ANALYSIS OF INDIVIDUAL HEALTH CHANGES BY GAIT USING A SMARTPHONE

N.V. Dorofeev, R.V. Sharapov, M.S. Goryachev

Vladimir state university, Murom, Russian Federation
E-mail: dorofeevnv@yandex.ru

The work reveals the features of measuring human gait parameters using a smartphone in free mode. The results of statistical processing of accumulated data are presented: daily, weekly annual trends, results of classification of data on human diseases. The probability of correct classification is more than 0.7. It is for basic model - logarithmic regression, for such health conditions as: headache, neck pain, leg swelling, lower back pain, regulation and other pain. Based on the results of the analysis, assumptions are made about the reflection in the accelerometer data (gait parameters) of individual characteristics of the functioning of the musculoskeletal system under the influence of external and internal factors.

Keywords: health; gait; mobile phone; smartphone.

АНАЛИЗ ИНДИВИДУАЛЬНЫХ ИЗМЕНЕНИЙ В СОСТОЯНИИ ЗДОРОВЬЯ ПО ПОХОДКЕ С ПОМОЩЬЮ СМАРТФОНА

Н.В. Дорофеев, Р.В. Шарапов, М.С. Горячев

Владимирский государственный университет имени Александра Григорьевича и Николая Григорьевича Столетовых, Муром,
Российская Федерация
E-mail: dorofeevnv@yandex.ru

В работе раскрываются особенности измерений параметров походки человека с применением смартфона в свободном режиме. Приводятся результаты статистической обработки накопленных данных: суточные, недельные годовые тренды, результаты классификации данных по заболеваниям человека. Вероятность верной классификации с помощью базовой модели – логарифмической регрессии, для таких состояний здоровья как: головная боль, боль в шее, отек ног, боль в пояснице, регулы и другие боли, составляет более 0.7. По результатам анализа выдвигаются предположения об отражении в данных акселерометра (параметрах походки) индивидуальных особенностей функционирования опорно-двигательного аппарата под действием внешних и внутренних факторов.

Ключевые слова: здоровье, походка, мобильный телефон, смартфон.

INTRODUCTION

Modern information technologies, data transmission systems and microelectronics make it possible to collect and analyze human biometric data in real time in the background, which is relevant in the field of personalized preventive and regenerative medicine, data protection and access control, management systems, etc. One of the developing areas is the analysis of gait parameters using wearable and mobile devices, in particular a smartphone [1, 2]. Research on the use of smartphones to analyze gait parameters has been conducted for more than 10 years, however, they are limited to controlled laboratory conditions or the assessment of explicit relationships between gait parameters and diseases (for example, Parkinson's disease or multiple sclerosis).

The goal of this work is the development of information technologies in the field of personalized preventive medicine by identifying the relationships between human health, external and internal factors with gait parameters and developing algorithmic support for an information and analytical health diagnostic system based on wearable devices.

DATA COLLECTION AND PROCESSING

Measuring gait parameters using a mobile phone it difficult to obtain high-quality data and imposes certain restrictions on the use of a smartphone as a measuring part in everyday conditions makes [3-5]. To reduce the impact of these shortcomings on the results of the analysis, we use a data pre-processing algorithm based on correlation analysis and neural network classification of movements when forming a digital biometric profile of a person based on smartphone accelerometer data on gait parameters [5].

Long-term data collection was carried out using the proprietary AcsaActive software, available for download on the RuStore, Google Play, App Store platforms (the application is currently available in testing mode for smartphones based on iOS). Using a smartphone, volunteers recorded gait parameters while moving in a straight line over a distance of 10-15 meters (which is sufficient according to work [6]), up to three times a day, and filled out electronic questionnaires about their well-being and lifestyle.

In the resulting measurements, the segments that were most correlated with each other were selected (sections of time series from the accelerometer of a mobile phone, corresponding to a double step). The parameters of the selected segments were analyzed among themselves and it compared with the volunteer’s personal data. Changes within days, weeks, and months were analyzed. Logistic regression and an ensemble of logistic regressions were used as basic models for classifying segments according to the types of diseases reflected in the questionnaire.

RESEARCH RESULTS

As a result of analyzing data on changes in the value of the cross-correlation function of segments, two types of daily trends were identified: downward and changing, when the downward trend is replaced by an upward trend. Statistics on the manifestation of trends by day of the week are individual for each person (see Table).

An example of the distribution of types of daily trends by day of the week, in %

Trend type	Monday	Tuesday	Wednesday	Thursday	Friday
Cascading	56	61	42	58	67
Changing	44	39	58	42	33

In Fig. 1 shows the trend of changes in distance in multidimensional space between the surfaces of hyperspheres that describe points within one dimension (each point corresponds to accelerometer data for one double step), and Fig. 2 graph of changes in the measurement correlation value during the day.

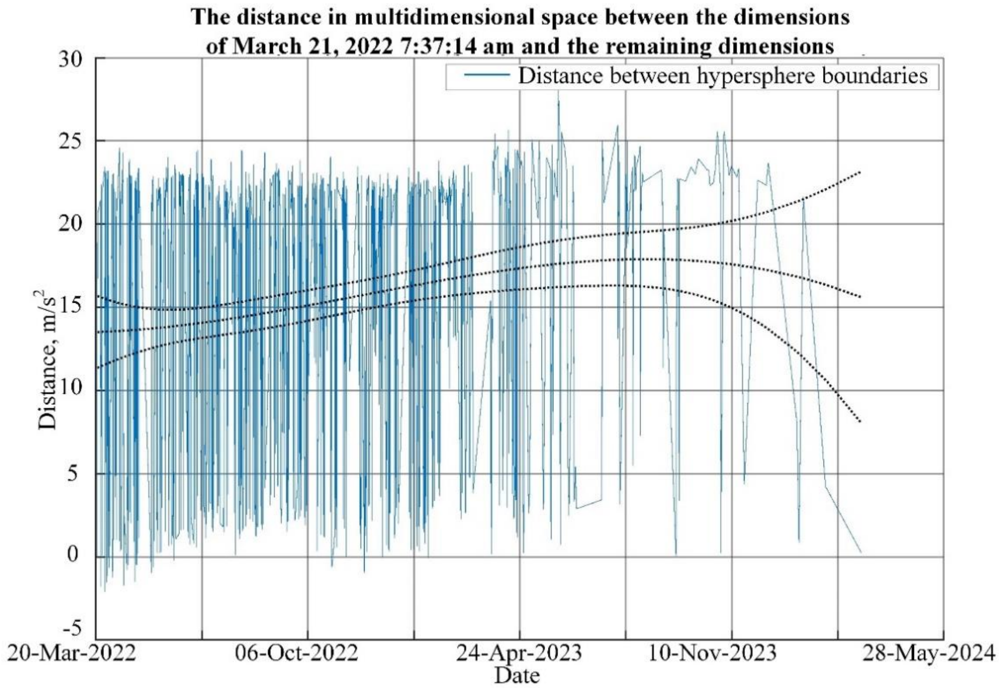

Fig. 1. Trend of changes in the distance between dimensions in multidimensional space

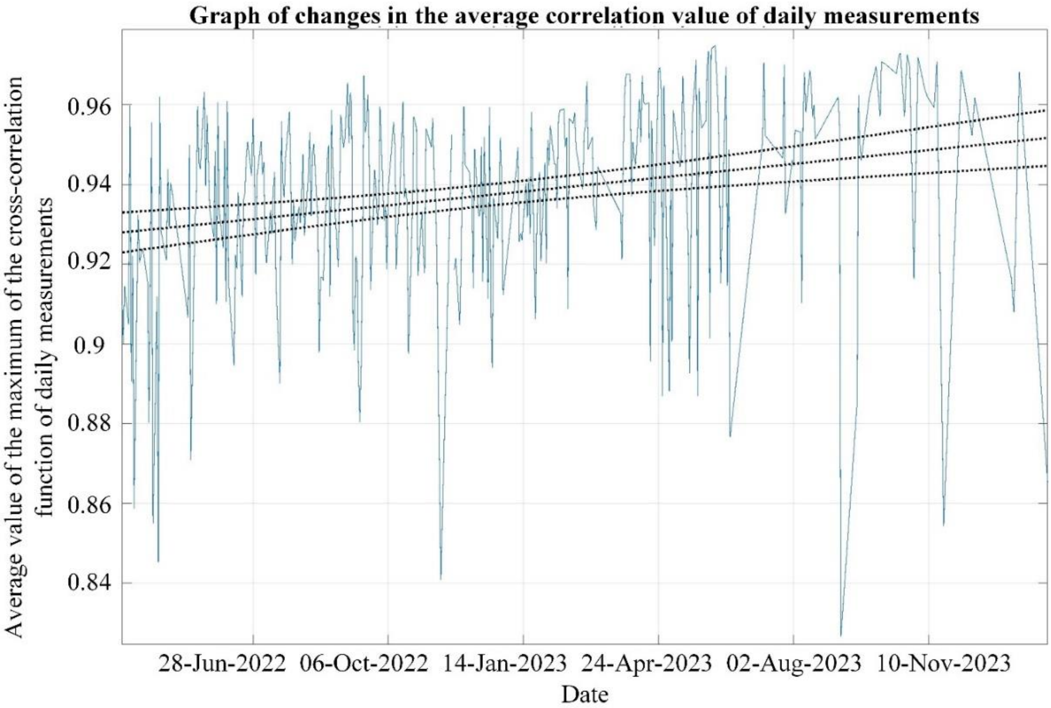

Fig. 2. Trend of change in the average correlation value of daily measurements

The use of logistic regression makes it possible to classify data segments into diseases with a probability (F-mera value) of more than 0.7. Among the diseases analyzed: headache, neck pain, swelling of the legs, lower back pain, regula and other pains.

DISCUSSION AND CONCLUSIONS

Analysis of data on a person's gait (it collected using a smartphone accelerometer in free mode over a long period) showed individual characteristics of changes in the functioning of the musculoskeletal system and the influence of external and internal factors on it. It is assumed that the features of changes in daily, weekly and monthly trends correlate with lifestyle and individual physiological characteristics. The influence of climatic factors (atmospheric pressure and ambient temperature) on a person's gait is not manifested in all volunteers, while the correlation is not higher than 0.4 when analyzing changes in the degree of similarity of segments. The high probability of classifying segments by type of disease confirms the possibility of distinguishing between events. To confirm the assumptions, further accumulation of statistical data is planned both within one volunteer and by the number of volunteers.

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