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Using an electromagnetic graphics tablet to analyse manually-created graphics

Streszczenie. *W artykule przedstawiona została analiza odręcznie tworzonych rysunków pozyskanych za pomocą graficznego tabletu elektromagnetycznego, którego właściwości dają potencjalną możliwość ilościowej oceny dynamiki i kinematyki czynności manualnych człowieka. Na podstawie zarejestrowanych danych podjęto próbę wykazania różnic w rysowaniu prawą i lewą ręką przez osoby praworęczne. (**Zastosowanie graficznego tabletu elektromagnetycznego do analizy odręcznie tworzonej grafiki**).*

Abstract*. The article presents an analysis of handwritten drawings obtained with a electromagnetic graphic tablet, the properties of which give the potential for a quantitative description of human manual activities with respect to kinematics and dynamics. On the basis of the recorded data, an attempt was made to demonstrate the differences in drawing with the right and left hand by right-handed people.*

Słowa kluczowe: tablet elektromagnetyczny, analiza grafiki odręcznej, przebiegi czasowe
Keywords: electromagnetic graphic tablet, handwritten graphics, time series

Introduction

The manner of creating a drawing is very individual and depends on numerous factors, such as, e.g. artistic abilities, right- or left-handedness, motor and spatial orientation, pen holding manner, age or simply the feeling of aesthetics in the creator of the drawing. As a result, an image or handwriting manually created by a man contain information on his/her individual traits. At the same time, the information hidden in graphics can be used to diagnose nervous system diseases, and already at an early development stage. When writing or drawing, we experience natural changes, the quantitative analysis of which can indicate the presence and progression of symptoms pointing to various diseases. An example are neurodegenerative diseases, one of the symptoms of which used in diagnostics is the tendency to reduce the font size when writing, so-called micrographia [1]. Furthermore, other symptoms may become apparent when drawing, such as motor slowness, limb tremors or muscle stiffness. As a consequence, the parametrization of the very process of drawing requested geometric structures can be used to evaluate cognitive functions and psychomotor abilities (Archimedean spiral, clock drawing test, etc.) [2].

Graphics tablet

There are currently devices available on the market, which enable recording data imaging the manner of manual drawing. These are technologically advanced graphics tablets, which operate in the electromagnetic induction technology. They enable recording a series of data when drawing on their surface, such as, the pen position, pressure force or the angle of pen inclination relative to the sheet surface. The properties of such tablets provide a potential to quantitatively describe the activities conducted on its surface and the changes therein. Besides the analysis of a created image, they also allow to evaluate the dynamics and kinetics of its creation. Studying the time waveforms created in the course of drawing increase the interpretative properties of a drawing [3]. An Intuos Pro Paper Edition PTH-860 graphics tablet by WACOM, which enables recording data with a sampling frequency of 200 Hz was used in the research. The data recorder in the course of drawing using this device enable imaging changes in the parameters, such as pressure force or the stylus position over time. They enable indicating difference in drawing a circle with the right and left hands.

Fig.1. Intuos Pro Paper Edition graphics tablet by WACOM

Material

40 persons participated in the study. This group include both men and women of different age, and their common trait was right-handedness. They were asked to outline two contours (one with the right hand and the other one with the left) on a piece of paper placed on the tablet. The circle templates had a diameter of 7 cm. The tablet was connected to a computer, which was used for data acquisition owing to the original software developed in the MATLAB environment [4].

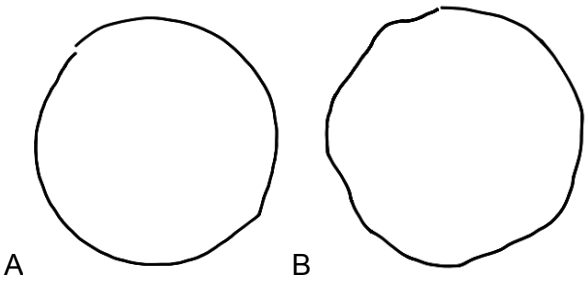

Fig. 2. Examples of recorded circles a) right hand, b) left hand

Position and rate analysis

The parameters recorded during the study included, among others, information on stylus position relative to the tablet surface. This can be primarily used to recreate on a computer screen the image drawn by a patient on the piece of paper (Fig. 2). However, the presented images

themselves do not provide information on their creation dynamics. Instead, such information can be acquired by determining the changes of the stylus position over time. Fig. 3 shows time waveforms obtained when drawing circles shown in Fig. 2. It shows the circle drawing time (shorter for the right hand), but also the characteristic shape. Time waveforms representing the stylus position over time in the course of creating an ideal circle should be in form of a single harmonic function period displaced relative to each s, e

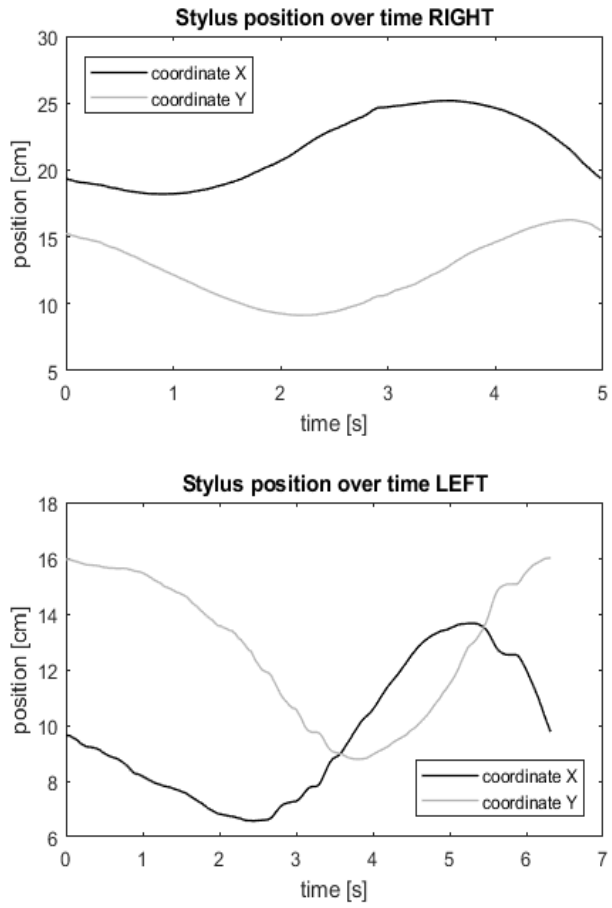

Fig. 3 Time waveform of the stylus position when drawing circles shown in Fig. 2.

Using available processed data, such as the position change over time, it is also possible to determine the mean drawing rate for a given person. And so, in the case of right-handed people, one can expect that a right-hand drawing will be completed faster than with the left hand. The rates obtained for the aforementioned data are listed in Table 1:

Table 1. Mean drawing rate

	mean drawing rate [cm/s]
right hand	4.43
left hand	3.52

Pressure analysis

The next parameter possible to record with a graphics tablet is the pressure applied by the drawing person onto a stylus when sketching. As with the position, also in this case the time waveform representing pressure over time can be plotted and analysed.

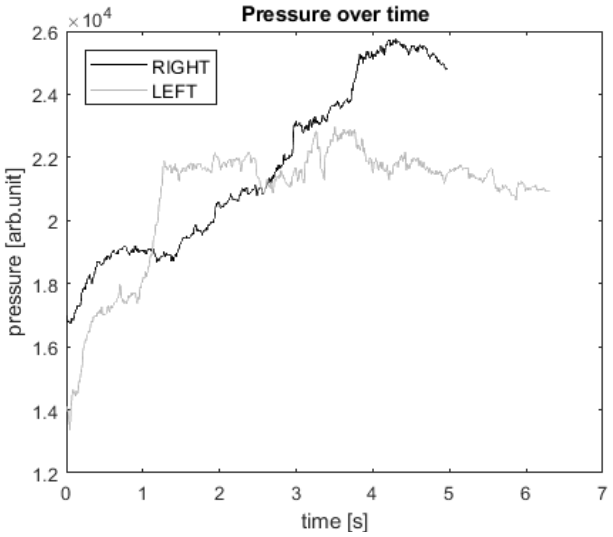

Fig. 4. Time waveforms of pressure when drawing circles shown in Fig. 2.

Analysing the waveform of the pressure generated when drawing circles, shown on the graph in Fig. 4, one can observe the characteristic increase in the pressure when using the dominating hand, that is, the right one in this case. Linear approximation using the least squares method was conducted and the approximating straight line directional coefficient was indicated as the numerical parameter in order to quantitatively determine the trend of these change, whether greater or lesser pressure is applied when drawing.

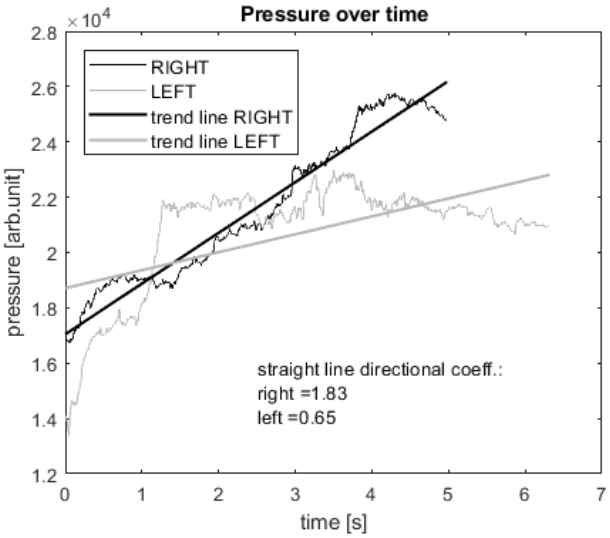

Fig. 5. Waveforms of pressure over time when drawing circles shown in Fig. 2. with determined trend lines

Fig. 5 shows plotted straight lines and calculated values of the directional coefficients. It can be seen that in the case of a studied person, the force applied onto the tablet was greater when drawing with the right hand, compared to drawing with the left one. In terms of pressure, it is also important to estimate the intensity of its changes, because the movements of right-handed people are smoother when they use their right hand. The first pressure derivative was determined and standard deviations of hence-generated waveforms were calculated for this purpose – Fig. 6. Table 2 shows the obtained values.

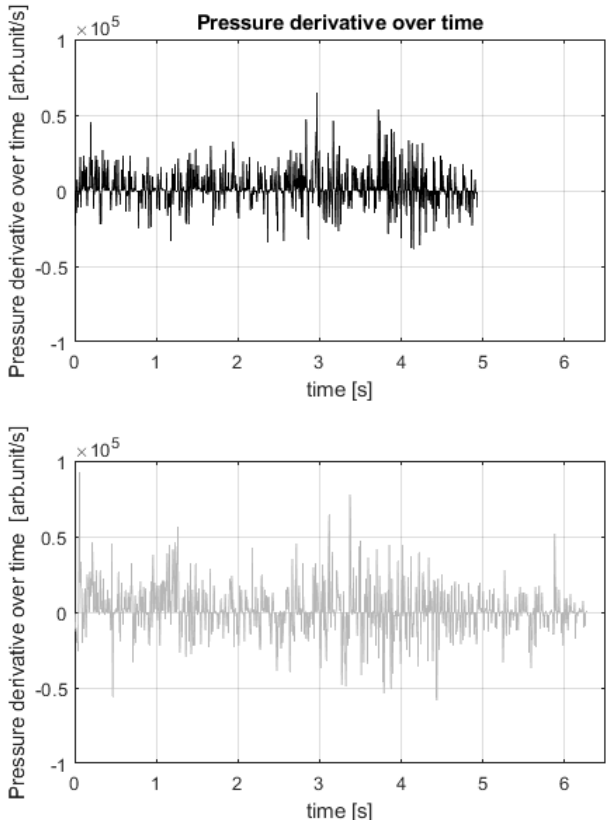

Fig. 6. Time waveform of pressure derivative when drawing circles shown in Fig. 2

Table 2. Pressure derivative standard deviation

	Standard deviation [arb.unit/s]
right hand	10856
left hand	14109

Analysis of image deformation relative to the original contour

Right-handed people draw more smoothly when using their right-hand, and when following a ready contour or a certain representation, achieve effects more resembling the original than using their left hand. This can be observed already when looking at a finished drawing (Fig. 2). Left-handed works will be more jagged, crooked, as well as intersecting and extending beyond outlined lines in many places, which is shown in Fig. 7.

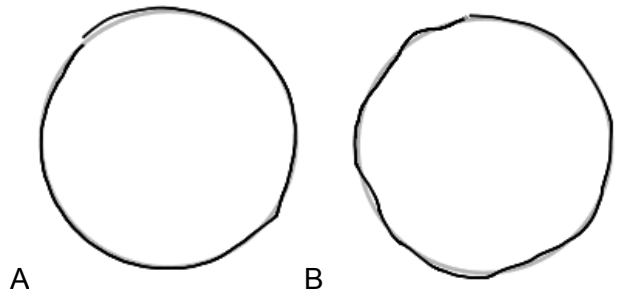

Fig. 7. Drawn circles (black) plotted on the original contour (grey)

The study attempted to find good indicators for such deformation. One of them can be the circle length. Given the fact that the radius of the original contour was 3.5 cm, which gives a circle length of approx. 22 cm, each deviation from this value can be treated as a quantitative measure indicating prevailing differences – Table 3.

Table 3. Lengths of drawn circles

	circle length [cm]
right hand	22.07
left hand	22.22

Other measures can be determined based on the waveform of distance to circle centre for all recorded points. The representation of these distances over time shows the way how the radius of the drawn circle changed. The greater these changes the higher the circle deformation relative to the original, which was outlined.

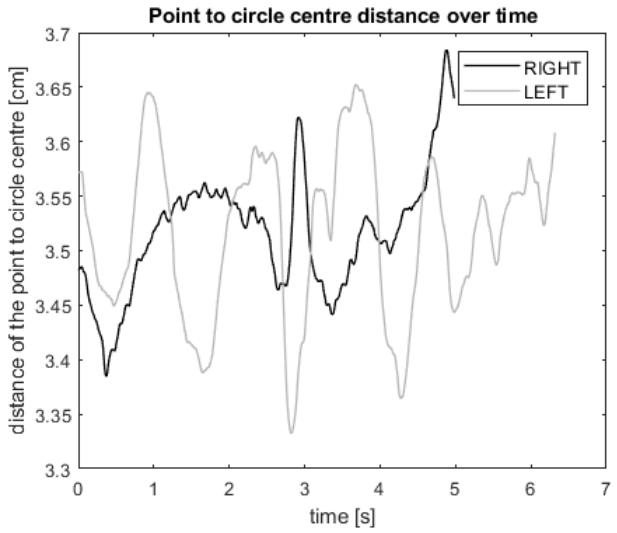

Fig. 8. Circle radii changes over time

The obtained data were used to calculate a mean value, which should be equal to the length of the contoured circle radius, i.e. 3.5 cm. Another calculated value was the standard deviation, which shows the spread around the mean value. Standard deviation, as a classic measure of variability, can be applied as a quantitative parameter of circle deformation. Calculation results are shown in Table 4.

Table 4. Mean value and standard deviation for circle radii

	Mean value [cm]	Std. deviation [cm]
right hand	3.5164	0.0557
left hand	3.5166	0.0757

However, due to the fact that radius standard deviation indicates only the radii value spread relative to the mean value, and does not characterize the manner of their changes, it was decided to also try another method of quantitative deformation determination. It involved determining a radius time waveform derivative and using it as a base to calculate the standard deviations (Fig. 9). Calculation results are shown in Table 5.

Table 5. Standard deviation for a point to circle centre distance derivative

	Standard deviation [cm/s]
right hand	0.3694
left hand	0.5572

The results obtained with both methods prove the conclusion based on the sole observation of the drawings, namely, that a circle drawn with the left hand is more deformed relative to the original than the one drawn with the right hand.

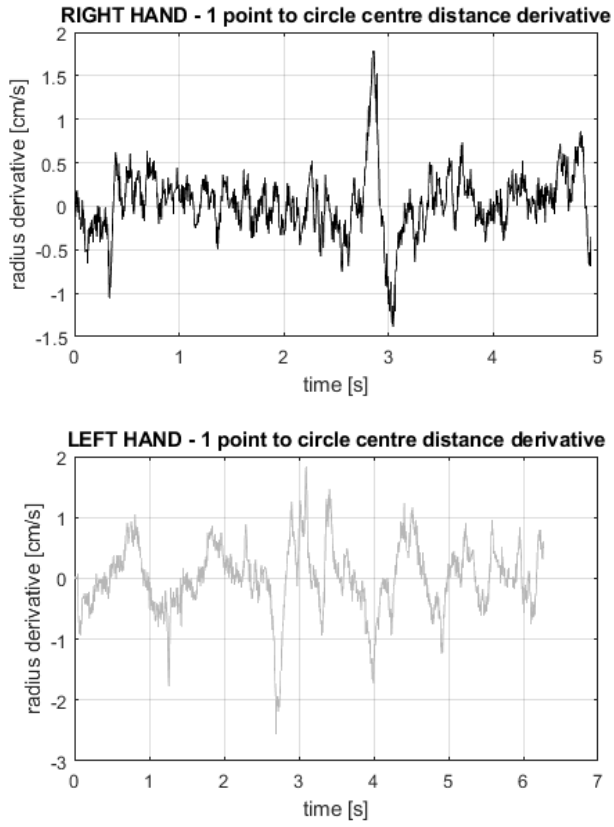

Fig. 9. Time waveform of radii derivative over time when drawing circles shown in Fig. 2

Conclusions

40 persons participated in the study. Based on the conducted analysis of hand-drawn circles, the following differences in the drawings created with the right and left hand by right-handed people can be indicated:

- in the case of 62.5% studied persons, tracing a contour with the left hand took longer than with the right hand;
- 65% of the studied persons drew faster with the right hand than with the left one;
- in the case of 75% people, the length of the circle drawn with the left hand was higher than of the one drawn with the right hand;
- 80% of the people applied more average pressure when performing the task with the right hand;
- in the case of 85% of the people, the standard deviation of the pressure derivative was higher for the left hand, compared to the right hand;
- both methods for the determination of the drawing deformation degree relative to the original sketch indicated that right-handed people completed the sketch with their left hand with greater fluctuations relative to the original contour. In the case of 90% of the people, this is confirmed both by the first, as well as the second method.

The study was carried out within a project aimed at obtaining additional biomarkers for the purposes of diagnosing neurodegenerative diseases. The tablet described in the article is one of the elements of a test stand for recording multimodal data [5].

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LITERATURA

[1] Pąchalska M., et. al. Kliniczny Test Funkcji Wykonawczych – zrewidowany w diagnostyce różnicowej depresji, zespołu lekkich zaburzeń poznawczych oraz otępienia typu Alzheimera *[Clinical Test of Cognitive Functions - revised in the differential diagnostics of depression, mild cognitive impairment syndrome and Alzheimer-type dementia]*, Psychogeriatria Polska 2004;1 (2), ss. 119-144.

[2] Jadczak K., Jakubowski J., Tomczykiewicz K., Koncepcja obiektywizacji testu zegara na potrzeby diagnostyki chorób neurodegeneracyjnych *[The objectification concept of the clock drawing test for the purposes of diagnosing neurodegenerative diseases]*, PRZEGLĄD ELEKTROTECHNICZNY, ISSN 0033-2097, nr 11/2019, ss 144-149

[3] Technical specification of a WACOM Intous Pro PTH-860 tablet

[4] Białek K., et. al., Wybrane zagadnienia wstępnego przetwarzania danych obrazowych w badaniu osób z chorobą Parkinsona [*Selected issues regarding preliminary processing of image data in people with Parkinson's disease]*, 10th Scientific Conference - Radioelectronic Equipment and Systems UiSR 2019, Jachranka, 20–21.11.2019, conference materials

[5] Chmielińska J., et. al.: Stanowisko do rejestracji multimodalnych danych na potrzeby obiektywnej oceny choroby Parkinsona *[Test stand for recording multimodal data for the purposes of objective evaluation of Parkinson's disease]*, 10th Scientific Conference - Radioelectronic Equipment and Systems UiSR 2019, Jachranka, 20–21.11.2019, conference materials