Activity recognition based on the movement of temporomandibular joint

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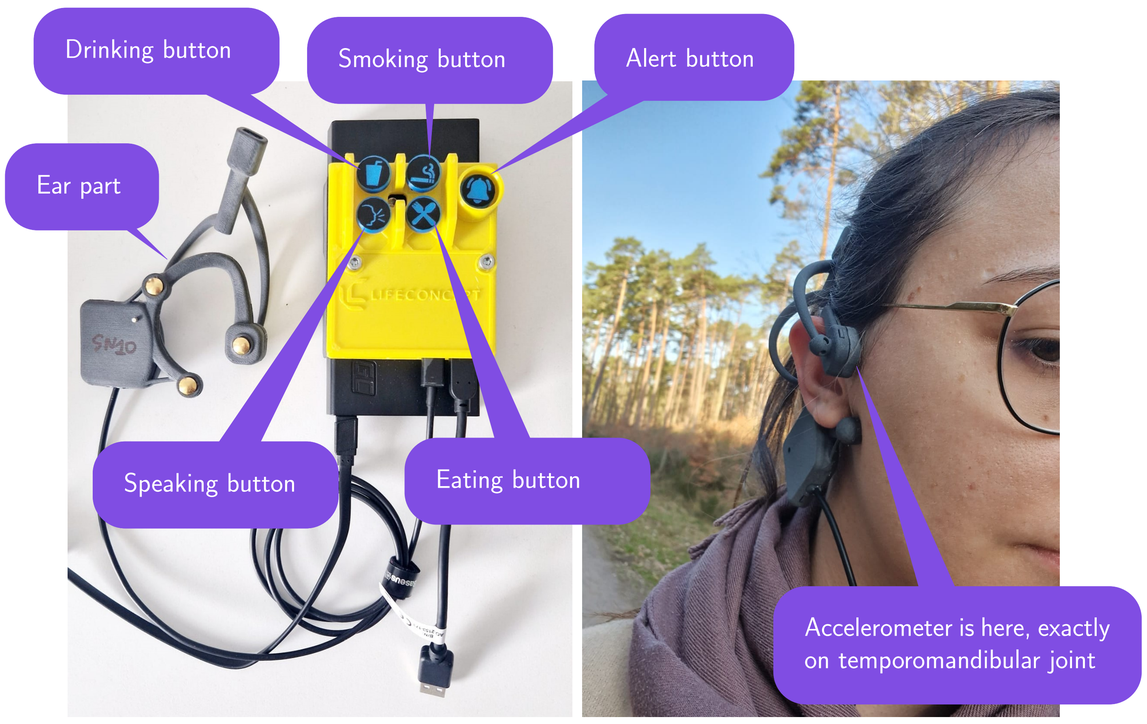
As part of the R&D project 'Measurement device supporting women in taking care of fertility and family planning based on continuous measurements of parameters of mandibular activity, electrodermal activity and body temperature together with original software for data acquisition and analysis based on machine learning algorithms and neural networks', carried out by Lifeconcept, the scientific team investigated the possibility of detecting specific activities based on mandibular activity. The project was cofounded from the European Regional Development Fund under the Regional Operational Programme Intelligent Development 2014-2020 and it aimed at supporting fertility assessment.

Appearance of the device and data collection

During the data collection process, we prepared several datasets with accelerometer signals, including male-only, female-only or nonsmokers-only datasets. Here, we present bullet points associated with the details of data collection:

- The person was instructed to place the device on their ear. That part of the device cointains an **accelerometer**.
- While performing an activity, the person had to press the corresponding button (**drinking, smoking, speaking, eating**).
- The button should be pressed at the very beginning of the activity and released after the activity is done.
- If no button is pressed, the activity is labeled as doing **nothing** – it practically means other activity.
- When wrong button is pressed, it should be released and the **alert button** should be pressed.



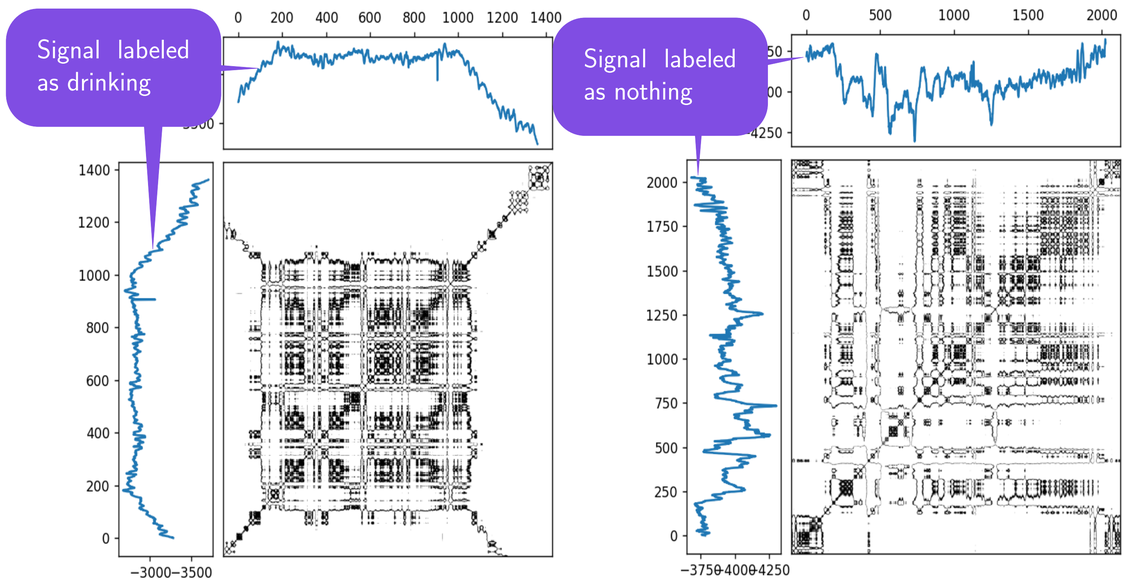
The aim of the project is to develop a new personal device (wearable) collecting and analyzing previously unconnected parameters such as body temperature, temporomandibular joint (TMJ) activity, electrodermal activity, to support female fertility and increase the chances of pregnancy. The implemented innovation, through the use of multivariate analysis of parameters with ML and AI, will enable precise monitoring of the course of the cycle, fertile days/ovulation, fertility disorders and lifestyle factors affecting fertility.

Classifiers trained on various features of signals

As our data have time-series character, we decided to compute various features and use them to train machine learning models. We calculated classical statistics such as **means, standard deviations, kurtosis, cumulants**. Additionally, we computed more advanced features, including **Fourier transforms** and **recurrence plots**. A recurrence plot is a techique of time series analysis. It can be seen as a tool which measures recurrences of a trajectory.

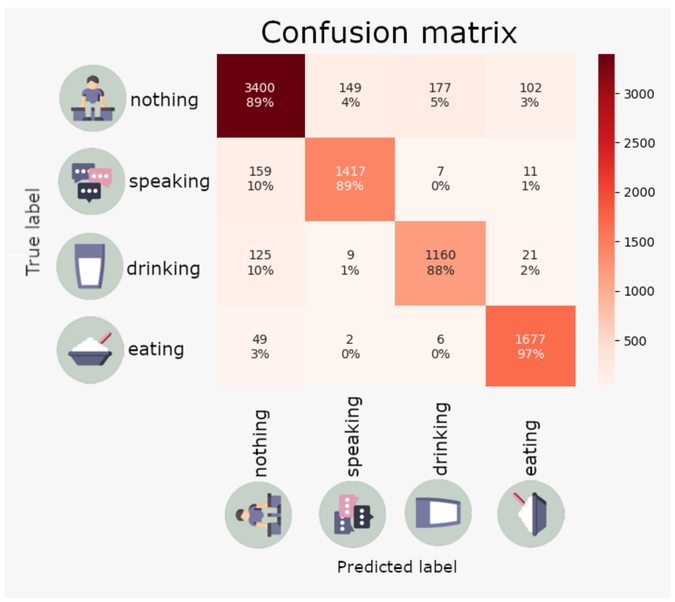
Using recurrence plot features for training improves model accuracy, but calculating these features for many signals demands substantial computing power.

Here we present two examples of signals and their recurrece plots:



Accuracy results for artificial neural networks

Each signal was labeled with one of the following activities: eating, drinking, speaking, nothing. We skipped recognizing smoking because the dataset with smokers was quite small. We trained ANN model for signal recognition task. Here, we present the results:



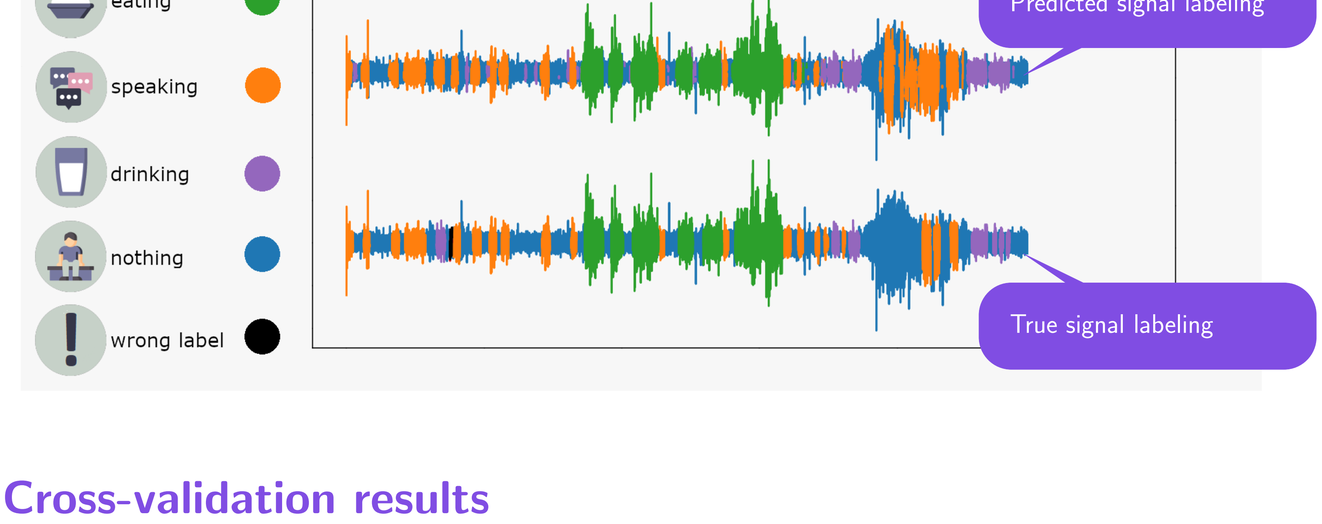
Our goal was to classify accelerometer signals according to the labels.

For training and testing model we used female-only dataset because the device is designed to monitor women's fertility.

During testing our model in real time, we noticed some interesting observations:

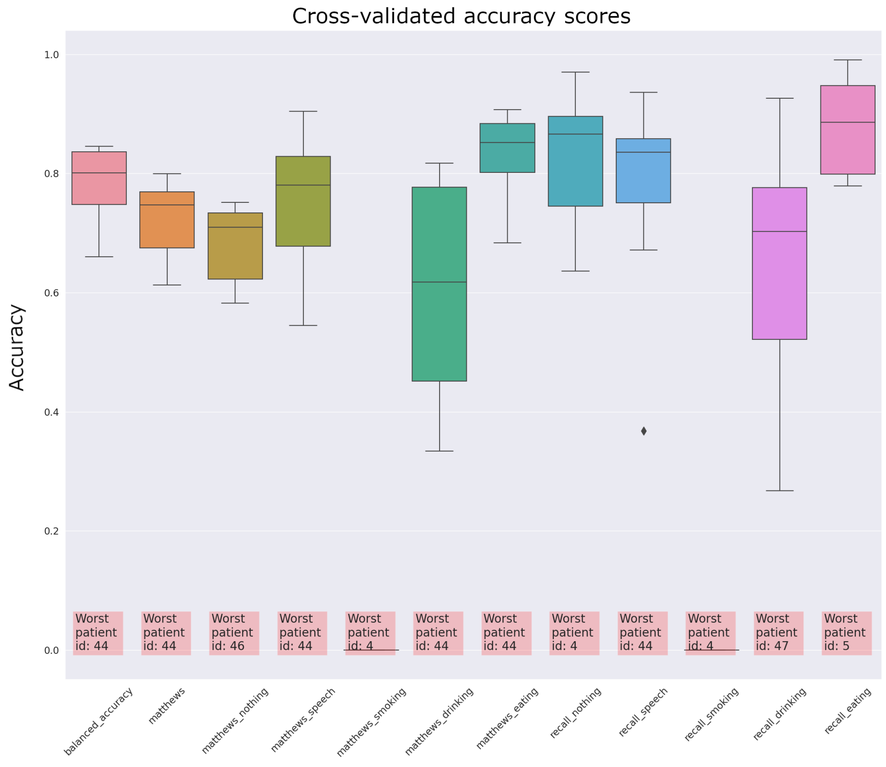
- Our model recognizes swallowing saliva and classifies it as drinking.
- Our model recognizes a single note being sung (without mouth movement) and classifies it as speaking.
- Speaking recognition works better when the speaker's technique is healthy (e.g., speaking from the diaphragm).

To better visualize the classification problems of our algorithm, we present comparison of labeling:



Cross-validation results

We validated our ANN model by testing it on one person and training it on the rest. It turned out that there are some differences in accuracies. While our model works well for some people, it may not perform as effectively for others.



The device is designed to support women's fertility, and in the perspective – fight against addictions, maintain a healthy weight, optimise stress. Additional possible applications for the device in senior care are monitoring actual fluid intake and hydration in the elderly, as well as detecting falls.

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