The method for processing electromyography and inertial sensors supporting chosen set of neurological symptoms for clinical trials support and treatment assessment

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Abstract: This paper discusses method and tool for supporting and assisting clinical trials of pharmaceutical drugs utilising wearables and mobile technologies. Biomedical sensors and handhelds deliver new opportunities to gather and process medical data. Presented method implements such observations and delivers new, convenient means for remote patient monitoring. Clinical trials require methodology and tools to support iterative, accurate assessment of drug intake and treatment effects. Currently available methods rely mostly on analogue approach (booklets) in which a trial participant is reporting symptoms in a booklet. Such approach often can be biased by unpunctual, not precise reporting. Handhelds can support trial processes by automatically scheduling and recording an actual time of reports and most of all it can record the inertial and biometric sensor data during the survey process. Presented analytical method (tremors recognition) and its software implementation offer consistent approach to clinical trials assistance transforming Android smartphone into remote reporting and notification tool. PatronDroid tool supplements also features for sensor based disease diagnostics identifying PD tremors as well as specific tonic or clonic phases. The tool's feature composition delivers convenient and reliable utility which can assist patients and medical staff during the process objectifying the clinical tests, helping to ensure good quality of the clinical trial data, instantly available and easily accessible.

Key□rds: mobile applications, wearable sensors, telemedicine, clinical trials, neurological symptoms

1 Introduction and main concept

The main idea presented in the work is to utilise handhelds and wearable biometric and inertial sensors in order to assist clinical tests and medical examinations [1][7][8]. Such an approach can deliver promising results in order to obtain objective data during massively executed clinical tests. The tool can also lower costs of conducting and analysing results of clinical tests, as the logistics of the tests can be simplified. Presented method, algorithms and its implementation delivers handheld application and a sensor armband, which are managed by the central server service. The central server service can be further integrated with any SOA infrastructure delivered by clinical test provider. Such construct is flexible easily configurable and can be deployed as a cloud services to support scalability.

The use of accelerometer and/or electromyography in neurological diseases treatment were mentioned in various publications. There were discussed ideas to monitor Parkinson's disease with the smartphone [2] or to provide automatic detection of tremors and dyskinesias with accelerometer and electromyographic signal of specified monitoring device [3]. Idea of use an accelerometer during detection of epilepsy's seizures were mentioned in [4][5][6]. What is more, since 2012 Military University of Technology has developed several sensor based solutions for neurological disease assistance and monitoring - SENSE [7], PATRON

[8] utilising smartphone's inertial sensors proprietary wireless biometric sensors.

2 Tool for assisting clinical tests

PATRON [8] (smartphone-based mobile system utilising wearable sensors) offers innovative approach of Parkinson's Disease symptoms examination delivered through application of myography and inertial sensors integrated with handheld devices. The utilisation of sensor-assisted diagnostics of tremors and motor skills, delivers new opportunities for neurological research especially in the domain of effective drug usage and clinical testing of pharmaceutical therapies. The developed hardware, the PATRON multi-sensor is first fully mobile, wireless sensor fusing several channels of data gathered from surface electromyography, mechanomyography, 3-axis inertial sensor and magnetometer. The sensor can be seamlessly attached to a forearm or calf in order to remotely gather, filter and transfer the data to a handheld. The multistage DSP analysis of the data is performed in real time, delivering data of tremors frequency and magnitude, the intensity of muscle tensions and the orientation of the sensor. Fused data describing the neurological examination is than stored, aggregated with the time and location and uploaded to the reporting server. The mobile application delivers two main functionalities ad-hoc tremor examination and on-demand clinical test surveying. Therefore, the application can be used for examining, the tremor intensity and limb movement fluency, evaluating the Parkinson's Disease on-off fluctuations and dyskinesia. System supports the PD patient by estimating current health state and in consequence providing recommendation for medicine usage. PATRON can also be used as a clinical test support toolkit for researchers and pharmaceutical companies guiding patients through the complete process of reporting the drug effectiveness. Sensor-based tests complement the patient's surveys, delivering objective information about the patient's health state therefore evaluating the effectiveness of a drug and applied treatment. The system offers also a server based reporting services which serve as a clinical tests warehouse. Web portal visualizes the clinical test process organizes the data and evaluates the characteristics of the medicine effectiveness [12][16]. PATRON server has been deployed on Microsoft Azure Cloud environment, which provides high-scalability and security characteristics. Web application can be accessed by the researchers, medical staff and pharmaceutical companies in order to inspect and monitor current state of clinical test process.

3 Utilization of various devices to receive signals

The MYO armband is a gesture and movement control device. Its purpose is to receive signals during arm's movement and gestures. The device contains eight EMG sensors (device segments) detecting muscle tension with sample rate 200 Hz and accelerometer, gyroscope and magnetometer inside built-in IMU with sample rate 50 Hz (Invensense MPU-9150 9-dof motion sensor). It is controlled by the Free-scale Kinetis Cortex M4 120MHz processor and communication is realized with Micro USB port or Bluetooth LE protocol. Armband can be expandable between 7.5 - 13 inches (19 - 34 cm) forearm circumference and weights 93 grams [9][10].

The vendor has provided SDKs dedicated for various mobile platforms and capabilities. For example, the iOS SDK contains methods providing ability to read data from EMG sensors, while the Android SDK lacks such features. According to [11], sensors of the Myo have the following characteristics:

- electromyograph – unit of measurement: mV, range: +/- 0.45 mV,
- accelerometer – unit of measurement: g, range: +/- 16 g,
- gyroscope – unit of measurement: °/s, range: +/- 2000 °/s,
- position sensor – unit of measurement: quaternion.

The manufacturer claims that sensor's battery should last a whole day of continuous use (which is one of crucial requirements for the clinical test assistance). For the band in a sleep mode, disconnected from any devices, expected operating time is about a week. There are two batteries inside, with a capacity of 260 mAh each. The communication range via Bluetooth is up to 15 meters. Armband's sensors can work on the leg what can be useful in various diagnostic purposes.

During Patron Droid's diseases evaluation there are also being used inertial sensors from smartphones and smartwatches.

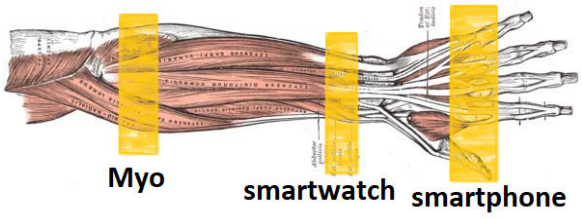

Fig. 1. Location of sensors on the patient's arm

All sensors are placed at the appropriate locations of the user's body. For the operation of the algorithm, it is necessary to locate sensors in planned places. Myo's headband is made to be worn on the forearm. Smartwatch has to be located on the wrist, while the smartphone must be held by the user in his hand.

4 Monitoring of the patient's health

The application allows to collect patient's state data in two ways:
- periodically, when a patient is asked once in a defined time to complete a survey about his condition
- forced, when the patient at his own request initiate the test procedure.

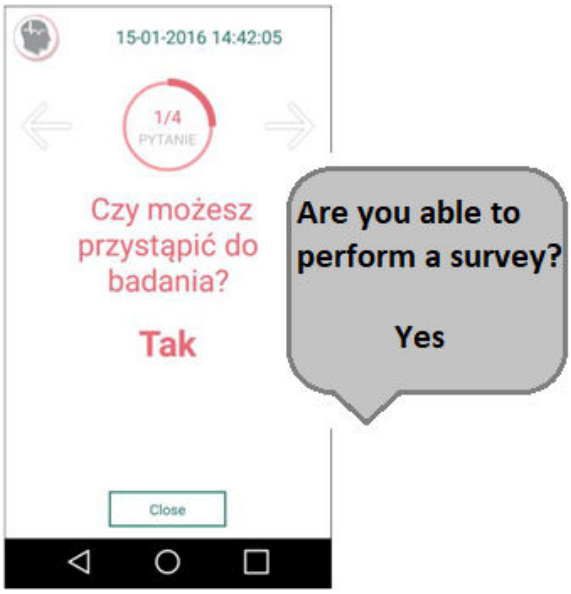

Fig. 2. Patron Droid survey screen

Periodic mode means that a new survey is displayed to the patient in a regular time intervals. The survey contains of basic questions about the patient's health. At the moment these questions are written in Polish, because the research is currently being conducted in Poland. The questionnaire at the beginning contains questions that concern:
- a patient's ability to complete the survey
- subjective assessment of the patient's condition
- evaluation of dyskinesias

These questions can be modified and adapted to the needs of the patient. In addition, during the completion of the survey by the patient, simultaneous collection of sensor's data is available at the same time. These signals are being recorded in the device and the correlation between the subjective responses given by the patient and the objective signals collected from the sensors is checked by the clinical test process manager [12][16].

This approach allows for a continuous verification of the patient's state of health. On this basis, it is able to assess the severity of the disease, the effectiveness of drugs and monitor the disease progresses what can provide useful information about a treatment to choose.

In addition to the periodic mode, it is also possible to perform a forced test. This means that the patient first selects the configuration in which the test will be performed (sensors to use, which arm, one or both arms test, time of the test), followed by signal collection at a predetermined time.

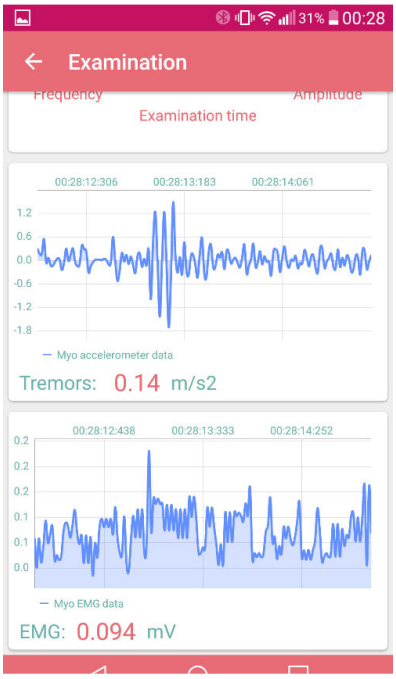

Fig. 3. Patron Droid examination screen

During the test, the application provides basic information such as the test time, current sensor reading, and graphs showing the signal characteristics throughout the test. If the patient has previously selected the appropriate option, received signal values can be stored in the device memory during the test.

Apart from the possible data recording, the signals received during the test are continuously transmitted to the reasoner component. This is where the signal analysis is done, what is described in more detail in the next section.

During the examination, the algorithm determines the individual parameters for specified time frame. At the end of the operation time, the reasoning is performed on the obtained parameters, and the result of the test is displayed to the user.

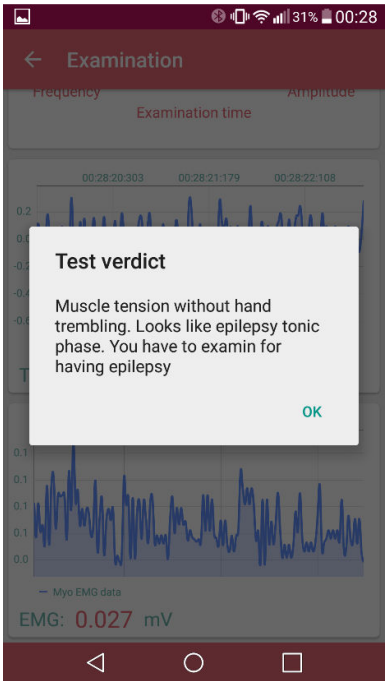

Fig. 4. Patron Droid examination result screen

Features and views of the application was described in details in [17].

4.1 The algorithm of disease detection

The purpose of the algorithm's current version is to detect symptoms of Parkinson's disease and epilepsy. To aim the purpose, two types of signals are used if they are possible to receive:

- inertial signals that tell where and how fast the patient's limb was moving,
- electromyographic signals presenting limb's muscles tension.

Based on the information collected from these signals and the correlation between them, a final diagnosis is made. The possibility of receiving selected results depends on the measuring device that is used for the test. This is due to the fact that Myo has both inertial and electromyographs sensors when smartphones and smartwatches allow to collect signals only from inertial sensors.

Having recorded both signals, it is possible to distinguish some features of epilepsy and Parkinson's disease:

- Parkinson's disease is characterized by slight tremors without increased muscle tension.
- The epilepsy tonic phase is associated with a strong muscle strain of the patient who remains without any move.
- The clonic phase of epilepsy is associated with substantial tremors of the patient's limbs as well as rapid muscle strain.

Based on these features, the algorithm is trying to make a diagnosis. Where the test is carried out with a Myo armband, it is possible to check all of them. When a smartphone or smartwatch is used for a test, the diagnosis is based only on inertial signals, which limits monitoring the patient's behaviour to the characteristics of his limb movement.

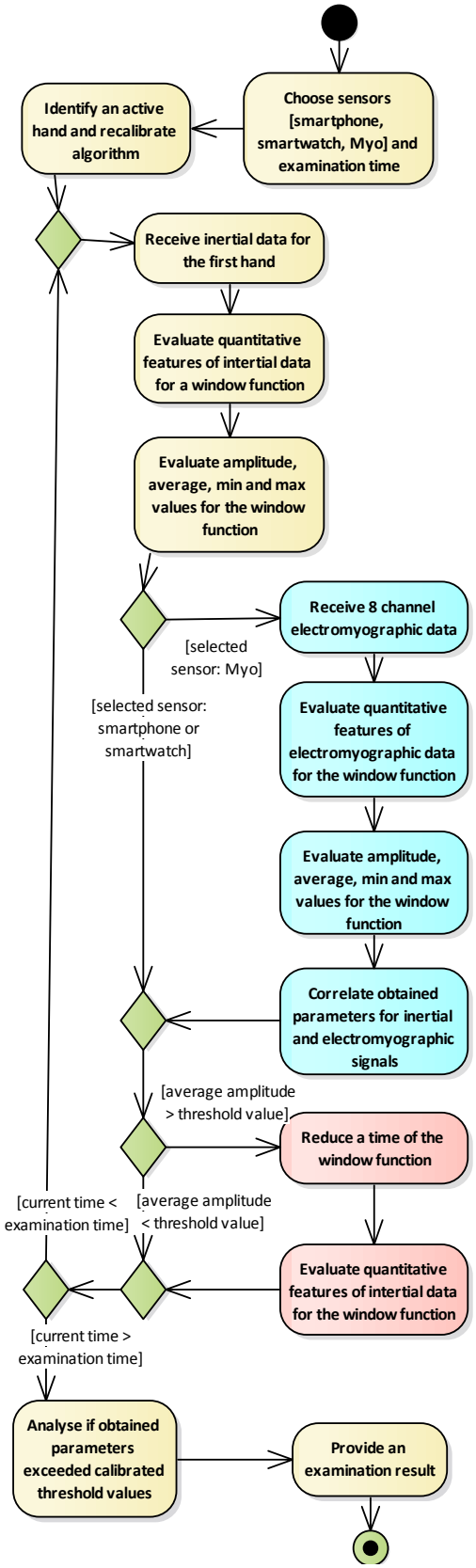

Fig. 5. Flow of the decision algorithm

This means that depending on the test configuration, it is possible to receive results with an different accuracy.

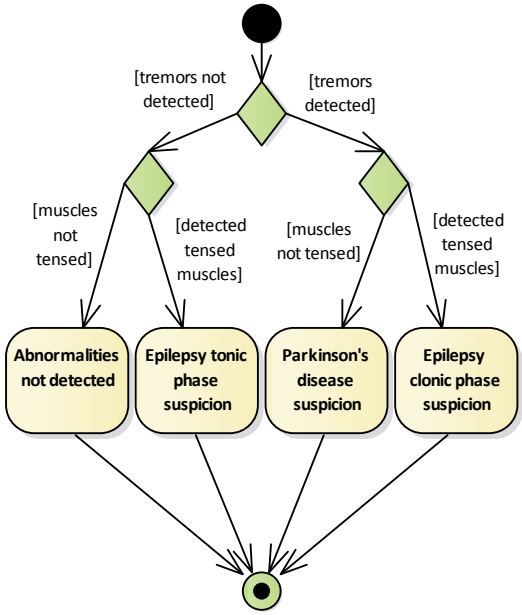

Fig. 6. Possible decisions of the algorithm

In every test configuration, the examination is always similar. In each time window are gathered signals from the accelerometer and - if possible - from the electromyograph. For each time window, the features of the collected signals are determined and stored in the device memory. At the end of the examination, these features are appropriately analysed and correlated between them, and the user appropriate result is presented to the user. The present form of the algorithm is described in more detail in [17]. Obtained results depend on the occurrence of the problems identified during the examination:

- No abnormalities means there was not set any of the examination flags.
- The Parkinson's disease or the epilepsy suspicion based on arm trembling during examination of one arm without the armband sensor.
- The Parkinson disease suspicion implies that there was arm trembling without muscle tension during examination of one arm with the armband sensor or only one arm trembling during any examination of both arms.
- The epilepsy tonic phase suspicion is based on increased muscle tension without arm trembling during an examination with the armband sensor.
- The epilepsy clonic phase suspicion means that there was variable muscle tension and arm trembling during an examination with armband sensor use.

4.2 Further development of the algorithm

The current algorithm is not sufficient for advanced diagnosis purposes, so a plan for its further development has already been prepared. In the next stage the algorithm will be significantly expanded. The diagnosis of Parkinson's disease will use an actigraphy to measure mobility of the limb. In the case of epilepsy, the purpose is to detect particular types of seizures. To achieve this, during the test will be determined muscle activation function and measured intervals between succeeding slopes on the signal record. Based on these data and accelerometer the tonic and clonic phases will be detected. The algorithm will search for similar characteristics as currently (described in 4.1). Atonic seizures will be detected by sensors located on the patient's neck, as a best place to observe their characteristics. This is a sudden momentary stroke of muscle tension along with the following drop on the EMG signal. It will be correlated with patient's behaviour (usually a fall-off) found on the inertial sensor. The algorithm will also detect myoclonic seizures that are characterized by sudden muscle spasms in the electromyographic signal. It is also intended to use the machine learning technique in patterns comparing.

Considered decision support mechanism was a decision tree. After the research, it was decided it will not be used, because each decision have to be explicitly described in advance. Computer systems which supports of making a decision generally require gathering and ongoing access to all knowledge about the issues to be resolved. Nowadays, work is being done on the use of neural networks for pattern recognition. Neural networks seem to be suitable for the algorithm due to their ability to adapt dynamically to learning patterns. In addition, they can be used when the data was not present in the teaching pattern. They are able to match the most similar pattern and make a decision.

Neural networks require a one-time learning, but they show tolerance for discontinuities, accidental disorders, or even lacks of a knowledge in the learning set. In the case of neurological diseases, the course of which may be individual for each patient, it seems more appropriate to use neural networks.

The algorithm will be based on more signal characteristics than the current version. Based on this, there will be an inference related to disease detection. In the Section 5 are presented selected signal features:
- number of zero crossing,
- mean waveform length,
- mean absolute value,
- mean frequency,
- mean power,
- peak frequency,

calculated for test cases. These characteristics are part of these which will be used during future development of the algorithm.

At the moment, software authors do not have large sets of research data yet. At this point the research is done in several dozen attempts on patients who reported to study.

In addition, research are still conducted to make it possible to identify if obtained sensors data allows to accurately identify conditions in patients' behaviour which are needed to diagnose properly. One of the issues is to determine the visibility of Parkinson's tremors in the electromyography record.

Currently, the goal of the algorithm is to record seizures to determine the effectiveness of the treatment. Based on the recorded signals, a doctor is able to arbitrarily determine whether the treatment provided has produced the desired effect in an objective way, not subjective from the patient's perspective.

Attempts will be made to ensure that the algorithm next to the seizure recording also detects the symptoms of the impending attack. This means that during the analysis, appropriate signal characteristics will be detected to indicate that the patient will have a seizure. He would be noticed and be able to prepare himself for the seizure.

Evaluation of Parkinson's disease progress will be based on:
- Frequency and intensity of Parkinsonian tremors (sensor-based)
- Occurrence of ON and OFF phases (time, duration, intensity)
- Sleep cycle schedule – as evaluation of the sleep quality
- Analysis of the drug effect on the occurrence of dyskinesia
- Self-assessment survey analysis to rate the patient's comfort level
- Analysis of survey completion to evaluate the patient's compliance

The application is intended to be a patient's helper during his life with the disease. In the event that a seizure is registered, the application will automatically send an information to persons defined in the contact list. In addition, during a seizure, through a device's speaker a message will be issued informing observers of the attack what is happening with the instructions for them how they can help the patient.

5 Experiments and tests

Tests were made by the application developer and was simulated to cover different examination cases. Every test was made with different arm movement, different muscle tension and the same test configuration. Test were conducted with the armband sensor use. Charts were made based on the data received and saved from sensors during examination.

5.1 Test case 1

The first test case was the recording of a healthy person's behaviour. The arm was held stably, without any movement and the accelerometer signal (blue) was maintained throughout the examination at a low level. Low values on the electromyograph chart (orange) indicates that throughout the study muscles were not significantly tightened. Similar results have been obtained for each time window sample. For the accelerometer the number of zero crossings in all cases is close to 100.

Table 1. Statistics of the Test case 1 for ACC

Time window	1	2	3	4
No. of zero crossings	94	97	97	85
Mean waveform length [s]	0.54	0.51	0.51	0.59
Mean absolute value [m/s^2]	0.08	0.06	0.05	0.05
Maximum amplitude [m/s^2]	0.19	0.21	0.19	0.21
Median frequency [Hz]	21.45	24.96	21.91	17.26
Mean frequency [Hz]	21.01	22.20	23.72	18.83
Mean power	0.07	0.01	0.01	0.01
Peak frequency [Hz]	19.27	19.51	19.70	17.09

Table 2. Statistics of the Test case 1 for EMG

Time window	1	2	3	4
No. of zero crossings	78	79	88	106
Mean waveform length [s]	0.0	0.0	0.06	0.0
Mean absolute value [mV]	0.0	0.0	0.0	0.01
Maximum amplitude [mV]	0.0	0.0	0.0	0.0
Median frequency [Hz]	20.51	19.46	21.0	23.1
Mean frequency [Hz]	17.5	20.0	22.0	23.8
Mean power	0.00	0.00	0.00	0.00
Peak frequency [Hz]	16.07	15.9	17.71	21.5

Even the healthy person's arm involuntarily moves in a small range and recorded vibration frequencies are about 22 Hz. The average value of tremors during the test was negligible, about 0.06 m/s^2. Maximum received amplitude exceeds 0.2 m/s^2. As is the case of the accelerometer signal, the results obtained with the electromyograph also show a negligible muscle tension during arm's holding. The number of zero crossings is about 90, and in all cases, the average value for every time window is minimal and its value is 0.01 mV. This shows that during the test muscles were hardly strained.

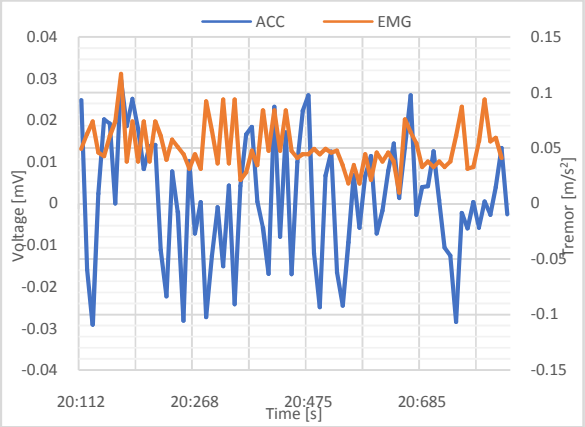

Fig. 7. Graph of extracted 150 samples started at 1000th sample of the Test case 1. Blue line is an accelerometer signal, orange line is an electromyograph signal.

5.2 Test case 2

The simulation of a person suffering from the Parkinson's disease. During the test, arm was still raised and entered in a gentle tremor. Muscles were relaxed during whole examination. Compared to the Test case 1, a reduced number of zero crossings can be observed in the case of the accelerometer. This means that tremors were slower, but based on mean absolute value can be stated that it was stronger than in a healthy person examination.

Table 3. Statistics of the Test case 2 for ACC

Time window	1	2	3	4
No. of zero crossings	64	67	67	67
Mean waveform length [s]	0.08	0.07	0.07	0.0
Mean absolute value [m/s^2]	0.37	0.8	0.7	0.7
Maximum amplitude [m/s^2]	1.7	1.9	2.1	2.32
Median frequency [Hz]	15.8	14.8	14.8	14.45

Mean frequency [Hz]	14.2	14.90	14.7	14.4
Mean power	0.37	0.81	0.72	0.73
Peak frequency [Hz]	13.53	13.47	13.6	13.4

Table 4. Statistics of the Test case 2 for EMG

Time window	1	2	3	4
No. of zero crossings	18	22	26	19
Mean waveform length [s]	0.27	0.22	0.20	0.2
Mean absolute value [mV]	0.02	0.01	0.0	0.0
Maximum amplitude [mV]	0.05	0.05	0.06	0.05
Median [Hz]frequency	5.87	5.59	7.53	7.17
Mean frequency [Hz]	5.90	5.55	7.29	6.62
Mean power	0.00	0.00	0.00	0.00
Peak frequency [Hz]	3.82	4.44	5.27	3.8

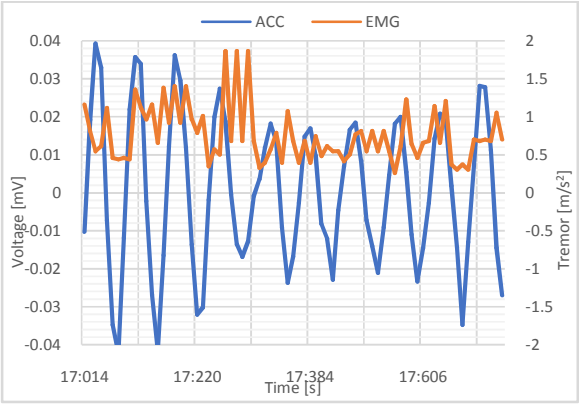

Fig. 8. Graph of extracted 150 samples started at 1000th sample of the Test case 2. Blue line is an accelerometer signal, orange line is an electromyograph signal.

The maximum reached amplitude approached 2 m/s^2. On the basis of frequency measurements, it is possible to confirm that author failed to precisely reproduce the behaviour of the patient, as values around 14 Hz are higher than model values for the Parkinson's disease. Similar results as with the inertial signal occurred with the electromyograph. The signal is slightly higher than in the case of a healthy person test (mean 0.02 mV and maximum amplitude 0.05 mV). But shivering was slower as the number of passes was zero.

5.3 Test case 3

The test was an example of algorithm behaviour in case of the epileptic tonic-clonic seizure. The seizure consists of two parts and its picture every time looks similar: it starts with the tonic phase and then passes into the clonic phase. The duration of each phase is not determined, it is an individual feature of the patient. In the test case, the data obtained during the test were divided into two separate parts: for the tonic and the clonic phase, to distinguish behavioural differences of different stages of the seizure. In the initial phase of the attack, the muscle tension significantly exceeds the threshold values and the corresponding flag is set to true. However, there is no arm movement at the same time, so that no tremors are detected. Only in the second, clonic phase, tremors are present and they are rapid along with significant strains and muscle relaxation. Both these features are detected in the phase and flags are set. For the first stage application detected an tonic phase of the seizure and a clonic phase for the second.

5.3.1 Tonic phase

The simulation of a person in the tonic phase of epilepsy. Arm was held in one position. To keep muscles tightened, a fist was clenched. Muscles were tensed all the time with a full strength. After muscles having tensed, this state was maintained for about 8 seconds and then muscles were relaxed. Accelerometer measurements for the test phase shows that despite extensive muscle tension, slight arm tremors occurred during the examination. Mean absolute value and maximum amplitude were higher than in Test 1 but tremors were shorter, what can be observed by a greater number of zero crossings. The most important feature of the test is observable in the case of the electromyographic signal. The number of zero crossing is very low for the test, which means that the signal value has remained on high values during whole examination. For the second time window, it never dropped to zero. Signal values were significantly higher than for previous test cases.

Table 5. Statistics of the Test case 3 for ACC

Time window	1	2	3	4
No. of zero crossings	79	116	112	34
Mean waveform length [s]	0.06	0.04	0.05	0.0
Mean absolute value [m/s^2]	0.18	0.16	0.16	0.07
Maximum amplitude [m/s^2]	0.99	0.56	0.77	0.28
Median	15.91	24.67	24.64	14.76

frequency [Hz]				
Mean frequency [Hz]	16.97	25.03	24.07	17.47
Mean power	0.55	0.33	0.37	0.29
Peak frequency [Hz]	15.88	23.33	22.52	13.16

Table 6. Statistics of the Test case 3 for EMG

Time window	1	2	3	4
No. of zero crossings	10	0	14	22
Mean waveform length [s]	0.26	5	0.15	0.11
Mean absolute value [mV]	0.08	0.11	0.06	0.01
Maximum amplitude [mV]	0.29	0.27	0.20	0.03
Median frequency [Hz]	0	0	0	13.45
Mean frequency [Hz]	7.67	0	3.19	11.81
Mean power	0.01	0.02	0.01	0.00
Peak frequency [Hz]	2.02	0.20	2.84	8.63

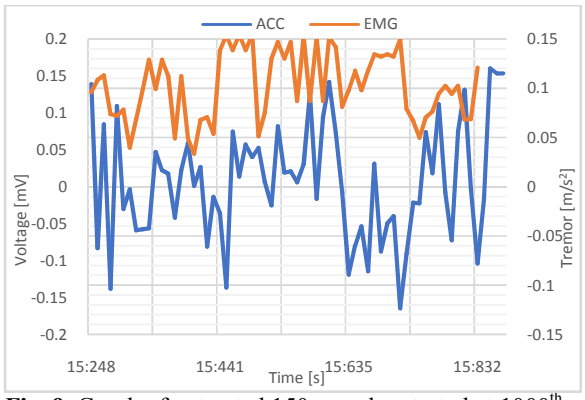

Fig. 9. Graph of extracted 150 samples started at 1000th sample of the Test case 3. Blue line is an accelerometer signal, orange line is an electromyograph signal.

It can be seen that the maximum amplitude reached values close to 0.3 mV, while the average signal value during the attack was about 0.1 mV. Significant increase in muscle tension with lack of visible tremors characterizes the tonic phase of the epilepsy.

5.3.2 Clonic phase

The second part of the tonic-clonic seizure is the clonic phase. During the test execution, there were performed some rapid limb movements with tensioning and relaxing of muscles. The significant increase in both accelerometer and electromyograph signals can be observed. For the accelerometer the average value was over 3.5 m/s^2 and the maximum amplitude was near 20 m/s^2. This means very rapid arm movements. These movements was fast, as the number of passes by zero is close to Test case 2, where tremors received smaller accelerometer values. In the case of the signal from the electromyograph there is also visible considerable muscle tension. In the case of second and third time window, the signal did not fall to zero. In addition, the mean absolute value was 0.1 mV, while the maximum amplitude was 0.3 mV, indicating that muscle strain was significant. The clonic phase of the epileptic seizure is characterized by strong limbs tremors and significant muscle strain.

Table 7. Statistics of the Test case 4 for ACC

Time window	1	2	3	4
No. of zero crossings	86	64	56	51
Mean waveform length [s]	0.05	0.08	0.09	0.10
Mean absolute value [m/s^2]	0.060	2.45	3.86	1.22
Maximum amplitude [m/s^2]	5.70	15.36	19.48	7.45
Median frequency [Hz]	21.67	14.01	12.51	11.83
Mean frequency [Hz]	19.93	13.84	12.24	11.60
Mean power	1.53	9.52	16.90	5.89
Peak frequency [Hz]	19.80	12.87	11.26	10.25

Table 8. Statistics of the Test case 4 for EMG

Time window	1	2	3	4
No. of zero crossings	44	0	0	10
Mean waveform length [s]	0.38	5	5	0.25
Mean absolute value [mV]	0.05	0.11	0.10	0.07
Maximum amplitude [mV]	0.27	0.30	0.22	0.24
Median frequency [Hz]	13.18	0	0	0
Mean frequency [Hz]	17.36	0	0	7.68
Mean power	0.04	0	0	0.21
Peak frequency [Hz]	10.01	0.20	0.20	2.02

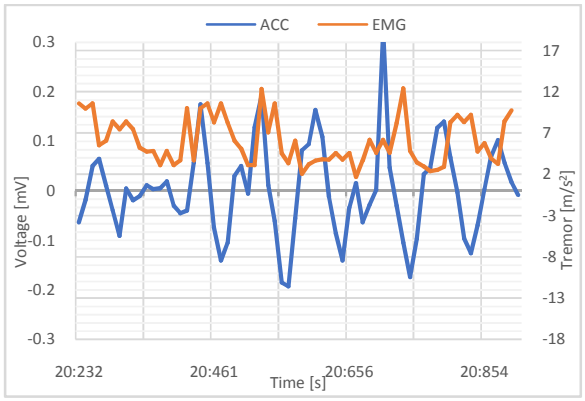

Fig. 10. Graph of extracted 150 samples started at 1000th sample of the Test case 4. Blue line is an accelerometer signal, orange line is an electromyograph signal.

6 Summary

Presented in the paper method and tool offers proprietary algorithms to support acquisition, analysis and medical diagnostics of selected neurological symptoms. The mechanisms cannot replace the professional help and detailed medical diagnostics. During system tests implemented algorithms proved their usefulness especially in the range of tremors intensity evaluation. Such information can be used for PD's drug usage forecast, as the pharmaceuticals have specific action time.
many but can assist clinical tests, but can be helpful when Application of sensors and complex algorithms requires specific configuration and environment preparation.

Results received during tests were consisted with theoretical expectations. Signals that were picked up by the application from the armband sensor reflected the behaviour of the tested person. With increased muscle tension, electromyographic signal significantly increased its value and vary depending upon the strength of the tension. A similar situation was observed in the accelerometer signal. Values were changing with the movement of the limb and band sensor obtained values corresponded to smartphone accelerometer signal. This allows to state that data received from the band were correct.

In addition, results of tests were consistent with the assumptions. On the basis of signals' characteristics, algorithm properly diagnosed diseases. This allows to evaluate that produced diagnostic tool has been implemented correctly. It is a good base for further development or research related to the diagnosis of neurological disorders with mobile devices. RFID technology [14][15] proved to be useful channel for clinical test initial configuration and on-site clinical test collection mechanisms. It has been used to authenticate and preconfigure transmission channel while maintaining patient's clinical records anonymous. Further extensions of RFID usage for automatic drug dose configuration and drug repository maintenance.

What is more, the way the application was built allows to expand it with another measurement devices or to implement more complex mechanisms for inferring and analysing user behaviour.
The system has been officially deployed after successful beta tests on population of 10 patients which have been using the application for at least 4 months. At the time of paper submission a formal acceptance of system and sensor clinical tests have been approved.

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