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Parkinson*Check* Smart Phone App

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Abstract. The paper introduces the Parkinson*Check* application. It is an app for smart phones based on spirography (spiral drawing) intended to detect signs of Parkinson's disease (PD) and essential tremor (ET), which is the main differential diagnosis from PD in the early stage of the disease. The app is equipped with an expert system and is the first such app to be completely automated. Its intended use is twofold: (a) to act as a standalone test for general population, advising potential patients to seek medical help as early as possible, and (b) to be used by neurologists as a portable and inexpensive fully digitalised clinical decision support system. Parkinson*Check* is currently freely available in Slovenia on four mobile platforms as a pilot study. After potentially upgrading its expert system with new learning data, the plan is for it to be translated into English and offered worldwide.

1 Introduction and motivation

Parkinson's disease (PD) is a chronic, progressive neurological disease. It is the second most common neurodegenerative disorder after Alzheimer's disease. PD is estimated to affect between four and six million individuals over the age of 50 worldwide, and that number is expected to double by the year 2030 [1]. The costs associated with 1.2 million PD patients in European Union were estimated at 13,934 million EUR in the year 2010.

Essential tremor (ET) is the most prevalent movement disorder. Although distinct clinical entities, ET is very often misdiagnosed as Parkinsonian tremor (PT) [6]. Results from clinical studies show that ET is correctly diagnosed in 50-63% of all cases, whereas PT in 76% of the cases. Co-existence of both disorders is also possible.

Digitalised spirography [5] is a relatively new computer-assisted method for detection and evaluation of tremors. The task of the patient is to draw an Archimedean spiral on the tablet, and different quantitative parameters are provided by the computer. A few typical spiral drawings are shown in Figure1.

The main goal of Parkinson*Check* application is to reliably detect signs of PD or ET in the user's spirals and to suggest an appointment with the neurologist at the onset of the disease. The main motivation are indications that early diagnosis is beneficial in terms of treatment [4]. The secondary goal is to differentiate between PD and ET, and be able to serve neurologists as a portable and inexpensive fully digitalised clinical decision support system.

The rest of the paper is organised as follows. First the added value of artificial intelligence is discussed in the next section. Then follows a presentation of the application, including a brief description of the app's AI. The complete details of the application's core expert system are too extensive to cover here and will appear in a separate journal paper. We conclude with the discussion of some interesting aspects of the application.

2 Benefits of built-in artificial intelligence

The main idea behind the Parkinson*Check* application is to take spirography from the physician's office and put it on smart phones to become widely available. As the main goal of the application is to act as an early warning system for potential patients, a broader spectrum of people would be encouraged to use it. In turn, this would make it impossible to simply send the data (drawn spirals) to a neurologist to visually assess. The sheer number of tests prevents such a set-up. Therefore, to make it truly useful, the application needs also to emulate the physician, not just the hardware. This is the task of the built-in expert system described in the next section. We believe this is a way to improve healthcare and reduce costs at the same time.

As discussed in the introduction, the differential diagnosis between PD and ET is not an easy task for neurologists. With the built-in expert system the application can serve as a clinical decision support system to offer an additional diagnostic test to clinicians giving an instant second opinion.

An additional important issue is the privacy of users' data. There are existing systems for spirographic testing on mobile phones, however, all these systems send the data to a clinical repository where it is analysed by the physician. Having a built-in expert system sets aside the need to transmit the sensitive data as the spiral assessment is performed directly on their smart phones. This often neglected aspect is very important to some users prompting some not to use the application if it involves sending their private data to a remote server.

3 The Parkinson*Check* application

Parkinson*Check* (see Figure 2) is made available for the following mobile platforms: Android, iOS, BlackBerry, and Windows Phone. Moreover, we developed a HTML 5 web service[8], which allows users of any mobile platform to use our application in a web browser. At the moment the application is available in the Slovenian language and is being translated into an English version after the pilot appraisal. The application is freely available in the corresponding app stores,

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[8] Available at http://www.parkinsoncheck.net/pc

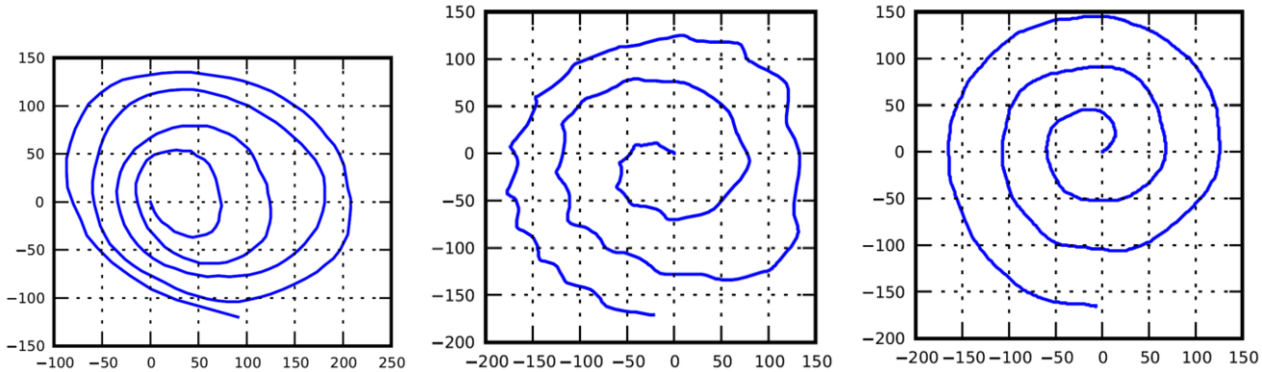

Figure 1. Typical spirals for PT-affected (left), ET-affected (middle), and a healthy person (right).

and we have an agreement with a supporting company to keep it updated until at least the end of 2018.

Figure 2. Screen shots of the Parkinson*Check* application.

The application is currently being evaluated at the Department of Neurology, University Clinical Centre Ljubljana, Slovenia. After the appraisal, we intend to update the expert system to further improve its accuracy.

The application's expert system uses a logistic regression model. Other models were explored, namely a naive Bayes classifier, support vector machines, and random forests (the latter two in the case some nonlinear patterns were present in the data). However, logistic regression performed slightly better than the other algorithms (measured in terms of classification accuracy, AUC, and Brier score). Entropy-based discretisation [3] was used as it proved useful (albeit somewhat surprising in combination with logistic regression). The logistic regression is from a ported version of the *liblinear* library for large linear classifications [2] and was used with the default parameters.

The model makes use of over 80 constructed attributes for describing the spirals. The most important groups of attributes measure the disparity between the drawn spiral and the spiral template, the asymmetry in the spiral and between drawing with the left and the right hand, power spectrum density analysis, number, shape, and distribution of local extrema of the spiral, smoothness of the spiral, and changes in radial speed/direction.

The initial evaluation of the expert system is as follows. The classification accuracy for detecting signs of PD or ET is 90.2%, the AUC is 95.1%, and Brier score is 0.153 (ten-fold cross-validation repeated ten times with results averaged).

4 Discussion

When designing the Parkinson*Check* application we were faced with some practical research questions. The first and foremost question was whether the spiral data contains enough information to be of use on its own. It is worth noting that the neurologists mostly use spirography as a confirmation test for a tentative diagnosis based on other patient's data. This can often lead to a confirmation bias and therefore this question was far from answered beforehand. Relating to this main question were two further questions: (a) Are smart phone screens big enough?, and (b) Is there enough information in the spirals drawn without the stylus? The results so far indicate that the answer to all three questions is positive.

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REFERENCES

[1] World Health Organization, The global burden of disease, 2008.
[2] Rong-En Fan, Kai-Wei Chang, Cho-Jui Hsieh, Xiang-Rui Wang, and Chih-Jen Lin, 'Liblinear: A library for large linear classification', *Journal of Machine Learning Research*, **9**, 1871–1874, (2008).
[3] Usama M. Fayyad and Keki B. Irani, 'Multi-interval discretization of continuous-valued attributes for classification learning', in *Proceedings of the 13th International Joint Conference on Artificial Intelligence*, pp. 1022–1029, (1993).
[4] DL Murman, 'Early treatment of parkinson's disease: opportunities for managed care', *Am J Manag Care*, **18**(7), 183–8, (2012).
[5] Seth L. Pullman, 'Spiral analysis: A new technique for measuring tremor with a digitizing tablet', *Movement Disorders*, **13**(S3), 85–89, (1998).
[6] Bhomraj Thanvi, Nelson Lo, and Tom Robinson, 'Essential tremor – the most common movement disorder in older people', *Age and Ageing*, **35**(4), 344–349, (2006).