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Original Research Article

PARKINSON′S DETECTOR APPLICATION

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Abstract

This paper presents the Parkinson “Parkinson detector" application, which was developed in the Android environment and which should provide a modest contribution to the timely detection of the initial symptoms of Parkinson's disease. The application was developed for a smartphone, commercially available to everyone and using existing, already built-in sensors, gyroscopes, and accelerometers. The development of the application „Parkinson Detector“ is intended for use on smartphones to control the condition of the human body, as well as prevention and signaling in case of detection of the initial state of the disease. In time detection of such severe degenerative diseases as Parkinson's disease (PD) would enable the timely application of therapy and improve the chances of care and control of the disease, because currently, PD is diagnosed when wide areas of the brain are already damaged, motor symptoms of patients are evident and begin to influence their common activities. We believe that the use of the application „Parkinson Detector“ can help improve the quality of life, especially in the elderly.

Keyword: Android; Detection; Parkinson’s; Sensors; Smartphone.

INTRODUCTION

Parkinson’s disease (PD) is the second most common neurodegenerative disorder, after Alzheimer’s, and represents a major cause of neurological morbidity globally, [1].

The core clinical features of PD are bradykinesia (without which a diagnosis cannot be made) and a combination of muscular, tremor, and/or postural instability not explained by visual, cerebellar, proprioceptive, or vestibular failure, [1].

The diagnosis of PD remains essentially a clinical one, and it is important to recognize the early features together with symptoms and signs suggesting other causes of parkinsonism, [2]. A key barrier for future disease-modifying therapies is that with current diagnostic criteria, where the focus is on motor symptoms and signs, the diagnosis of PD can only be made once at least 60-70% of SNpc neurons have already degenerated [3-4].

From all the above, it can be concluded that early diagnosis of the disease would be very important in order to introduce therapy in time.

In an extensive study conducted in Article [5], the results of trials carried out in 168 other articles were systematically investigated. From 168 articles included in this study, research has yielded 22 wearable devices, 38 non-wearable devices, and13 instruments with combined technology used for monitoring PD clinical manifestations. The authors briefly summarize that „the PD symptoms that can be objectively measured using the reviewed devices are postural control, tremor, bradykinesia, freezing, dyskinesia, gait, and daily activity/physical activity".

In our article, we decided to analyze tremor because it is "one of the most characteristic manifestations of Parkinson's disease (PD) and often the presenting sign, occurs in approximately 75% of patients with PD, who rank it as their second most troublesome symptom", [6].

2. SMART HOME SENSORS IN HEALTH MONITORING

With today's pace of development of mobile networks, primarily cellular (2G, 3G, 4G, 5G), and then WiFi, Bluetooth, Wi-Max ...), we are in a position to receive a signal from at least one mobile network wherever we meet.

According to the report of the International Telecommunication Union from 2021, the total number of users who use at least the 3G network signal is 7.4 billion, while the total number of users who use the LTE / WiMAX network signal is 6,863 billion,[7].

Diseases related to the cardiovascular system, eye, respiratory system, skin, and mental health are widespread globally. Most of these diseases can be avoided and/or properly managed through continuous monitoring,[8].

Some papers deal with the activity recognition and monitoring system that can identify and record the user's activity in real-time using multiple sensors [9-11] and using collected data in health monitoring and prevention.

Most of these monitoring systems require a system with inertial sensors, [11] which are applied to different parts of the body: joints, arms, sternum, lumbar region, feet, and lower legs.

The widespread use of smartphones as well as modern mobile high-speed communication technologies, bring out the idea of using smartphones as cheaper, commercially available devices, which doesn′t require any additional activities like wearing some external sensors on different parts of the body, because most modern smartphones have a number of the new built-in sensors like gyroscope, compass, accelerometer, proximity sensor, ambient light sensor but also older commercially available sensors like microphone, GPS, WiFi, and Bluetooth.

Such good signal coverage of different mobile networks as well as such great penetration of mobile users has led to the application of mobile phones increasingly integrated into the health care system, and many papers discuss just that [12-28].

One of the interesting ideas is to use smartphones sensors in the IoT application for example creating smart home surrounding for elderly healthcare, [24].

3. USING GYROSCOPE AND ACCELEROMETER IN OUR PARCISON DETECTOR APPLICATION

Sensor-equipped mobile phones will revolutionize many sectors of our economy including business, healthcare, social network, environmental monitoring, and transportation, but in this paper, we will focus only on healthcare.

Practical medicine and healthcare services supported by mobile devices are called mHealth solutions. This field is growing fast recently [12].

mHealth applications are delivered via online stores, such as App Store, Google Play, Ovi Store, and others that increase the availability of mobile healthcare solutions, [12].

Mobile phones can have many built-in sensors, but in this paper, we will be focus only on the use of two of them: a gyroscope and accelerometer.

The Gyroscope represents an extension of locations, providing the phone with increased awareness of its position in relation to the physical world (e.g its direction and orientation) enhancing location-based applications, [7]. The gyroscope measures how fast the device rotates along the three axes, [10].

Accelerometer data is capable of characterizing the physical movements of the users carrying the phone. Distinct patterns within accelerometer data can be exploited to automatically recognize different activities (e.g. running, walking, standing), [17].

Accelerometer measures acceleration across two or three directions. The resulted data are used to change screen orientation. Many papers considered the application of this sensor in fall detection and fall prevention.

Whereas the accelerometer in the mobile device allows measuring the linear acceleration of the device, a gyroscope helps to directly determine the orientation relative to the earth's magnetic field. Generally, these sensors are used for navigation but also can be applied in new techniques to interact with mobile devices using a properly shaped permanent magnet.

4. DATA COLLECTION

Upon the test completion, the measurement results are sent to the server in JSON format. On the server, we have built a database that is automatically populated with measurement data. By using the following code, information about the patient’s name, date and time, adn the test results are sent to the our server:

```
postmap = new HashMap<>();
postmap.put("Name", user_name.trim());
postmap.put("Date/Time", new SimpleDateFormat("yyyy-MM-dd hh:mm:ss").format(calendar.getTime()));
postmap.put("Steady Hand", String.valueOf(Math.round(sh)));
postmap.put("Mild Tremors", String.valueOf(Math.round(mt)));
postmap.put("Serious Shaking", String.valueOf(Math.round(ss)));
postmap.put("Stage", Postmap_result);
postMap.add(postmap);
ata.put("data", new Gson().toJson(postMap));
send_data.setParams(data, eldin.turkic.parkinson.RequestNetworkController.REQUEST_BODY);
send_data.startRequestNetwork(eldin.turkic.parkinson.RequestNetworkController.POST, "https://parkinson.cf/api".concat(db.getString("secret", "")), "", _send_data_request_listener);
```

The patient can also choose to send this data to their doctor by SMS, mail or another app. The following code shows how the meassured data is sent from the app to the doctor via SMS:

```
public void onClick(DialogInterface _dialog, int _which) {intent.setType("vnd.android-dir/mms-sms");
contact_doctor.setAction(Intent.ACTION_VIEW);
contact_doctor.setData(Uri.parse("smsto:".concat(settings.getString("doctor_phone", ""))));
contact_doctor.putExtra("sms_body", text_to_send_to_doctor);
startActivity(contact_doctor);
settings.edit().putString("sent sms", String.valueOf((long)(Double.parseDouble(settings.getString("sent sms", "")) + 1))).commit();
```

By regular monitoring, the application can also detect if the patient is in the initial stage of Parkinson's disease

By using the application in cooperation with the doctor and repeating the measurements for several months in a row, it is possible to facilitate the monitoring of the course of the disease.

This application greatly facilitates the monitoring of the development of Parkinson's disease, but also the transition from one phase to another.

5 CREATING AN APPLICATION

Creating a new app usually starts with creating a new project in Android Studio. Already on the welcome screen, the developer can choose whether to start a new project or open an existing project or create it by importing existing project files from other sources. Here, developers are expected to fill in basic information about the application, such as:

App Name - The name users see in the launcher and Google Play Store

Domain name - Website of the author or company, used to generate a unique package name

Package name - a unique identifier of the application, usually the reverse domain of the company with the application name is used, which greatly reduces the risk of name conflicts with other applications

Project location - the location on the local computer where project data will be stored.

6. PARKINSON DETECTOR APPLICATION

The application creation started in the Android SDK Studio To create the application, we used Java, Kotlin, Groovy, and XML.

The app works by using phone sensors to detect tremors. Immediately after launching the application, it determines its rotation using Sensor.TYPE_GAME_ROTATION_VECTOR, which uses a gyroscope to determine the exact rotation in degrees along the X, Y, and Z axes as opposed to the gyroscope itself which measures the rotation in rad / s.

The Game Rotation Vector also has better compensation for non-horizontal drift.

The only drawback of the Game Rotation Vector is the horizontal drift, that is, when the phone is in a horizontal position (screen up), measurements along the X-axis can vary, and the application can confuse this with slight tremors.

So when testing, it is best to hold the phone in your hand at an angle of 45 degrees.

Raw sensor data: shows raw X, Y, and Z sensor readings

The application detects tremors by taking a sample of the sensor every few milliseconds and comparing it with the previous sample. Based on the deviation it determines whether the tremor occurred and if so, how strong was it.

The default sampling rate is every 50ms, but both the sampling rate and the deviation tolerance can be changed in the settings.

The application calculates deviation by taking the absolute value of X minus X of the previous sample, Y minus Y of the previous sample, and Z minus Z of the previous sample.

```
x_difference = Math.abs (x - xp);
y_difference = Math.abs (y - yp);
z_difference = Math.abs (z - zp);
```

The difference between X, Y, and Z is displayed in the “Difference from the last sample” field.

The application checks if the device has a gyroscope by using the following code:

```
gyro = (SensorManager) getSystemService(Context.SENSOR_SERVICE); if (gyro.getDefaultSensor(Sensor.TYPE_GYROSCOPE) == null) { eldin.turkic.parkinson.Util.showMessage(getApplicationContext(), "Gyroscope is not supported on this device"); }
```

If the device doesn’t support the gyroscope, the app can use an accelerometer for tremor measuring

Above the Start button (Fig 1) is a field where a name can be entered, and that name will be saved with the test result.

The test starts 3 seconds after touching the START TEST button and lasts for the number of seconds specified in the settings (default 20 seconds).

The blue Progress bar below the START button shows how much is left until the end of the test. The other 3 Progress bars below, are showing the percentages of how much your hand was completely still and how much it shook.

The program puts these 3 values through our algorithm and gives the diagnosis and the percentage of how sure it is that the diagnosis is correct.

Figure 1. App Home Screen

Figure 2. Test in progress

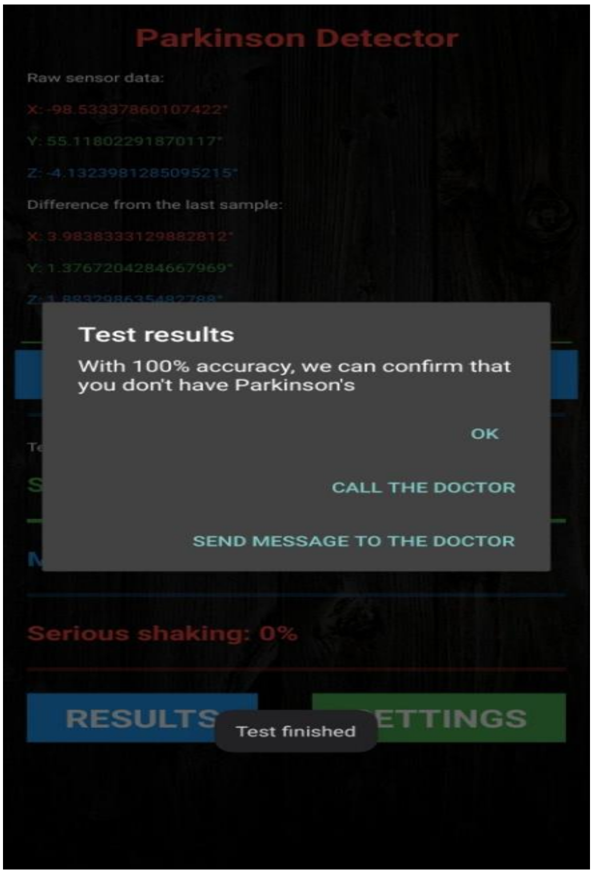


Figure 3. No Parkinson's

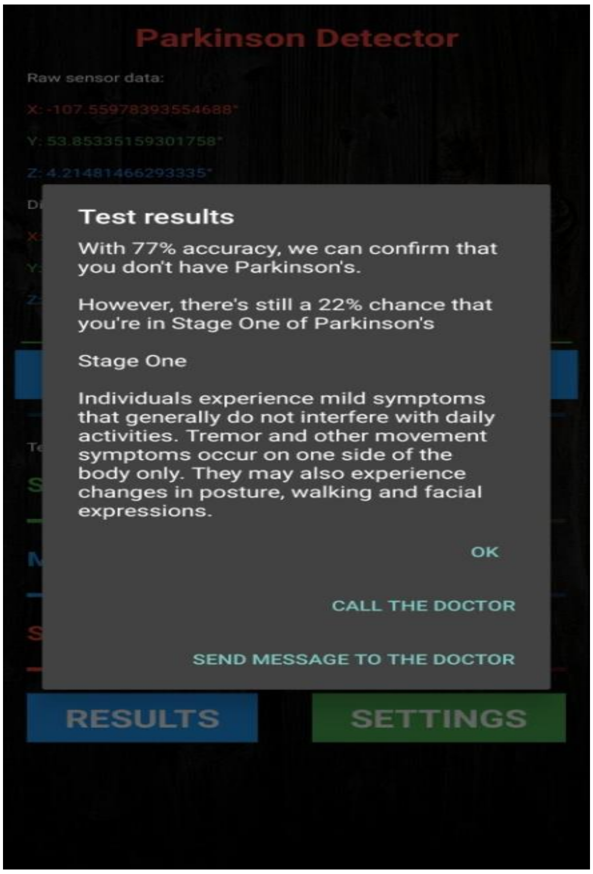


Figure 4. Stage 1

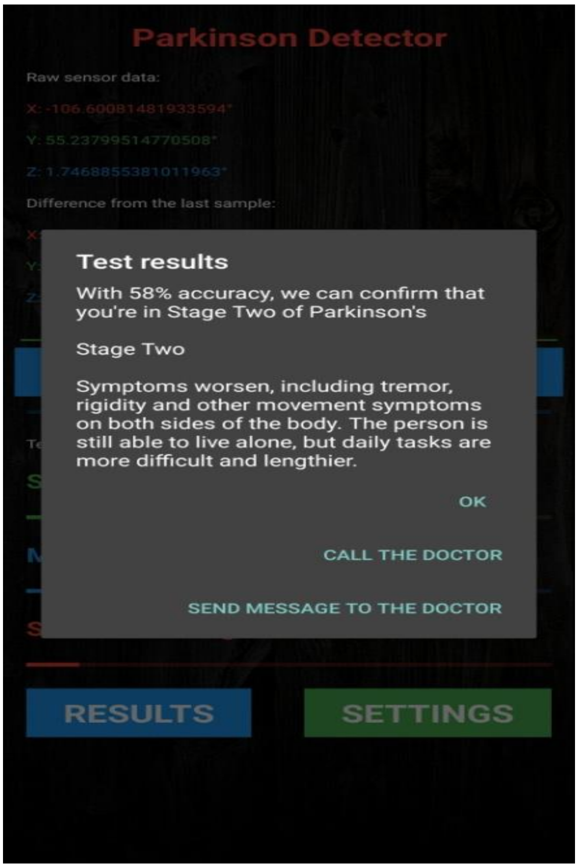


Figure 5. Stage 2

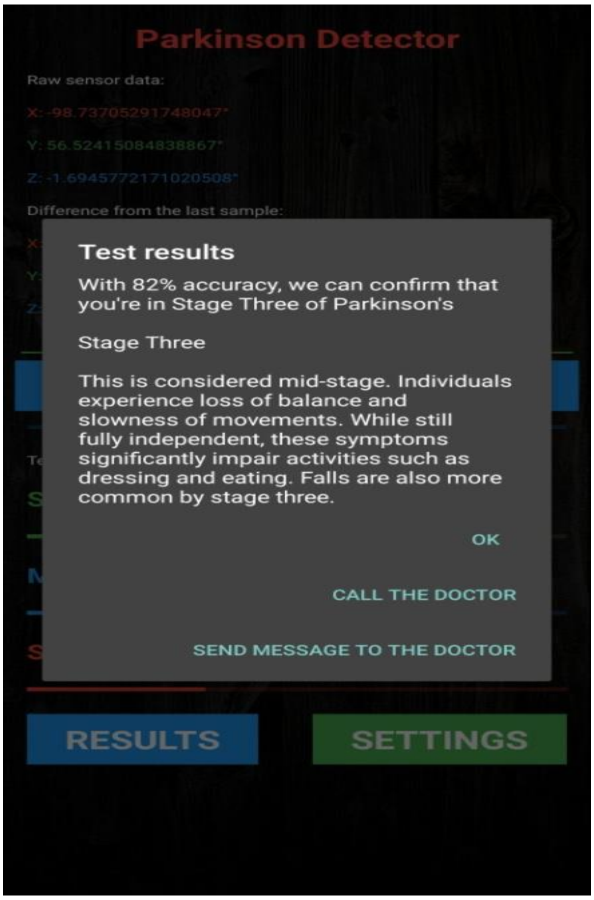


Figure 6. Stage 3

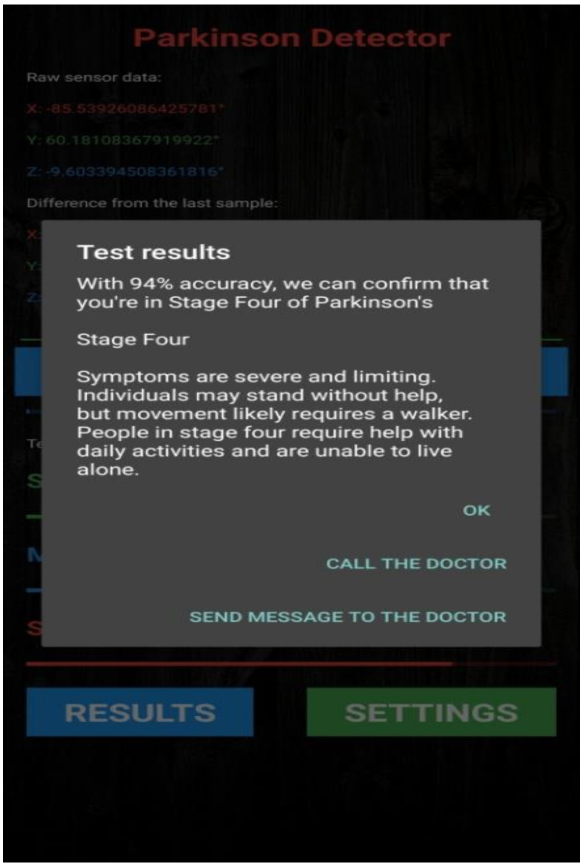


Figure 7. Stage 4

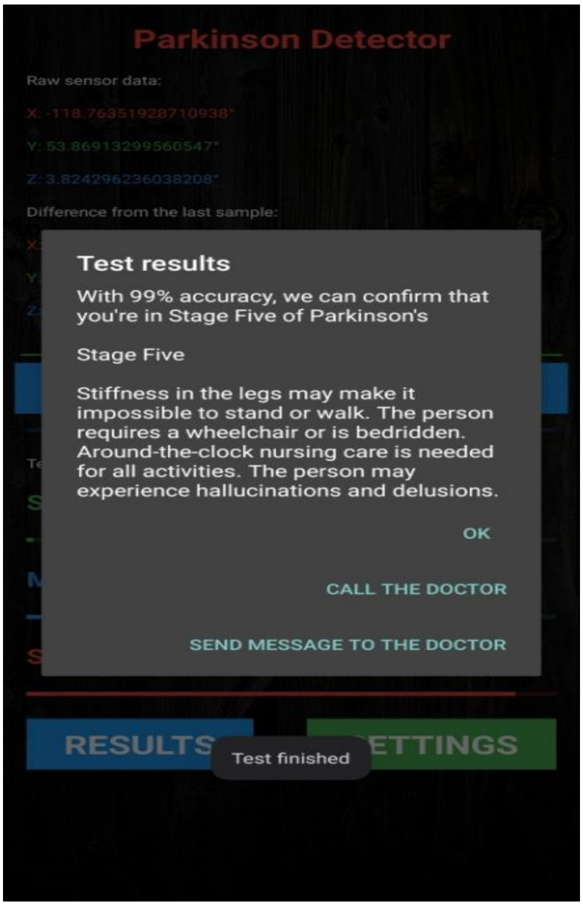


Figure 8. Stage 5

After the test is completed, a dialog with 3 options appears.

- The OK option only closes the Call the doctor dialog.
- The Call The Doctor option calls the number previously entered in the settings.

The call can be established directly via GSM or via a VoIP application such as Viber.

- If Send Message to the doctor is selected, a new dialog opens asking how do you want to send the message.

It is possible to send SMS, Mail, or message via any other application you have installed.

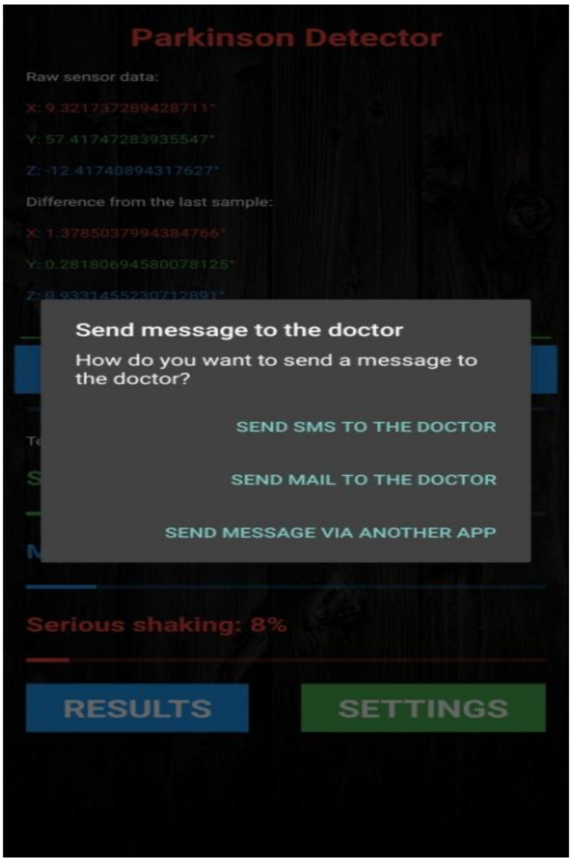


Figure 9. Sending a message to the doctor

If we click Send Mail To The Doctor, the Gmail application will open and automatically fill in the recipient, subject, and message with the results.

This code is responsible for sending the results data via mail application:

```
public void onClick(DialogInterface _dialog, int _which) {
Intent selectorIntent = new Intent(Intent.ACTION_SENDTO);
selectorIntent.setData(Uri.parse("mailto:"));
final Intent emailIntent = new Intent(Intent.ACTION_SEND);
emailIntent.putExtra(Intent.EXTRA_EMAIL, new String[]{(settings.getString("doctor_mail", ""))});
emailIntent.putExtra(Intent.EXTRA_SUBJECT, subject_to_send_to_doctor);
emailIntent.putExtra(Intent.EXTRA_TEXT, text_to_send_to_doctor);
emailIntent.setSelector( selectorIntent );
startActivity(emailIntent);
settings.edit().putString("sent mail", String.valueOf((long)(Double.parseDouble(settings.getString("sent mail", "")) + 1))).commit();
```

For this example, we put the contact information of dr Elvir Čajić in the settings and these are the result (Fig 10).

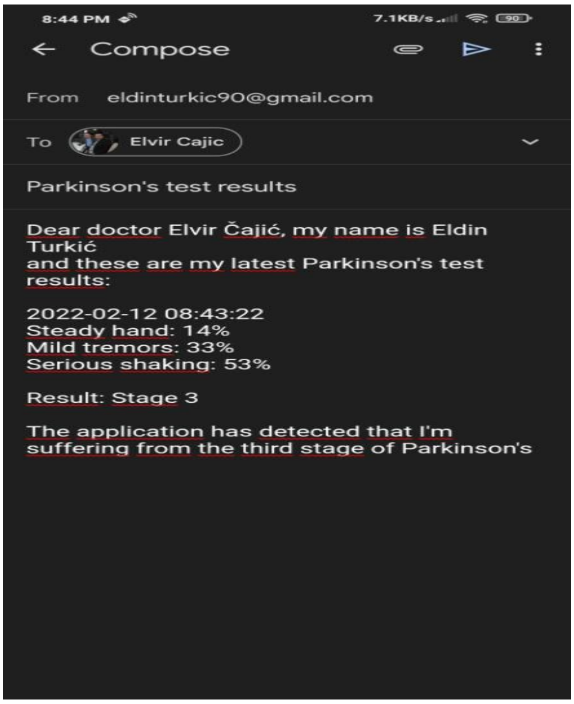


Figure 10. Automatically filled in mail

6.1. Settings Screen

The app has 2 adjustable deviation values. One for small tremors, and the other for more serious ones. They determine the sensitivity to tremors and which tremors detected during the test are categorized as small and which as severe

While testing on a Xiaomi POCO X3 NFC phone, we concluded that the most optimal values for Gyroscope measurements are 0.6°/sample for small tremors and 2°/sample for severe shaking. And for Accelerometer measurements 0.02m/s²/sample and 0.1m/s²/sample.

- Sampling rate is the sampling frequency (in milliseconds)

We used SensorManager.SENSOR_DELAY_FASTEST so it is possible to use very low values of as much as 16ms for Gyroscope and 18ms for Accelerometer without any problems.

Lower value = Higher precision.

- Test duration is the duration of the test in seconds
- The 4 switches are used to turn on / off sounds and vibrations during the test.

If the sounds are on, the phone will play a low-frequency beep tone for low tremors and a high-frequency beep tone for heavier shakes.

If vibration is on, the phone will vibrate slightly for 20ms when it detects smaller tremors, and 50ms when it detects heavier shakes.

These vibrations are strong enough to let the user know that his hand has shaken, but not strong enough to interfere with sensors that detect tremors.

- The 2 checkboxes are where we can choose whether the app will use Gyroscope or Accelerometer to measure vibration.
- It is also possible to change the background of the application by choosing one of the 4 offered, or choose one of the 3 offered colors as wallpaper (Pure Black, Dark Gray, or Blue-Gray)The bottom 3 fields are where we can enter the doctor's contact information.

This is used so that the user, after the test, can easily call or send the results to their doctor via message or email.

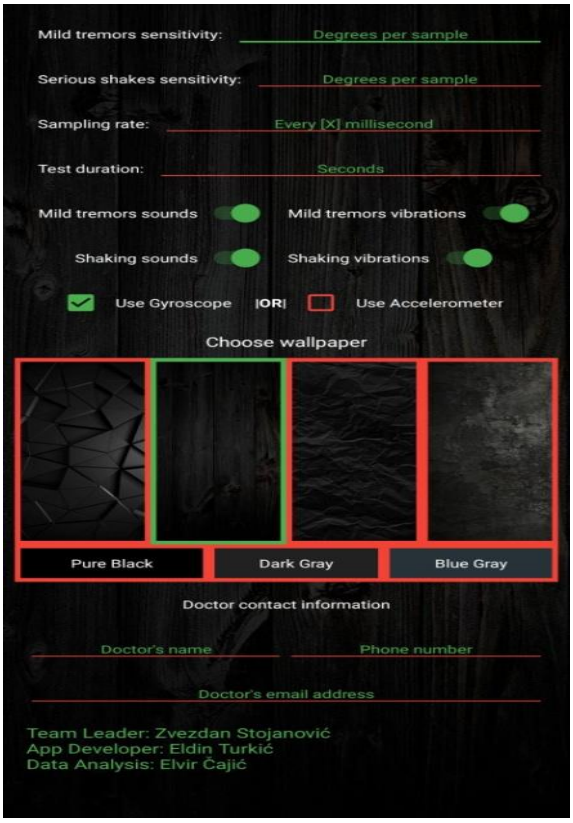


Figure 11. Settings Screen

6.2. Results Screen

The results of all tests performed on the device can be viewed by clicking on the Results button. The entire list can be deleted, edited, or forwarded. Clicking the Send button will open a list of installed applications that you can use to send all the results to someone.

Upon the test completion, the results are sent via the Internet to our database using the JSON API.

The results of all tests of all users can be seen on this webpage: https://parkinson.cf

This webpage is hosted on Apache web server on Raspberry Pi 3 Model B +.

The website is using an SSL certificate issued by Cloudflare Inc. and all connections to the webpage are encrypted using 128-bit Advanced Encryption Standard (AES).

All data obtained from the Parkinson's Detector app are password protected by the login page and the server is protected by Cloudflare's reverse proxy.

Figure 12. Results Screen

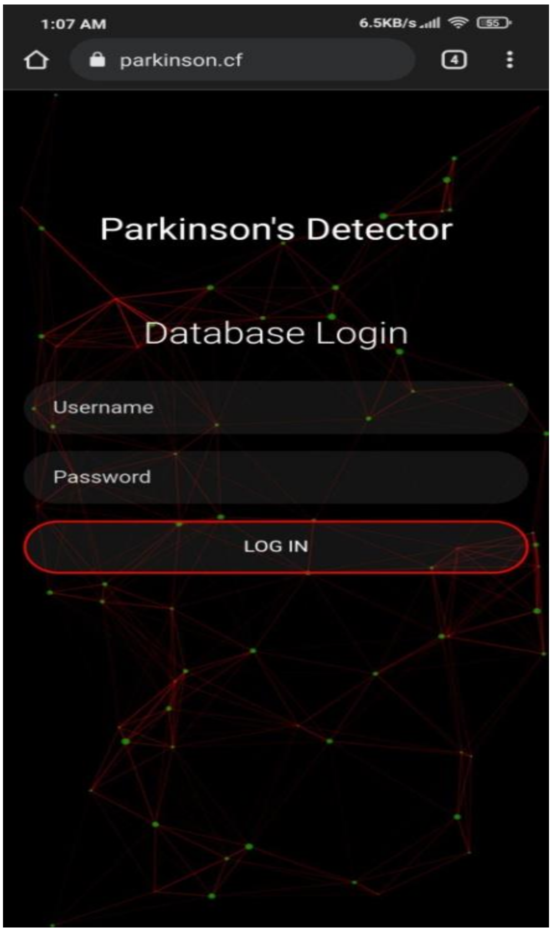
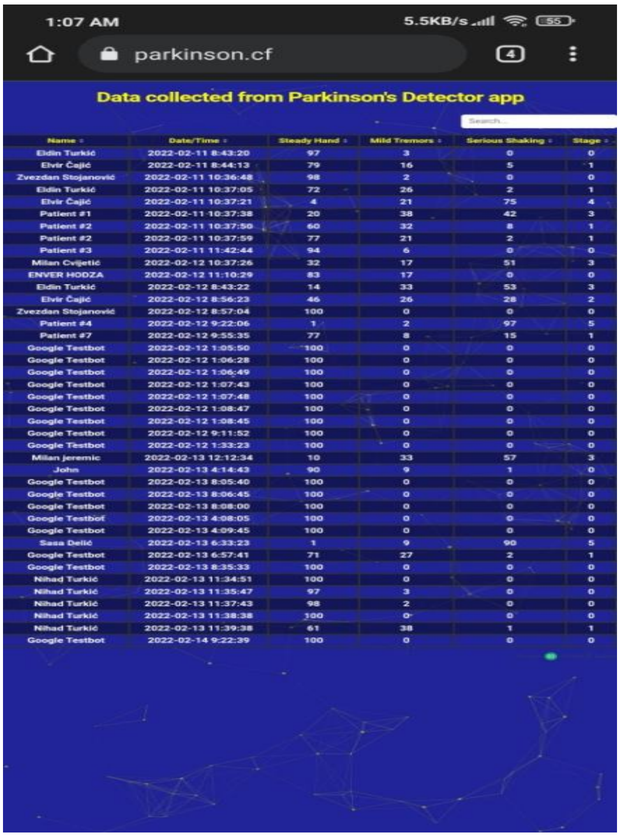


Figure 13. Parkinson's Database Login



Name	Date/Time	Steady Hand	Mild Tremors	Serious Shaking	Stage
Eldin Turkić	2022-02-11 8:43:20	97	3	0	0
Elvir Čajić	2022-02-11 8:44:13	79	16	5	1
Zvezdan Stojanović	2022-02-11 10:36:48	98	2	0	0
Eldin Turkić	2022-02-11 10:37:05	72	26	2	1
Elvir Čajić	2022-02-11 10:37:21	4	21	75	4
Patient #1	2022-02-11 10:37:38	20	38	42	3
Patient #2	2022-02-11 10:37:50	60	32	8	1
Patient #2	2022-02-11 10:37:59	77	21	2	1
Patient #3	2022-02-11 11:42:44	94	6	0	0
Milan Cvijetić	2022-02-12 10:37:26	32	17	51	3
ENVER HODZA	2022-02-12 11:10:29	83	17	0	0
Eldin Turkić	2022-02-12 8:43:22	14	33	53	3
Elvir Čajić	2022-02-12 8:56:23	46	26	28	2
Zvezdan Stojanović	2022-02-12 8:57:04	100	0	0	0
Patient #4	2022-02-12 9:22:06	1	2	97	5
Patient #7	2022-02-12 9:55:35	77	8	15	1
Google Testbot	2022-02-12 1:05:50	100	0	0	0
Google Testbot	2022-02-12 1:06:28	100	0	0	0
Google Testbot	2022-02-12 1:06:49	100	0	0	0
Google Testbot	2022-02-12 1:07:43	100	0	0	0
Google Testbot	2022-02-12 1:07:48	100	0	0	0
Google Testbot	2022-02-12 1:08:47	100	0	0	0
Google Testbot	2022-02-12 1:08:45	100	0	0	0
Google Testbot	2022-02-12 9:11:52	100	0	0	0
Google Testbot	2022-02-12 1:33:23	100	0	0	0
Milan jeremic	2022-02-13 12:12:34	10	33	57	3
John	2022-02-13 4:14:43	90	9	1	0
Google Testbot	2022-02-13 8:05:40	100	0	0	0
Google Testbot	2022-02-13 8:06:45	100	0	0	0
Google Testbot	2022-02-13 8:08:00	100	0	0	0
Google Testbot	2022-02-13 4:08:05	100	0	0	0
Google Testbot	2022-02-13 4:09:45	100	0	0	0
Sasa Delić	2022-02-13 6:33:23	1	9	90	5
Google Testbot	2022-02-13 6:57:41	71	27	2	1
Google Testbot	2022-02-13 8:35:33	100	0	0	0
Nihad Turkić	2022-02-13 11:34:51	100	0	0	0
Nihad Turkić	2022-02-13 11:35:47	97	3	0	0
Nihad Turkić	2022-02-13 11:37:43	98	2	0	0
Nihad Turkić	2022-02-13 11:38:38	100	0	0	0
Nihad Turkić	2022-02-13 11:39:38	61	38	1	1
Google Testbot	2022-02-14 9:22:39	100	0	0	0

Figure 14. Parkinson's Detector Database

Upon the test completion, the results are sent via the Internet to our database using the JSON API.

The results of all tests of all users can be seen on this webpage: https://parkinson.cf

This webpage is hosted on Apache web server on Raspberry Pi 3 Model B +.

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REFERENCES

1. Esmail S., "Diagnosis and Management of Parkinson's Disease", *Scholar Journal of Applied Science*, vo9, No1, 2018.
2. Davie CA, "A review of Parkinson's disease", *British Medical Bulletin*

2008;86:109–127,DOI:10.1093 /bmb/ ldn013.

3. Lang AE and Lozano AM (1998) *Parkinson's disease*. First of two parts. NEJM 339: 1044-1053.
4. Esmail S., "Diagnosis and Management of Parkinson's Disease", *Scholar Journal of Applied Science*, vo9, No1, 2018.
5. Davie CA, "A review of Parkinson's disease", *British Medical Bulletin* 2008;86:109–127,DOI:10.1093 /bmb/ ldn013.
6. Lang AE and Lozano AM (1998) *Parkinson's disease*. First of two parts. NEJM 339: 1044-1053.
7. Lang AE and Lozano AM (1998) *Parkinson's disease*. Second of two parts. NEJM 339: 1130-1143.
8. Godinho C, Domingos J, Cunha G, et al. A systematic review of the characteristics and validity of monitoring technologies to assess Parkinson's disease. *J NeuroengRehabil*. 016;13:24. doi:10.1186/ s12984-016-0136-7.
9. Gironell A, Sedano BA,Aracil I,, Lahoz JA,, Pagonabarraga J,Kulisevsky,J"Tremor yypes in Parkinsons disease: A descriptive Study Using a new classification", , Volume 2018, Article ID 4327597 *Hindawi Parkinson's Disease Journal* https://doi.org/10.1155/2018/4327597.
10. International Telecommunication Union (ITU) "Key ICT indicators for developed and developing countries, the world and special regions (totals and penetration rates)" (2021).
11. Majumder S and Deen MJ, "Smartphone Sensors for Health Monitorinand Diagnosis", *Sensors* 2019, 19, 2164; doi:10.3390/s19092164.
12. Pantelopoulos, A.; Bourbakis, N. A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis. IEEE Trans. Syst. Man Cybern. Part C Appl. Rev. 2010, 40, 1–12.
13. Takei, K.; Honda, W.; Harada, S.; Arie, T.; Akita, S.Toward flexible and wearable human-interactive health- monitoring devices. Adv. Healthc. Mater. 2015, 4, 487– 500.
14. 20 MaurerU., Smailagic, A., Siewiorek, D., &Deisher, M. 2006. Activity recognition and monitoring using multiple sensors on different body positions. In IEEE Proceedings on the International Workshop on Wearable and Implantable Sensor Networks, 3(5).
15. Stankevich E, Paramonov I, Timofeev I, "Mobile Phone
16. Sensors in Health Applications", Proceeding to 12th Conference of Frust Association, DOI: 10.23919/FRUCT.2012.8122097, 2012.
17. [13] Gawronska A, Pajor A, Zamyslowska-Szmytke E, Rosiak O,Jozefowicz-Korczynska M. Usefulness of Mobile Devices in the Diagnosis and Rehabilitation of Patients with Dizziness and Balance Disorders: A State of the Art Review. Clin Interv Aging. 2020;15:2397-2406
18. https://doi.org/10.2147/CIA.S289861
19. Breslauer DN, Maamari RN, Switz NA, Lam WA, Fletcher DA (2009) Mobile Phone Based Clinical Microscopy for Global Health Applications. PLoS ONE 4(7):e6320. doi:10.1371/journal.pone.0006320
20. Carrillo MA, Kroeger A, Sanchez RC, Monsalve SD and Runge-Ranzinger S., "The use of mobile phones for the prevention and control of arboviral diseases: a scopingreview", BMC Public Health (2021) 21:110 https://doi.org/ 10.1186/s12889-020-10126-4
21. Dai J, Bai X, Yang Z, Shen Z, Xuan D, "Mobile Phone-Based Fall

Detection", Personal and Ubiquitous Computing, 2010, DOI:10.1007/s00779-010-0292-x
22. Kwapisz JR, Weiss GM, Moore SA, Masoud M, "Activity Recognition using Cell Phone Accelerometers", ACM SIGKDD Explorations Newsletter · November 2010, ID 6514520 https://doi.org/ 10.1145/1964897.1964918
23. Lane ND., Miluzzo E, Lu H., Peebles D., Choudhury T and Campbell AT, "A survey of mobile phone sensing," IEEE Communications Magazine, vol. 48, no. 9, pp. 140–150, 2010.
24. Mohammad A. Habib, M. S. Mohktar, S.B. Kamaruzzaman,K. S.Lim, T. M. Pin, F. Ibrahim, "Smartphone-Based Solutions for Fall Detection and Prevention: Challenges and Open Issues" Sensors 2014, 14, 7181-7208; doi:10.3390/s140407181
25. Chen Y and Shen C., "Performance analysis of smartphone-ensor behavior for human activity recognition," IEEE Access, vol. 5, pp. 3095–3110, 2017.
26. Reyes JL, Ortiz, L. Oneto, A. Samà, X. Parra, andD. Anguita, "Transition-aware human activity recognition using smartphones," Neurocomputing, vol. 171, pp. 754–767, 2016.
27. Vavoulas G, Pediaditis M, Chatzaki C, E. G. Spanakis, and M. Tsiknakis, "The MobiFall dataset: fall detection and classification with a smartphone," in Communications of the ACM, pp. 1218–1231, ACM, 2017.
28. Brezmes, T., Gorricho, J.L., and Cotrina, J. 2009. Activity Recognition from accelerometer data on mobile phones. In IWANN '09: Proceedings of the 10th International WorkConference on Artificial Neural Networks, 796-799.
29. Masoud M, Jaradat Y, Manasrah A, Jannoud I, "Sensors of Smart Devices in the Internet of Everything (IoE) Era: Big Opportunities and Massive Doubts", Hindawi Journal of Sensors, Volume 2019 Article https://doi. org/10.1155/2019/6514520
30. Chen KH, Tseng WC, Liu KC, and Chan CT, "Using gyroscopes and accelerometers as a practical rehabilitation monitor system after total knee arthroplasty," in 2015 IEEEMTT-S 2015 International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-BIO), pp. 58-59, Taiwan, September 2015.
31. Cho, Y., Nam, Y., Choi, Y-J., and Cho, W-D. 2008. SmartBuckle: Human activity recognition using a 3-axis accelerometer and a wearable camera. In HealthNet.
32. Krishnan, N., Colbry, D., Juillard, C., and Panchanathan, S. 2008. Real-time human activity recognition using tri-Axial accelerometers. In Sensors, Signals and Information ProcessingWorkshop.
33. Yang, J. 2009. Toward physical activity diary: Motion recognition using simple acceleration features with mobile phones, In First International Workshop on Interactive Multimedia for Consumer Electronics at ACM Multimedia.