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PHYSIOLOGICAL UPPER LIMB'S TREMOR RESEARCH USING COMPUTER TABLET

Tomasz Lech

Institute of Mathematics and Computer Science, Czestochowa University of Technology

Abstract. The paper presents the research results of the computer tablet application in the diagnostics of physiological tremor of hands. The said research is a continuation of a wider research process aiming at the creation of a compact diagnostic system of nervous system diseases appearing in, inter alia, hand's tremor. The application of properly programmed computer tablet makes it possible to carry out the examination of the upper limb's tremor in a fast, easy and cheap way, assisting the neurologists in the diagnostic process, therefore the use of a very expensive medical equipment (EMG, accelerometer) can be minimized. Needless to say, the compact diagnostic system of hands' tremor and co-related tremors of the nervous system pathology must correctly diagnose the physiological tremor. In order to do it a comparative examination has been performed in healthy patients whose physiologic tremor has been intensified by adequate methods. The application of the Fourier transform and time/frequency relation enabled the analysis of signals and performance of the comparative analysis involving the data gathered in patients with clinically confirmed Parkinson's disease.

1. Introduction

In the contemporary world the digital science is accompanying all walks of life. It appears to be very helpful in medicine as well in which the application of computer has made all the diagnostic and paper processes easier and faster. The following paper presents the results of continuation of examination of hands' tremor, and in particular the comparative examination in healthy patients with hyperintensive physiological tremor. The whole research process is aiming at the creation of a compact system which is to support the diseases' diagnostics having symptoms in, inter alia, the tremor of hands.

2. The subject of research

The subject of research presented in this paper is the physiological tremor of hands. The research of physiological tremor is a logic and indispensable part of a research process aiming at the application of computer tablets in the diagnostic process of illnesses having symptoms in, inter alia, the tremor of hands. We can distinguish two kinds of physiological tremor - the first one as a result of a regular

or specific functioning of a healthy body, and the second one - pathological tremor caused by pathologic changes. Physiological tremor (not hyper-intensive) is a natural symptom of the work of muscles directed by nervous impulses and usually - owing to a little amplitude and high frequency (within the range of frequencies typical for tremor of hands) - is hardly visible to the naked eye. Physiological tremors can also be classified as intensified tremors resulting from the irregular work of the body - e.g. muscles' overloaded by intensive work, nervous system breakdowns (alcohol intoxication, nicotine poisoning), higher adrenaline level in blood resulting from, e.g. extrasomatic stressful situation, etc. Hyper-intensive physiological tremor can also be characterised by a high frequency rate tremor but when compared with a natural tremor it has a higher, visible to the naked eye, amplitude. Just because of similar mechanical symptoms hyper-intensive physiological tremor, without carrying out the examination of hands, can be diagnosed as pathological tremor, thus in order to create a compact system assisting the diagnosis of neurological diseases, it is necessary to carry out a comparative examination in healthy patients who have undergone the hyper-intensive physiological tremor.

Physiological tremor can be characterized by the frequency higher than 8 Hz [1]. The amplitude of tremors depends on the outside factors loading, therefore it is not the main parameter in focus of researchers and doctors diagnosing the reasons of hand's tremor. The amplitude of tremors - be it physiological or pathological - considered mainly as a relative value (considering the progress of the Parkinson's disease development or the effectiveness of anti-tremor pills being applied). The main parameter enabling to distinguish the pathological changes from natural tremor is the frequency.

3. The methodology of research

There are several methods of examining tremors (described in detail in [2]). This paper presents the author's results aiming at the application of a computer tablet in physiological tremor examination of hands during the process of research, drawing and writing. Because of a potential possibility of having other characteristics and parameters of signals, both for hands loaded and not loaded, the static and dynamic examinations have been carried out. The adequate software for a standard computer tablet enables to replace commonly used by doctors examination based on drawing on a piece of paper with an electronic digitizer storing the tremor signal directly in the computer. Tested tremor's signals can be widely analysed with the use of a mathematical apparatus thus making the evaluation more objective, and at the same time being a real progress as compared with a traditional method of examination during writing and drawing with the use of paper as well as a subjective opinion of doctors making the diagnosis.

Because of varied characteristics of static and dynamic examination, a different approach to each of the issues has been taken. The examination of not loaded hand

has been carried out without the necessity of drawing a curve on a tablet. Such an examination - not performed in case of a traditional method using a piece of paper - is possible owing to special features of used tablet enabling registering the data by an electronic pen held above the tablet's plane up to the height of 1 cm. This characteristic helps to apply 1 cm-area above the tablet as very sensitive area gathering information about the movement of the electronic pen tip being placed there. The static examination has been carried out in a way that the patient was holding the electronic pen within the area above the tablet. Because of the tremor of hand, the tip of the pen was moving according to the area above or within the tablet registering the frequency of tremors. It has been observed that the hyper-intensive physiological tremor made holding of the pen's tip at the same point within the three-dimensional area above the tablet impossible so in the examination considering the Z vertical component of pressure (the used tablet applies the component only in case when the pen's tip touches the digitizer area) was possible as well.

The dynamic examination was conducted in a way that the patient had to draw a curve called the Archimedes spiral on the tablet. During that examination the patient was trying to draw with the pen's tip on a pattern of spiral placed on the tablet. The hand's tremor was causing some deformation of the signal so the data collected in that way included - apart from a model curve - the elements resulting from the hyper-intensive physiological tremor.

There are many factors causing hyper-intensive physiological tremor. However, not all of them can be triggered artificially so it was necessary to carry out the examination based on situations accessible to researchers or possible to be stimulated. This paper presents the examinations of hand's tremor appearing in highly stressful situations, after an intensive physical effort and after 24-hour break in eating followed by some nicotine poisoning.

The data collected has been analysed by a mathematical apparatus used for a previous evaluation of signals taken from patients suffering from the Parkinson's disease [2]. Owing to the analysis' results of physiological and pathological tremor, the signals can be evaluated within the same range of answers.

4. Results

During the examination the tablet of Wacom, model Intous2 (resolution 2540 dpi, maximum frequency 200 units/second) was used. Seven patients have undergone the examination. It has been noted that not in every case it was possible to trigger the hyper-intensive physiological tremor resulting from the situations as described above. Because of the characteristics of the hyper-intensive physiological tremor (hand's tremor gradually disappearing after the trigger's cease) made the examination of both hands or both examinations (static and loaded) impossible. Below there have been presented the results of analysis for particular examples (the signal's analysis method presented in [2]).

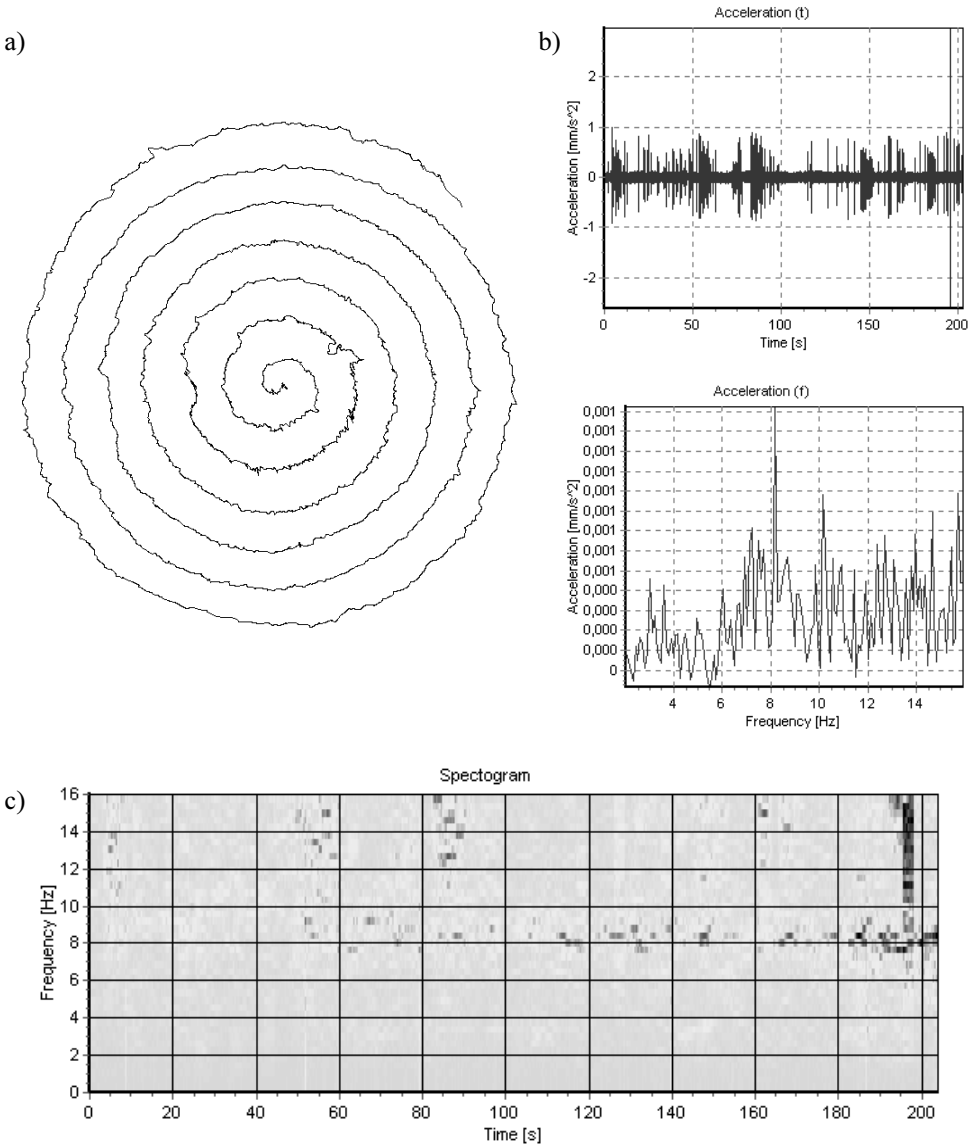

Fig. 1. Dynamic examination of the left hands of patients poisoned by nicotine after 24-hour break in eating: a) signal's record, b) acceleration in time function and spectrum of signal acceleration, c) spectrogram of signal acceleration

Figure 1 presents the record of examination of patients poisoned by nicotine after 24-hour break in eating (the patient does not normally smoke). The deformations of spiral caused by the hyper-intensive physiological tremor confirmed by the acceleration spectrum (a visible line at 8 Hz) and the acceleration spectrogram. High contents of high harmonics on the spectrogram at 195 second area results from the fact of holding the pen more than 1 cm above the tablet area.

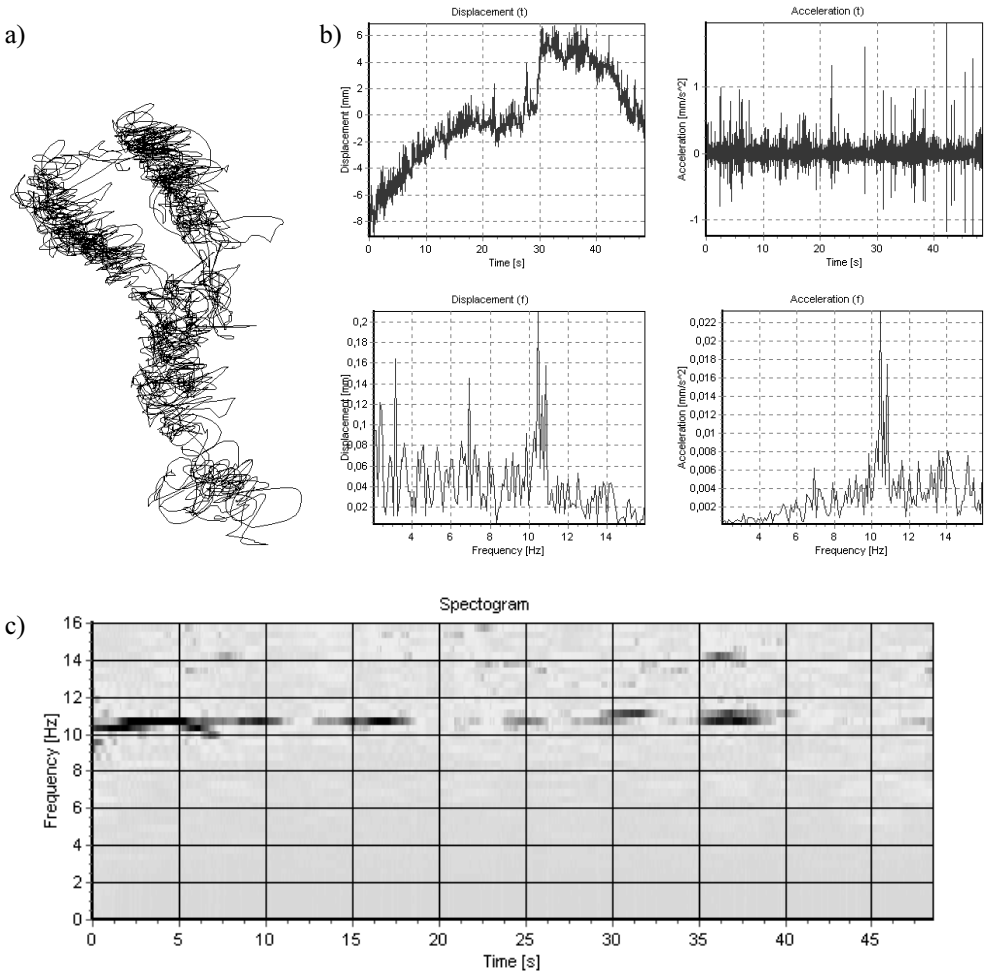

Fig. 2. Static examination of the left hand of a healthy patient nicotine poisoned directly after 24-hour break in eating: a) trajectory of a pen's tip record held above the area of tablet (the real size of figure is approximately 1.5 x 1.5 cm, b) development of the pen's trajectory in time, its acceleration and spectrums of both signals, c) spectrogram of signal acceleration

Figure 2 presents the results of static examination of the left hand of a patient described in Figure 1. The effort of holding the pen's tip at one point has resulted in a trace widespread on the area of 1.5 x 1.5 cm (Fig. 2a). Accelerator spectrum (Fig. 2b, left bottom graph) and spectrogram (Fig. 2c) includes a visible frequency line in the area at 11 Hz. Figure 3 presents the static examination of the right hand of the same patient. The presented analysis also confirms the visible contents of a line with a frequency of approximately 11 Hz. The real size of a trace from Figure 3 is approximately 2 x 1 cm.

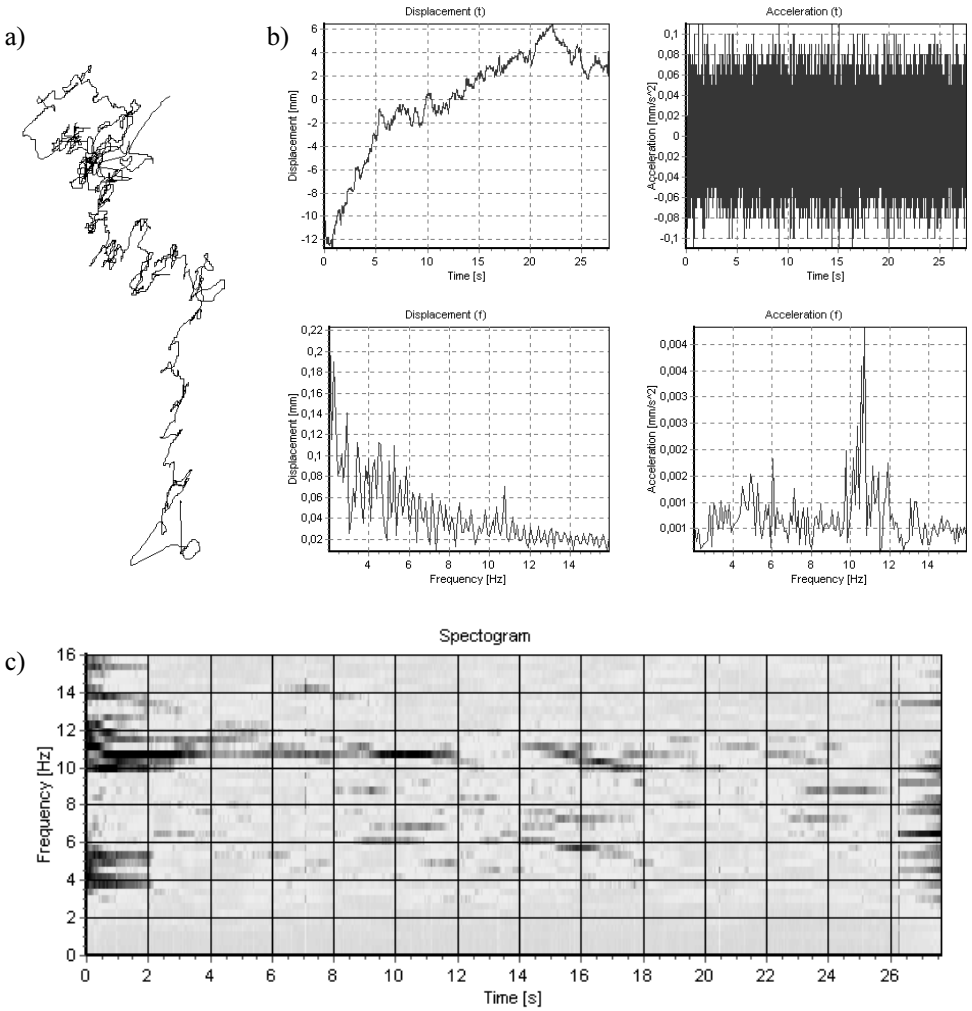

Fig. 3. Static examination of the right hand of a healthy patient nicotine poisoned directly after 24-hour break in eating: a) trajectory of a pen's tip record (the real size of figure is approximately 2 x 1 cm, b) development of the pen's trajectory in time, its acceleration and spectrums of both signals, c) spectrogram of signal acceleration

Figure 4 presents spectrograms of the static examinations of the left and right hands of patients who have undergone an intensive physical effort. Both spectrograms show visible lines of hyper-intensive physiological tremor within the range of approximately 11 Hz. The analysis of examination of the left hand (Fig. 4b) shows a gradual disappearance of the hyper-intensive physiological tremor what in fact confirms the observation that the muscles relax after the loading factors have ceased.

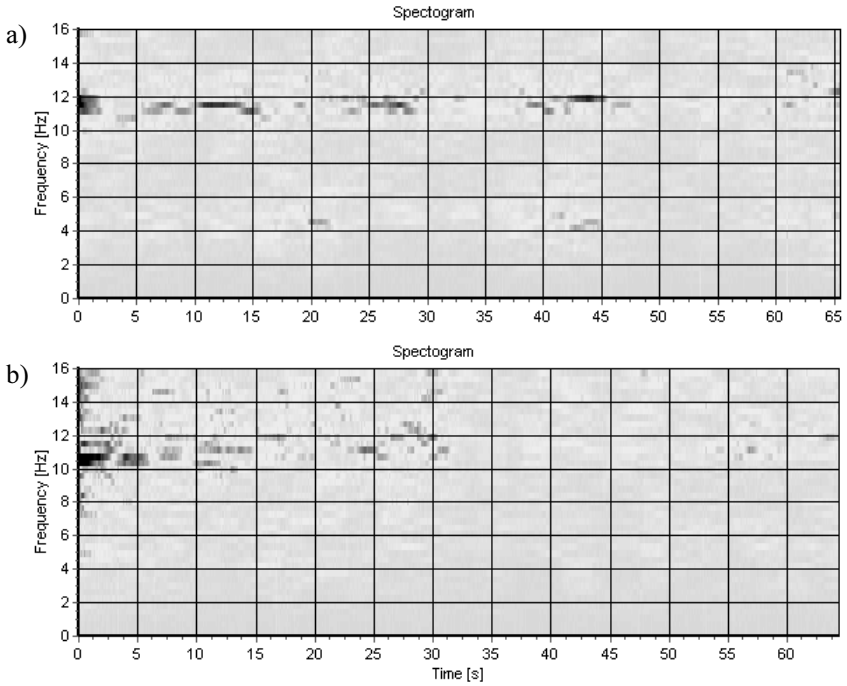

Fig. 4. Static examination of the hands of patients who have undergone intensive physical effort: a) spectrogram of signal acceleration for the right hand, b) spectrogram of signal acceleration for the left hand

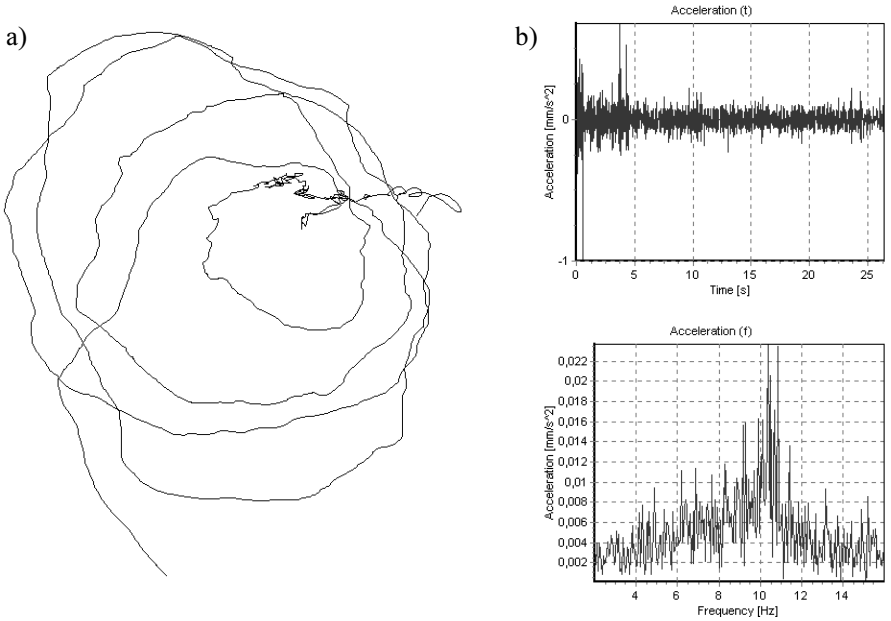

Fig. 5. Dynamic examination of the left hand of a patient in a highly stressful situation: a) record of Archimedes spiral signal, b) the graph of acceleration signal in time and acceleration spectrum

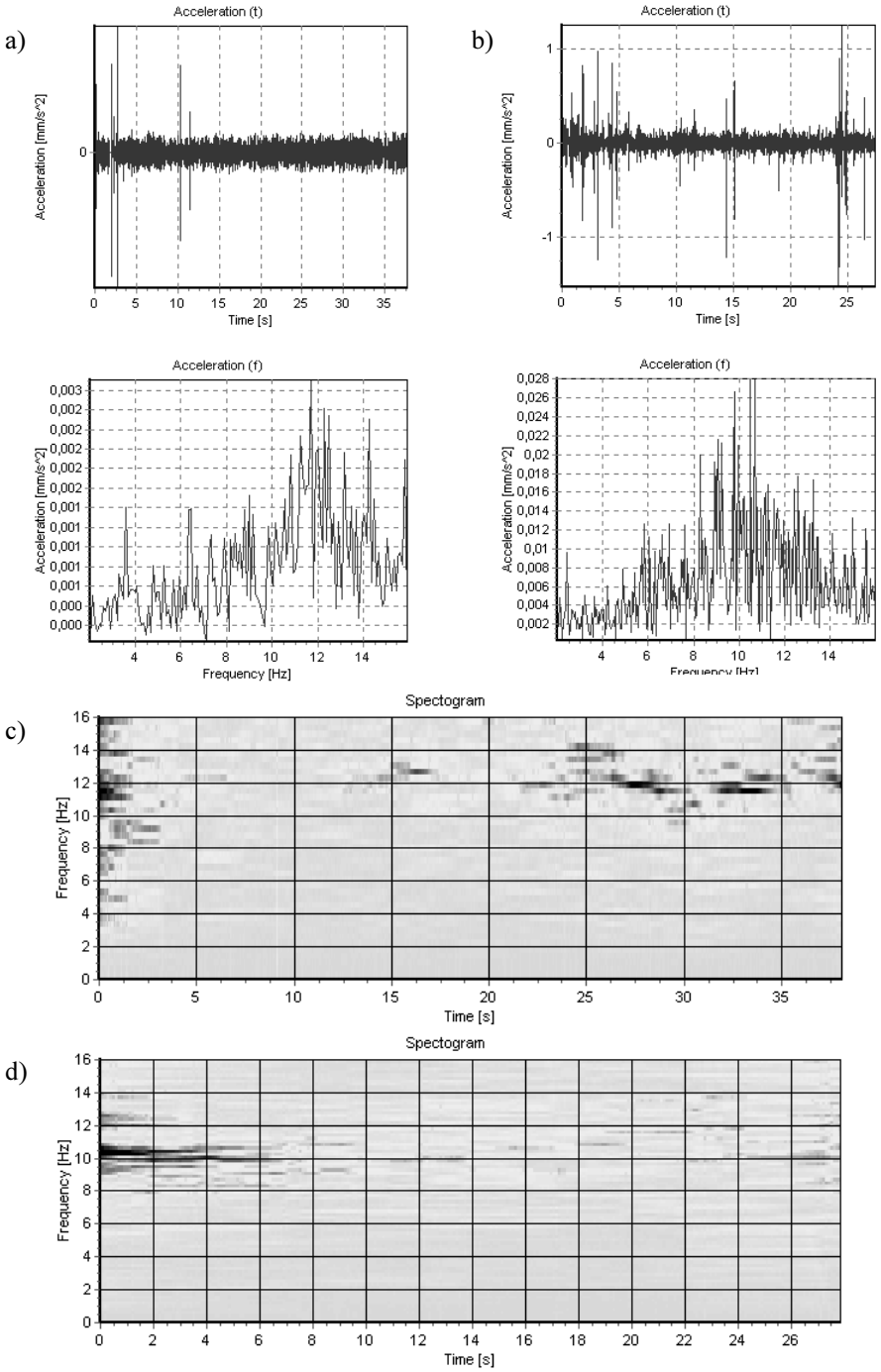

Fig. 6. Analysis of the static examinations of signals of a patient who has undergone a highly stressful situation: a) acceleration signal and acceleration spectrum for the left hand, b) acceleration signal and acceleration spectrum for the right hand, c) signal accelerator spectrogram for the right hand, d) signal accelerator spectrogram for the left hand

Figure 5 presents the dynamic examination of a patient in a highly stressful situation. Trajectory trace of the pen (Fig. 5) does not resemble the Archimedes spiral drawing of which was the patient's task during the examination. The acceleration spectrum (Fig. 5, bottom graph) of signal shows the visible contents of harmonics within the range of 10÷11 Hz.

Figure 6 presents the results of the static examinations of a patient who has undergone a highly stressful situation. The figure shows the results of analysis of both hands. The acceleration spectrums of signals for both hands (Figs 6 and 7) show a visibly higher value of harmonics contents within the hyper-intensive physiological tremors (more than 8 Hz). Spectrograms (Fig. 6c and 6d) confirm the above analysis including more precised results involving the phenomenon of increase and decrease of intensified physiological tremor caused by a higher adrenaline level.

5. Conclusions

Analysing the results of examinations on hyper-intensive physiological tremor, it can be concluded that the higher rate of harmonics appears within the range exceeding 8 or even 9 Hz. Certainly, the number of examinations (seven patients) is not enough to make general conclusions. Moreover, the most of the examined hyper-intensive tremors was caused by the mechanical over loadings of muscles (hard physical work or intensive physical training). Other reasons of higher tremor for hands (stress, nervous system poisoning, etc.) require the creation of some specific intra- and/or extrasomatic conditions so they are not easily accessible in experiments. The examinations of this nature will be continued as long as there are more patients available - especially those meeting the specific requirements. However, the analysis made so far enables to draw a conclusion that higher physiological tremors, owing to their specific features, can be distinguished from the pathological tremors caused by the Parkinson's disease development [2]. Thanks to that, the planned compact system of diagnosing the reasons of hands' tremor, and supporting the diagnostics of the nervous system diseases, with the use of computer tablet, could be extremely helpful in the automatic distinguishing of the pathological tremor from the hyper-intensive physiological tremors.

References

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[2] Lech T., Badanie drżenia kończyn górnych z użyciem sprzętu komputerowego ze szczególnym uwzględnieniem tabletu, Informatyka Teoretyczna i Stosowana 2003, 3, 4, 213-221.