# EVALUATION OF HAND TREMOR

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**Abstract: The present work was designed to discuss methods for investigating and evaluating tremor characteristics and stress. Further purpose of this study is to describe measuring procedures, review of devices and complex equipment, developed in our laboratories. Tremor is defined as an involuntary rhythmic shaking of a body part. Essential tremor is considered the most common form of neurological movement disorder. An analyser using passive markers (PAM) has been developed for clinical application at BME DMIS. Special device containing microcontroller and model of a miniature screwdriver was constructed for screening of candidates, applying for jobs in the precision instrument industry. Accelerometer adapter was adapted to a microcomputer for simultaneous investigations of the hand tremor. The actual stress of the tested person was measured. Relationship between the stress level and hand tremor was examined. Objective assessment of tremor helps in diagnosing and treating patients especially with neural diseases.**

**Key words:** tremor, stress, anxiety, measurement.

## Introduction

Tremor is defined as an involuntary, rhythmic shaking movement of a part of the body. On healthy subject tremor can be evoked by fatigue, stress or anxiety. Essential tremor, being usually hereditary, is quite common for the elderly. Essential tremor usually appears when the person is performing a movement and it does not show up at rest [1], [9].
Tremor is often present as a symptom of patients with neurodegenerative diseases. For a Parkinsonian patient tremor is usually present at rest and it disappears or eases during a movement. Characterisation of tremor is usually based on frequency and amplitude analysis [2], [6].The present work was designed to discuss methods investigating and evaluating tremor parameters. Further purpose of this presentation is to review devices for hand tremor assessment, developed in our laboratories, as well as the analysis of results gained on healthy subjects and patients.

## Materials and Methods

In the first experiment 5 college students (age range 21 to 24 years) participated in the study. We applied a passive marker-based motion analyser, PAM [5]. The device is easily applicable even in the clinical practice. The hand tremor was recorded for 30 s when the wrist or the elbow was supported, or, when the arm was stretched. Under these conditions the position of the hand was recorded with eyes open and closed.
An electronic apparatus, tester of precision manual work aptitude: "TPMWA", was developed for screening of candidates, applying for jobs in the industry requiring application of precision instruments [2], [3]. The device is capable to record and evaluate tremor parameters as well as to give biofeedback. It includes a digital electronic unit comprising display with 2 x 16 characters and interface for PC connection purposes. The design is based on a microcontroller. The mechanical part of the equipment contains adapter model, simulating a screwdriver used by watchmakers and a receiving unit
Fig. 1. demonstrates the usage of the device while the subject drives the adapter into one of the bores on the front plate, if possible, without touching the metal plate. In this case the elbow was supported.
The tremor was evaluated recording the sum of the contacts, when the screwdriver model touched the front plate, as well as the cumulated contact time.

Figure 1. Special device for hand tremor assessment and reaction time measurement.

In the second experiment 27 healthy subjects, college students participated in the study. In the third experiment 10 patients (age range from 20 to 62 years) were included in the study. The measurements were based on


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TPMWA device as well as on ADXL202, dual axis accelerometer (Analog Devices), providing analogue voltage and digital signals whose duty cycles are proportional to acceleration. Accelerometers require double integration to get position [2]. In order to complete information about the discussed phenomenon, CardioScan device was used to evaluate the ECG recordings in order to compute heart rate and stress factors (Energy Lab. Technology GmbH., Germany) (See.Fig.2.). The evaluation of the stress factor is based on the spectral analysis of ECG, the "HRV" and pulse rate average in the 60 s. measurement time.

Figure 2. Measurement of cardiac parameters and stress using CardioScan device.

**Results**

Figure 3 shows the trajectories of a marker attached to the index finger of a healthy subject. (Male subject, age: 22 years)

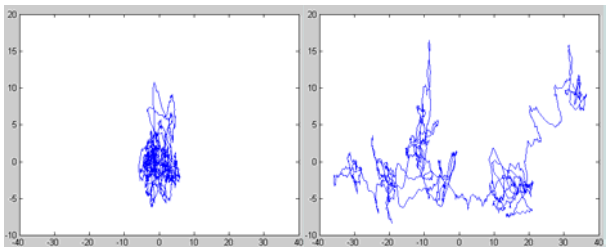

Figure 3.: Hand tremor with eyes open (left) and closed (right). Healthy subject, male, arm stretched.

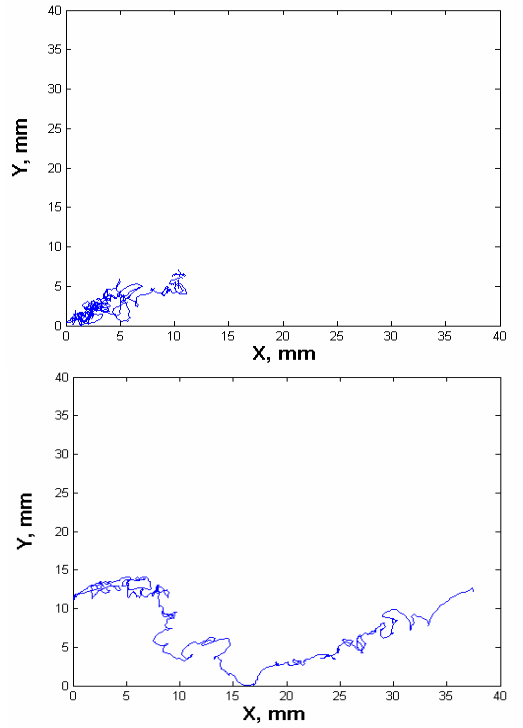


Figure 4. Hand tremor of a senior healthy subject. Top: eyes open, bottom: eyes closed.

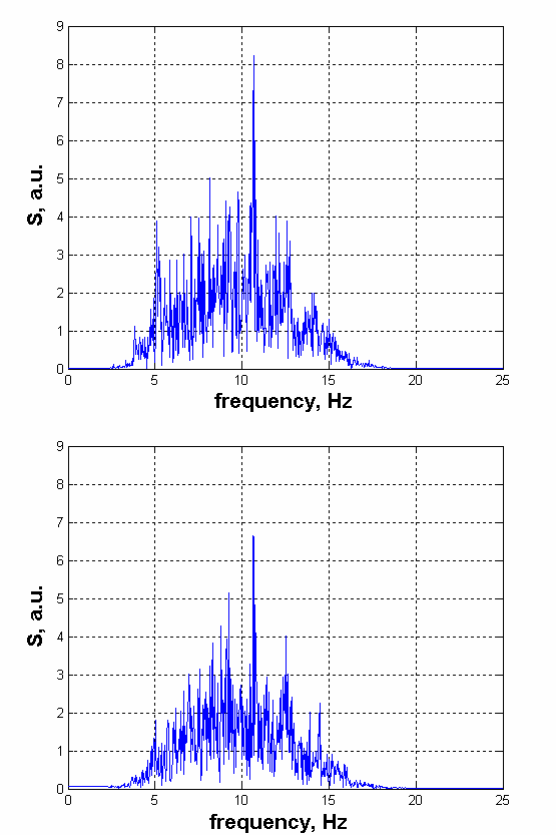


Figure 5. Power spectra of records shown in Fig.4.


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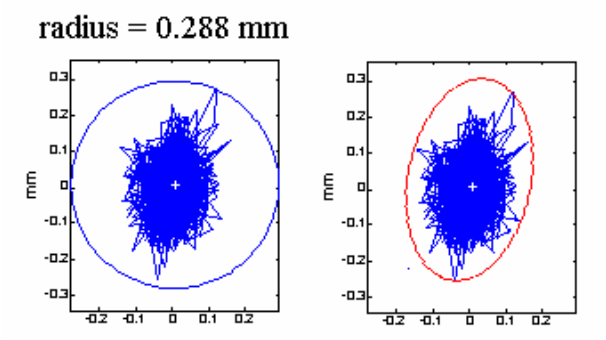


Figure 6. Fitting a circle or ellipse to the high-pass filtered trajectory can be used to characterise hand tremor.

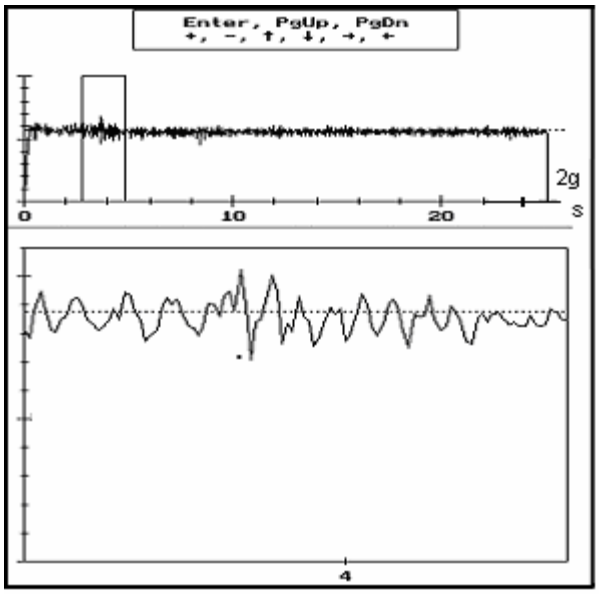


Figure 7.: Essential tremor, a record of 25 s using accelerometer transducer fixed to the index finger. of the subject, aged 46 years. Maximum acceleration of the tremor is equal to 0,44 g. The tremor frequency is 7 Hz.

| | TAIT | TAIW | TAIE | TR.N. |
|---|---|---|---|---|
| Mean | 38,9 | 13,7 | 17 | 84,2 |
| St.dev | 10,2 | 3,8 | 4,8 | 64 |

a./

| | RT.T. | RT | PR | Mark |
|---|---|---|---|---|
| Mean | 2,21 | 254,7 | 70,3 | 4,1 |
| St.dev | 1,9 | 94,1 | 10,6 | 0,81 |

b./

Table 1/a-b. Results of tremor, reaction time and anxiety tests performed by college students.

Average and standard deviation of results performed by college students are summarized in Table 1.

Abbreviations:
TAIT: total anxiety score
TAIW: score of worry in relation to the examination
TAIE: emotional excitement in relation to the examination
TR.N: result of tremor measurement, number of errors
TR.T.: result of tremor measurement, sum of the error times
RT.: disjunctive reaction time
RT.: errors committed in disjunctive reaction time test
PR.: pulse rate/min.
Mark: examination mark
[6][7].

The following correlation ($p<0,05$) was found between
tremor and emotional excitement (TAI/E): r = 0,3647
tremor and pulse rate: r = 0,4717
tremor and scores of the three anxiety tests: r = 0,4703
pulse rate and emotional excitement: r = 0,3782
pulse and reaction time: r = - 0,7131 (females).

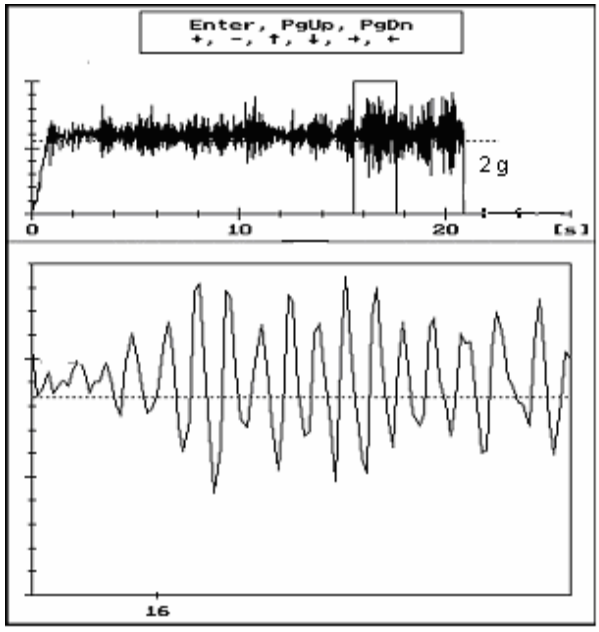


Figure 8. Essential tremor with high amplitudes and 9 Hz frequency. (Male subject aged 60 years.) In this case the maximum acceleration was equal to 1,3 g.. A 2 s. extent sector of the tremor diagram – from 15,5 to 17,5 s., -marked with a frame, and zoomed (see below) indicates a short paroxysm phenomenon with amplitude increase.

In the third experiment the procedure began with the CardioScan test. After recording cardiac parameters and stress data, subjects performed reaction time as well as


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tremor measurements using TPMWA. Finally, the subjects repeated the CardioScan test.

We found significant correlation between the tremor and the stress results, which were gained after the reaction time measurement and tremor testing: $r = 0,6499$ ($p<0,05$).

## Discussion

Tremor is present to differing degree in everyone. Hand tremor can be recorded and investigated using video movement analyser system. Accelerometer adapted to amplifier, A/D and computer, laser optoelectronic system, special device for fine manipulation evaluation. and simple tests of hand and arm functions (writing, drawing etc.) can also be used [4]. Measurements using PAM motion analyser made possible to get noise free diagrams on hand tremor. Employing motion analyser or accelerometer in the Romberg position, hand tremor was superimposed on body sway. Taking into account body sway frequencies, high–pass filter with 2 Hz cut–off frequency was adjusted to pick out hand tremor. We employed the abovementioned techniques and got statistically reproducible results. The application of the questionnaire of Spielberger and the CardioScan device made possible to clarify relationships among tremor, anxiety and stress [7][8]. Emotional disturbances have impact on tremor. Tremor classification scales have been proposed in the literature to assist specialists to distinguish between the different types of tremor. Descriptions on areas of the body affected by tremor (e.g., arms, hands, head, voice, tongue, legs, chin, trunk) were published. Amplitude / intensity and frequency of tremor have a direct correlation with functional disability. Computer evaluation of circle, spiral and line drawing, handwriting samples, or water pouring tests can be proposed to complete information about tremor of the patient, measured with the above described instrumental methods.. Investigating the tremor, other neurologic symptoms can be observed simultaneously. Examination may include assessment of postural abnormalities.

## Conclusion

It can be concluded that tremor is an objectively measurable physiological parameter, being important working capacity factor in the precision engineering and microelectronics. Although the application of the spectral analysis makes possible to describe tremor parameters with high accuracy, we have to take into consideration the stochastically occurring tremor components, shorter or longer paroxysm phenomena. Accelerometric tremor measuring instruments, one-, two- or three dimensional recording systems require double integration to get position. In consequence of the characteristics and frequency range of the tremor signal, DC transmission is not necessary and a high pass filter with 2 Hz cut-off frequency could be used advantageously to eliminate very low frequency vibrations due to the trunk movements as well as the effect of the Earth's gravity [2]. The passive marker-based motion analyser, PAM [5] was easily applicable even in the clinical practice.

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