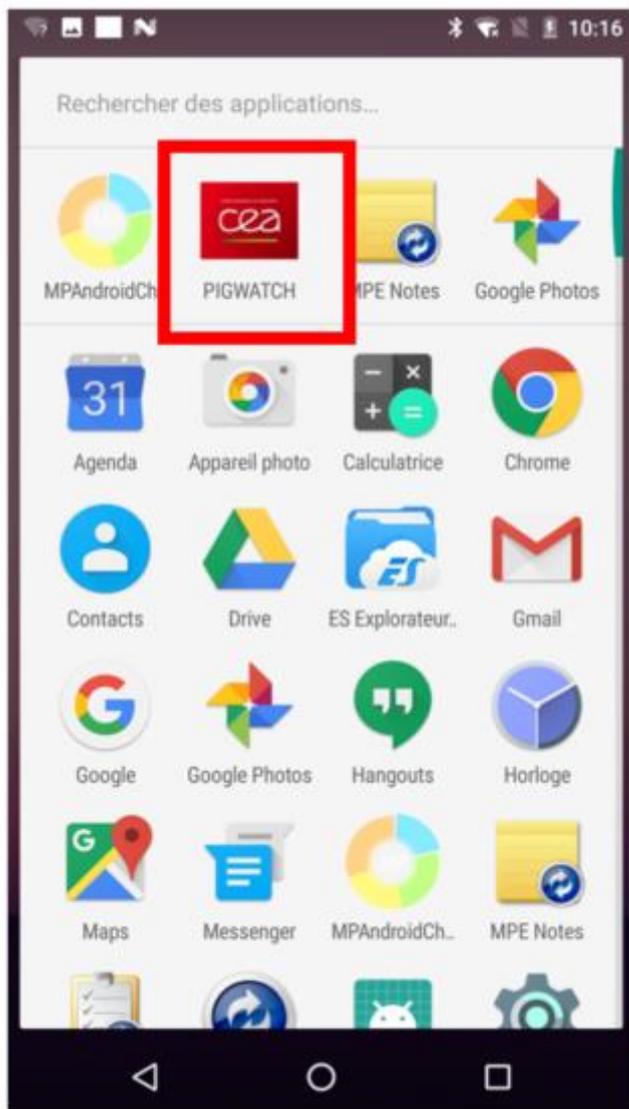
2.1.4 Monitor the appearance of a behavior (activity) and alert (send SMS)

The application offers a function of monitoring a particular behavior. When it is detected an SMS is automatically sent to the programmed number. The following diagram shows the filtering algorithm : implemented to eliminate false alarms.



2.2 Graphical User Interface

The Graphical User interface (the PIGWATCH App) starts automatically when the phone is switched on. However it is possible to close the application without questioning the operating system, (the service PigService is still running in background). In this latter case, simply restart the application by clicking on the Pigwatch icon.



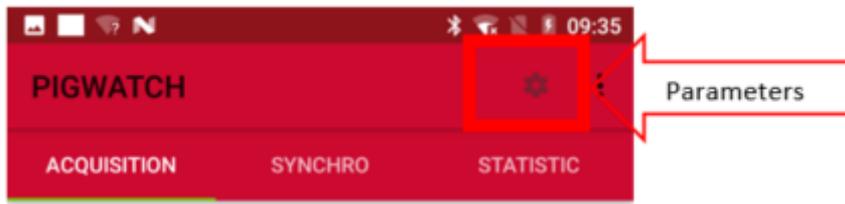
The Graphical User Interface of the "PigWatch App" is the communication interface between the user and the heart of the system (PigService).

It has 4 main functions:

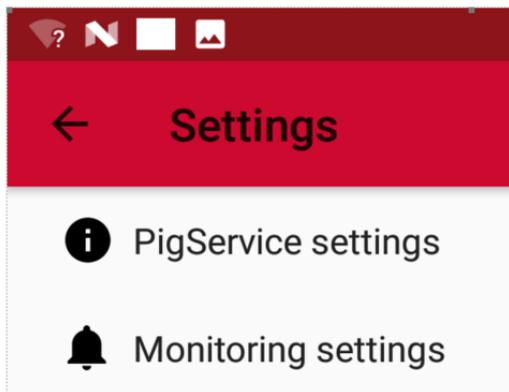
- Setting PigService
- Display of the service status "PigService": "Acquisition"
- Synchronization between phone acquisitions and videos using a QRcode
- Statistics on processed data

2.2.1 Parameters

To access to the parameters setting interface, click on the parameter icon.

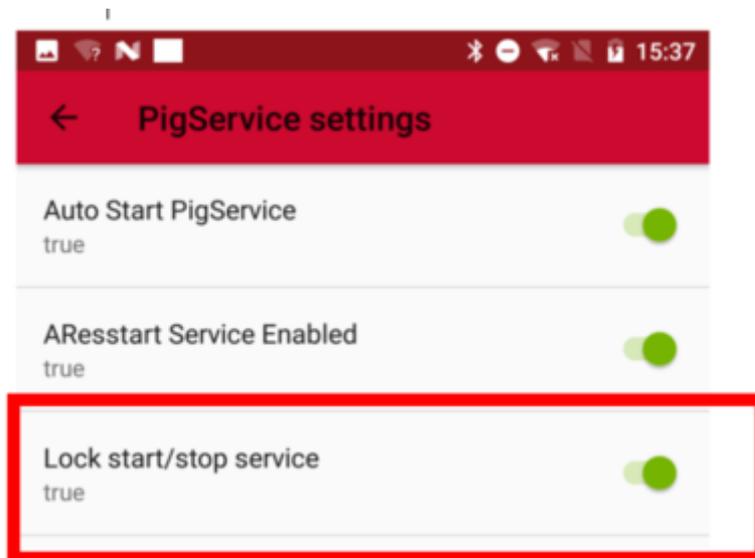


The following menu opens:



2.2.1.1 The « PigService Settings » menu

The option Lock start/stop service:

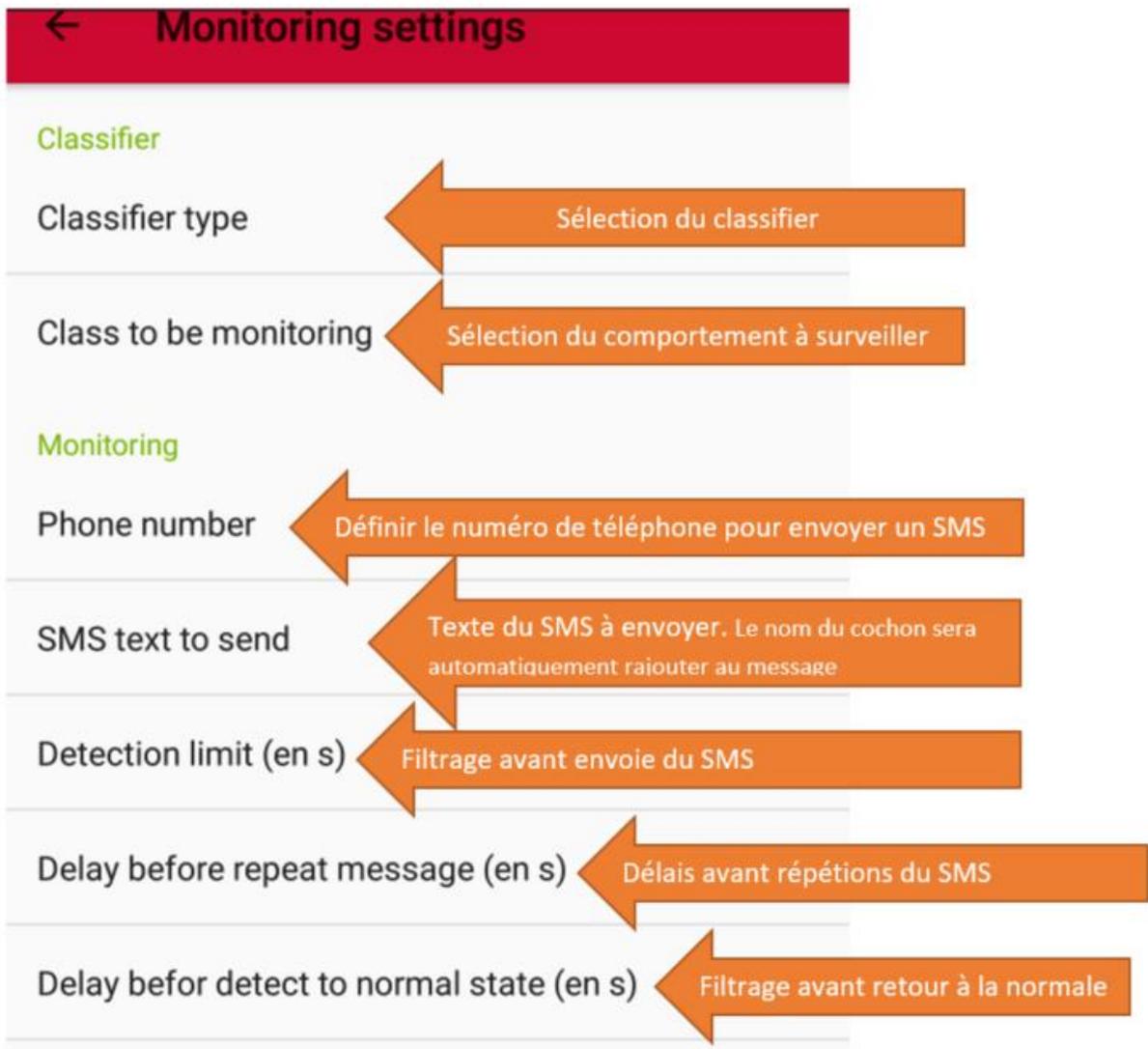


This option enables or disables the button on the Start / Stop service interface.

During the setting up step, it is possible to disable (value false) this option, which makes the button easily accessible. On the other hand, to avoid a false manipulation (unexpected stop of the service) during the use phase, it is preferable to activate this option.

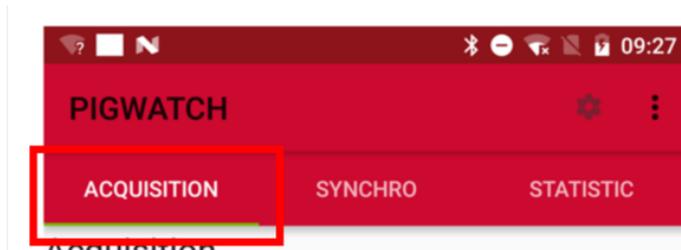
2.2.1.2 The « Monitoring settings » menu

This menu is used to define the default settings of the service. The new values will be taken into account only after a restart of the service. For this, we can use the Start / Stop Service button of the interface.

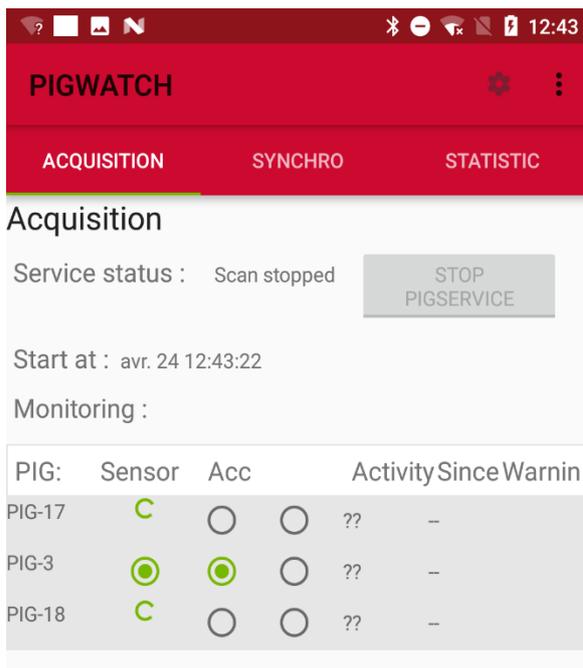


2.2.2 « Acquisition » tab

To access the "Acquisition" window, click on the ACQUISITION icon or drag from right to left (or from left to right).

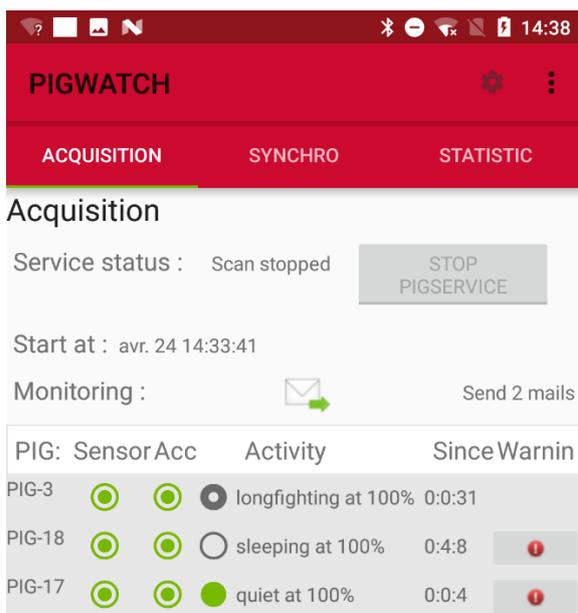


This tab displays the status of the service.



It indicates therefore:

- Service Status: if the service is looking for connection of one of the sensors
- Start at: start time
- Monitoring: if an SMS has been sent or if mail is failed.



The “Start / Stop Pig service” button: allows you to stop or restart the service. To enable or disable it, you have to disable the option: "Lock Start / stop service" from the menu PigService settings (se above).

For each pig defined in the phone's sensorList.txt file, information is given about:

- **Sensor:** connection status
- **Acc:** reception of acceleration data
- **Green or red button** flashes each time the data is received from the classifier
- **Activity:** The current behavior or activity with its percentage of probability. Note to classify "Hierarchical" the percentage is always 100%
- **Warning:** a red icon appears when the monitored behavior is detected.

2.2.3 « Synchronisation » tab

The "synchronization" function is a help to synchronize the video files and the data files (xxx_ACCEL.csv and xxx_CLASSIFIER.csv) of the Pigwatch application. For this purpose to the implementation of the experiment, (and according to the chosen protocol) we click on the button "CLICK HERE TO GENERATE QR CODE" in front of the camera in order to see the video generated QRcode. This is the date and time of the moment the click occurs. All data files (*.csv) have a synchronisation column (true or false).

It is advisable to hold the phone in portrait mode.

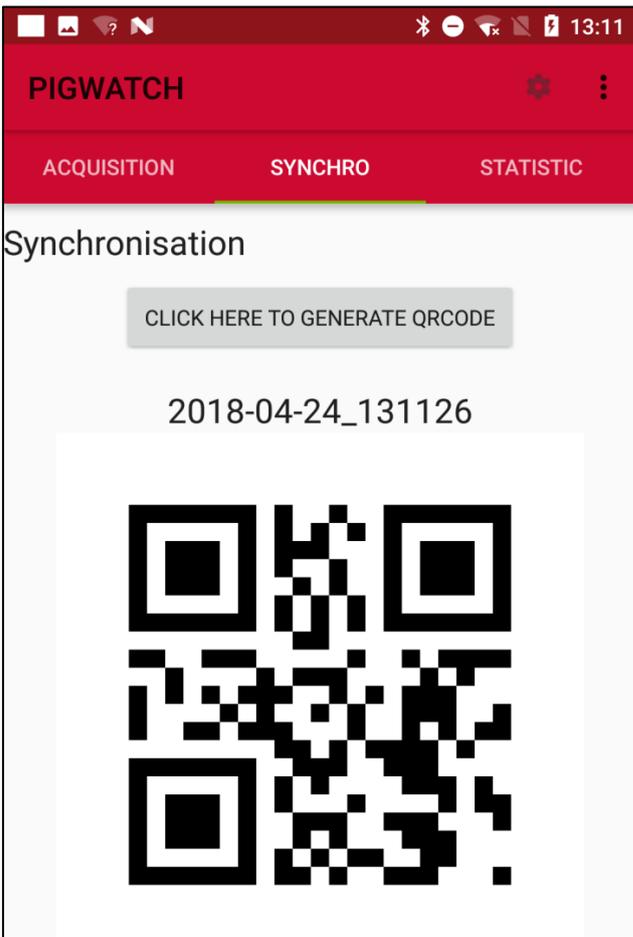
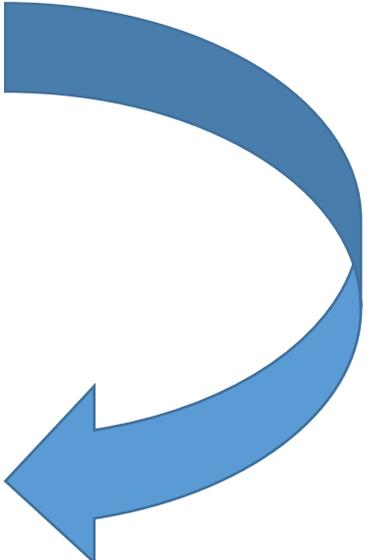
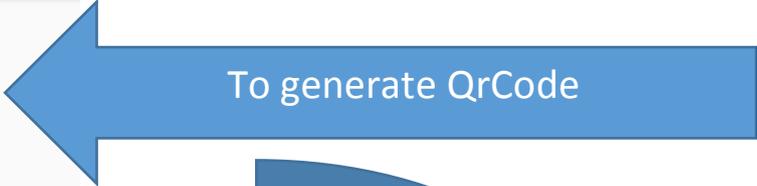
To access the "Synchronization" window, click on the SYNCHRONIZATION icon or slide from right to left (or from left to right).



Synchronisation

CLICK HERE TO GENERATE QR CODE

qrcode



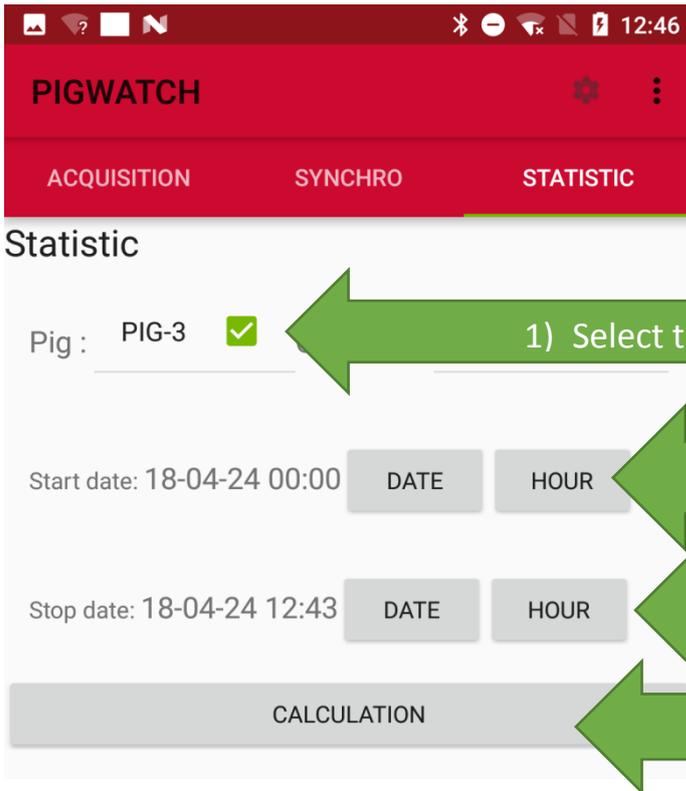
2.2.4 « Statistic » tab

The "statistics" tab makes possible to display for a given pig and a given period, the following information:

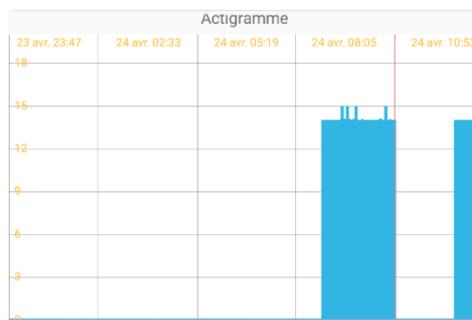
- Percentage of time per activity
- Activity as a function of time

This information comes from the database that is provided by PigService. To access the "Statistic" window, click on the STATISTIC icon or drag from right to left (or from left to right).



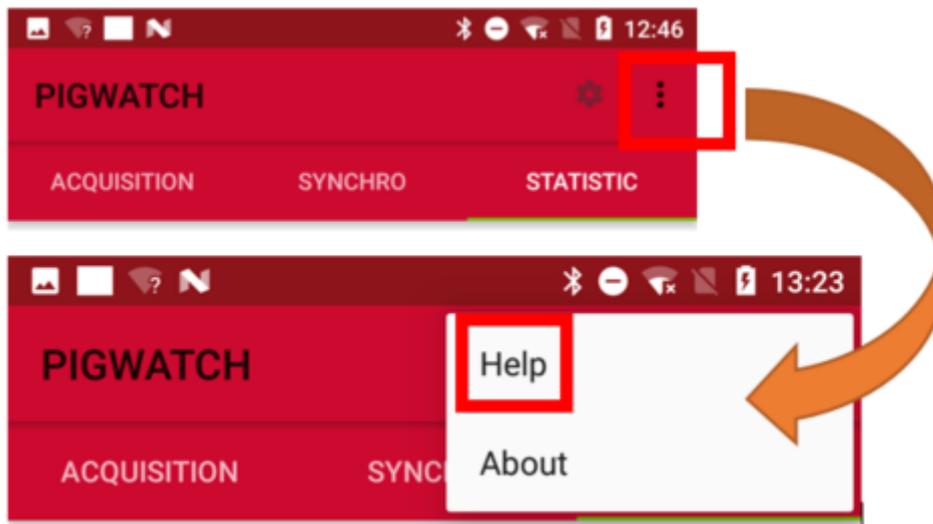


After selecting the time window and the pig, two graphical displays are generated:



2.3 Find help

The user manual is accessible from the "Help" menu of the application:



3. Final demonstrator: test at FBN

This final experimental phase aimed at evaluating in a larger scale the complete system.

At FBN in the experimental barn in Dummerdorf, Germany, 20 animals have been equipped with sensors via commercial ear tags and 5 smartphones for data recording, processing and alert sending. The test started on 12th June 2018 and lasted until 1st August 2018. From 26th June on also video recordings of the pigs were made. At the beginning, the connectivity between the smartphones and the sensors was good, but it quickly decreased so that after 2 weeks the smartphones/the Apps had problems or, in most cases, did not manage it to establish a connection to the sensors. Additionally, from the beginning, the App closed/crashed after relatively short time so that the App/smartphone had to be re-started each day. Therefore, the time of data acquisition was quite short. Just one smartphones worked at the beginning of the testing period continuously over 4 days, but thereafter could not establish a connection to the sensors. Moreover, the space between ear tag and sensors was too tight for the pigs` ears so that in several pigs the ear was squeezed, got inflamed and the ear tag started to grow in after 1-2 weeks.

Additionally, 8 sensors and 2 smartphones have been installed in two commercial farms, one large farm (Benitz) and a smaller one (Panzow) with 4 sensors and 1 smartphone per

farm. The test in the small commercial farm (Panzow) lasted from 10th July until 14th August. From the beginning they had the same problems as the experimental farm: bad connectivity between smartphone and sensors, closing of the app after short time and regular re-start of the app as well as growing in of the ear tags. The test was finished after the pigs destroyed the sensors. The test in the large commercial farm (Benitz) lasted from 13th July until 18th July. They also had the same problems with connectivity, app-closing and growing in of the ear tags (already after a few days). Additionally, the charging of the smartphone did not work. The test had to be finished when the battery of the smartphone was empty, because the charging cable was fixed in the protection box and could not be exchanged.

It has to be analysed which factors cause the bad connectivity between sensors and smartphones in the barn and what causes the regular closing of the app. Additionally, for fattening pigs, ear tags have to be used that have space enough for the sensor and the growing ear of the pig to prevent health and welfare issues due to inflammation and growing in of the ear tag.