Akademia Górniczo-Hutnicza
im. Stanisława Staszica w Krakowie

AGH University of Krakow

Study on EMG dynamics
in diagnosis needs

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Agenda

Motivations

Studies – how it all started...
A story about:
The bionic hand project
Comparative analysis of signals

The motivation behind the current research is to reduce stress and pain during muscle measurements.

Current Research

Frequency analyses
Spectral properties of global (sEMG) and elementary (nEMG) signals
Smoothed amplitude spectra as a basis for comparing signal properties
Time-domain analysis (impulse response)

Future Work

Deepening pilot studies, verifying hypotheses using extended empirical data.

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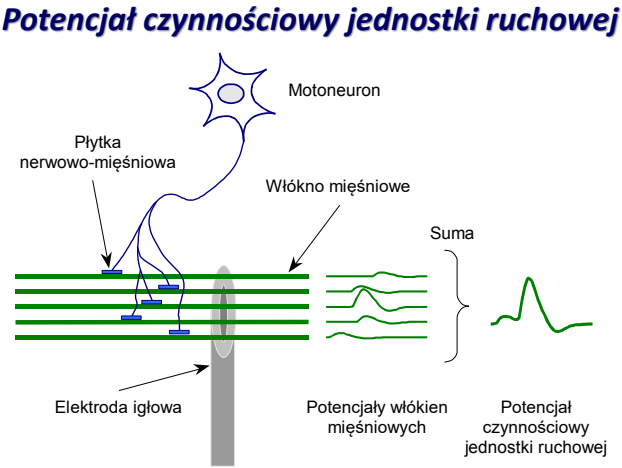
Part I

Descriptions

Biology of the Studied Phenomenon I



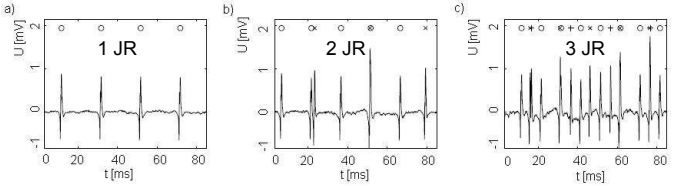
Motoneuron Properties

The motoneuron stimulates the motor unit. The duration of the impulse exciting a single fiber is approximately 1 ms; due to delays, it disperses to around 10 ms.

A motoneuron has between 4 and 4000 connections with synapses.

Regulacja siły skurczu mięśnia

- **Liczba aktywnych jednostek ruchowych (ok. 80%).**



- **Częstotliwość wyzwalania jednostek ruchowych (ok. 20%).**

Part II

Measuring (practice)

Why do we measure?

Neuromuscular disorders are currently diagnosed using invasive methods (needle EMG). Researchers are exploring applications where surface measurement (surface EMG) could be sufficient, such as in screening tests or early exclusion of chronic diseases, as in the case of tetany. From a forward-looking perspective, EMG measurement may also find applications in sports and rehabilitation.

EMG Laboratory

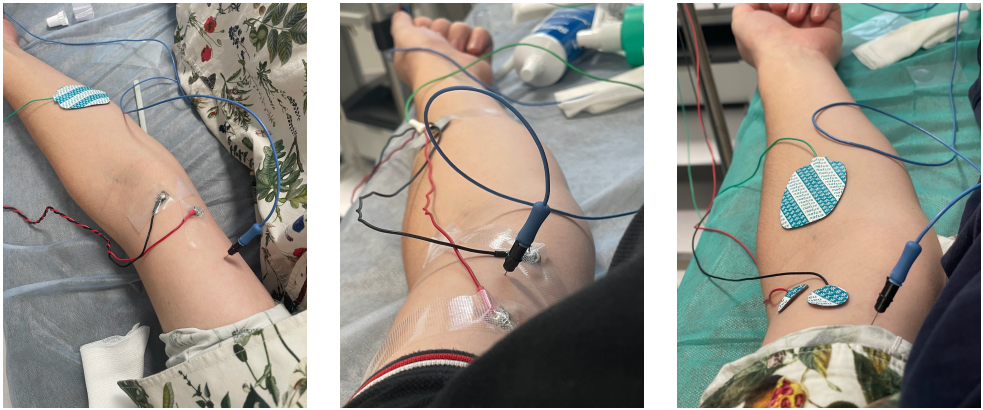


Figure: Simultaneous global and elementary measurement

Equipment setup

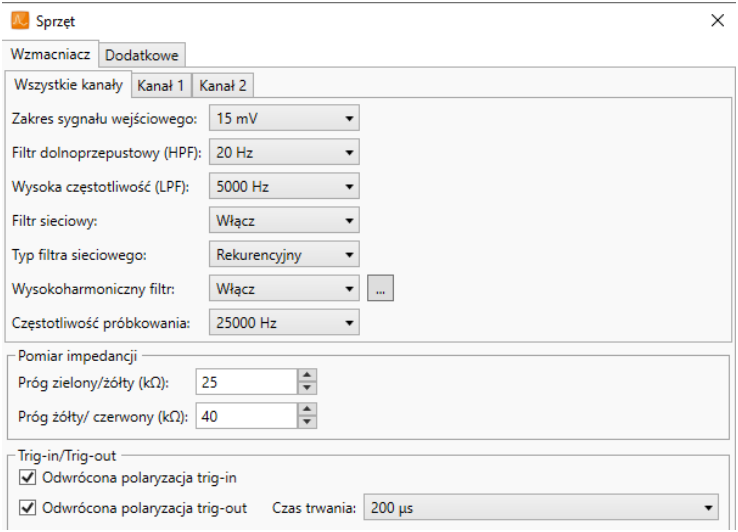


Figure: Default settings

Biology of the Studied Phenomenon I

Techniki elektromiograficzne

Sygnały biomedyczne i metody ich rejestracji na przykładzie *mięśniowych sygnałów elektrofizjologicznych*

- ✓ **Potencjał czynnościowy jednostki ruchowej.**
- ✓ **Zapis prosty, pośredni i interferencyjny.**
- ✓ **Elektromiografia ilościowa.**
- ✓ **Potencjał czynnościowy jednostki miogennej i neurogennej.**
- ✓ **Techniki rejestracji:**
  - ***Surface EMG*,**
  - ***Needle EMG*,**
  - ***Single Fiber EMG*,**
  - ***Macro EMG*,**
  - ***Scanning EMG*.**

Part III

Analytical theory

Fourier's theorem

$$y(n\Delta t) = a_0 + \sum_{i=1}^{I} \left[a_i \cos\left(\frac{\pi i}{N}\, n\right) + b_i \sin\left(\frac{\pi i}{N}\, n\right) \right]$$

The criterion of similarity

The basic criterion for the similarity of EMG signals measured in different ways may be the compatibility of their Fourier amplitudal spectra calculated taking into account different disturbing factors.

The amplitude spectrum expresses the formula

$$A = \sqrt{a_i^2 + b_i^2}$$

Phase spectrum

$$\phi(i) = arctag\left(\frac{a_i}{b_i}\right)$$

is less important (it is random)

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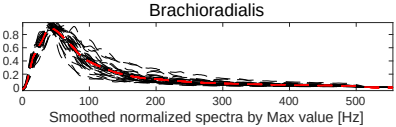
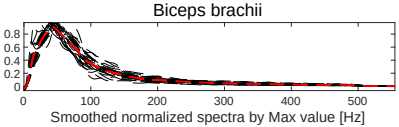
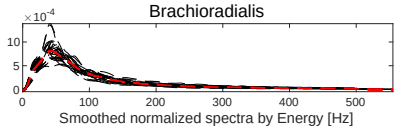
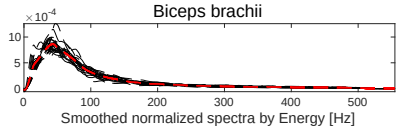
As part of the master's thesis, I conducted extensive analyzes of a healthy patient, smoothed specters of many repetitions of the same gesture for the same patient and many titles allowed to develop a pattern as the arithmetic average of the spectra obtained in individual experiments. The measurements were carried out using the global method, which illustrates ...

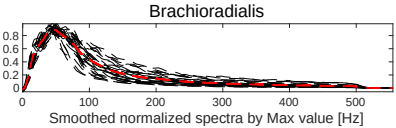
Centroids from all trainings (55) Intermediate(1:4) and Supinated grip(5:8)

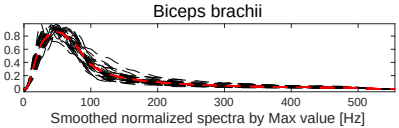


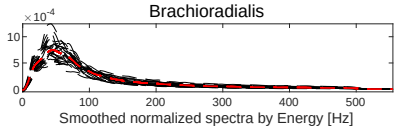


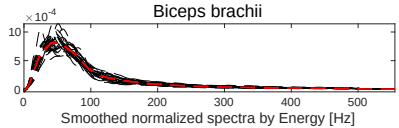












These experiments are currently supplemented with patterns of patients with diseases, as you can see the dominant frequency is 50 Hz. So measurements are carried out using filtration around 50 Hz. This technique was further used for the spectral analysis of simultaneous sEMG and nEMG signals, which are the subject of intensive research.

FIR class filters have been used.

The MTbF filter has a linear phase characteristic.

Part IV

Figures

Fig. I

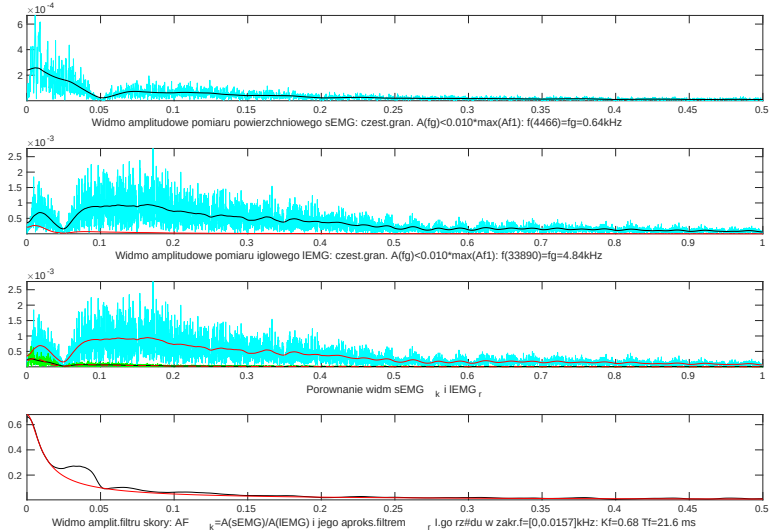

×10^-4
Widmo amplitudowe pomiaru powierzchniowego sEMG: czest.gran. A(fg)<0.010*max(Af1): f(4466)=fg=0.64kHz
×10^-3
Widmo amplitudowe pomiaru iglowego IEMG: czest.gran. A(fg)<0.010*max(Af1): f(33890)=fg=4.84kHz
×10^-3
Porownanie widm sEMG k i IEMG r
Widmo amplit.filtru skory: AF k=A(sEMG)/A(IEMG) i jego aproks.filtrem r I.go rz#du w zakr.f=[0,0.0157]kHz: Kf=0.68 Tf=21.6 ms

Fig. II

Note: The matching of the skin filter was carried out on the basis of the initial fragment (up to 15 Hz). Regression func. of nEMG and sEMG measurements, in order to obtain information on the combination of the sum of all extortion, a decomposition is proposed. For the "U" differential signal on U1 and U2, the decomposition was carried out, suggesting the method presented in the engineering publication, by square programming method.

Fig. III

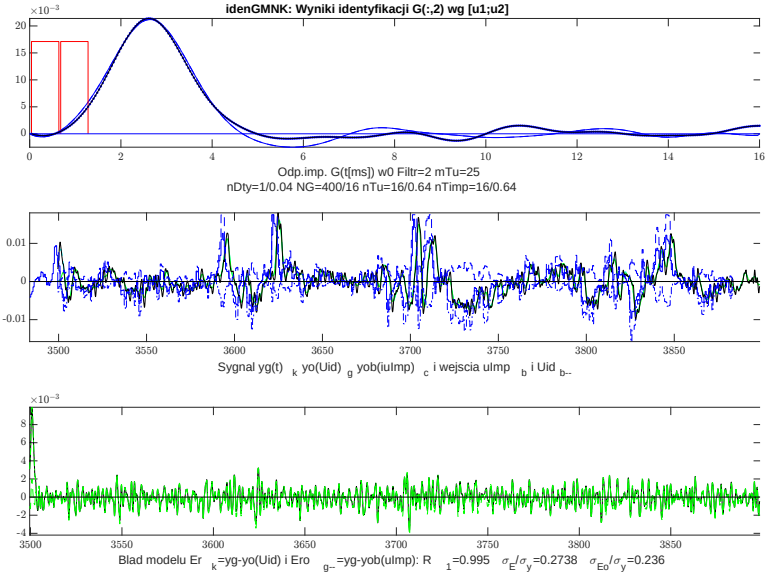
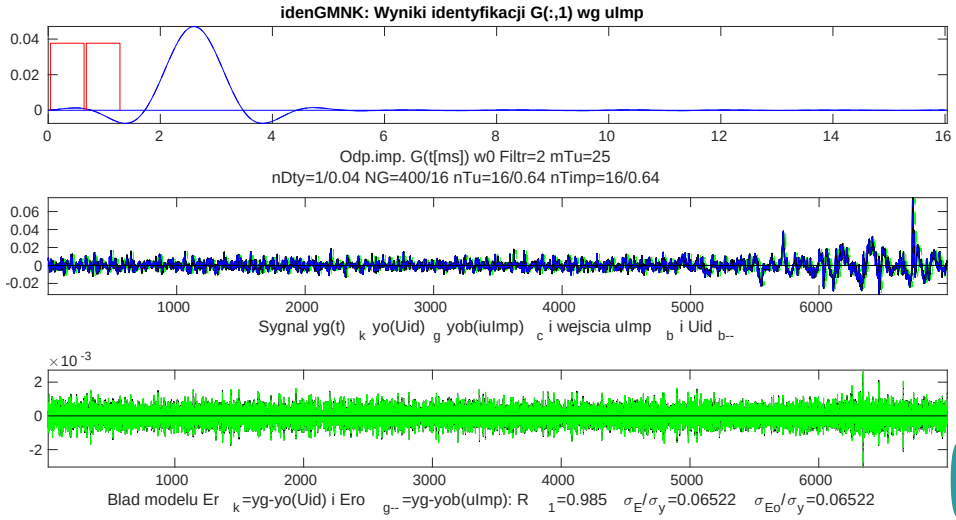

idenGMNK: Wyniki identyfikacji G(:,2) wg [u1;u2]
Odp.imp. G(t[ms]) w0 Filtr=2 mTu=25
nDty=1/0.04 NG=400/16 nTu=16/0.64 nTimp=16/0.64
Sygnal yg(t) k yo(Uid) g yob(iuImp) c i wejscia uImp b i Uid b--
Blad modelu Er k=yg-yo(Uid) i Ero g-- =yg-yo(uImp): R 1=0.995 σE/σy=0.2738 σEo/σy=0.236

Fig. IV


idenGMNK: Wyniki identyfikacji G(:,1) wg uImp
Odp.imp. G(t[ms]) w0 Filtr=2 mTu=25
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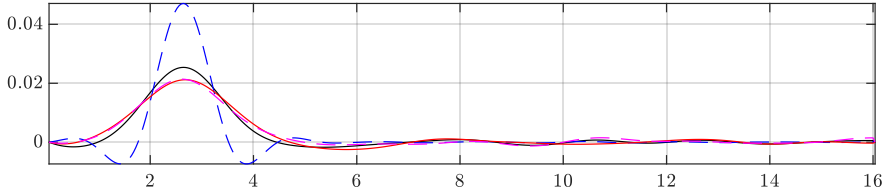
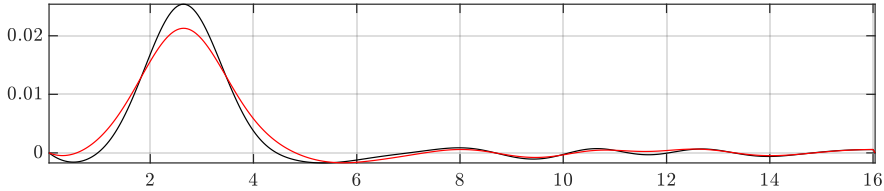
×10 -3
Blad modelu Er k=yg-yo(Uid) i Ero g--=yg-yob(uImp): R 1=0.985 σE/σy=0.06522 σEo/σy=0.06522

Fig. V



Odpowiedzi impulsowe: srednia pelna $G(t,uImp)_{b--}$ i $G_N(t,uImp)_k$, dla skladowych $G_{2N}(t,u1)_r$ i $G_{2N}(t,u2)_{m--}$



Odpowiedzi impulsowe srednia $G_N(t,uImp)_k$ i srednia skladowych $[G_{2N}(t,u1)+G_{2N}(t,u2)]/2_r$

Fig. VI

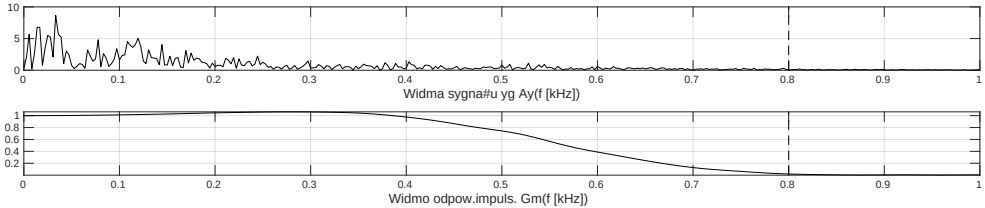


Fig. VII

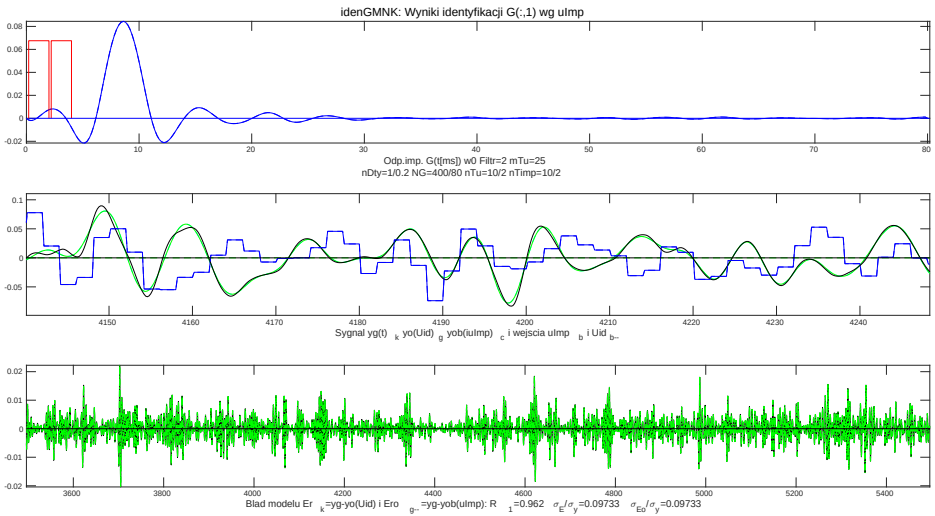
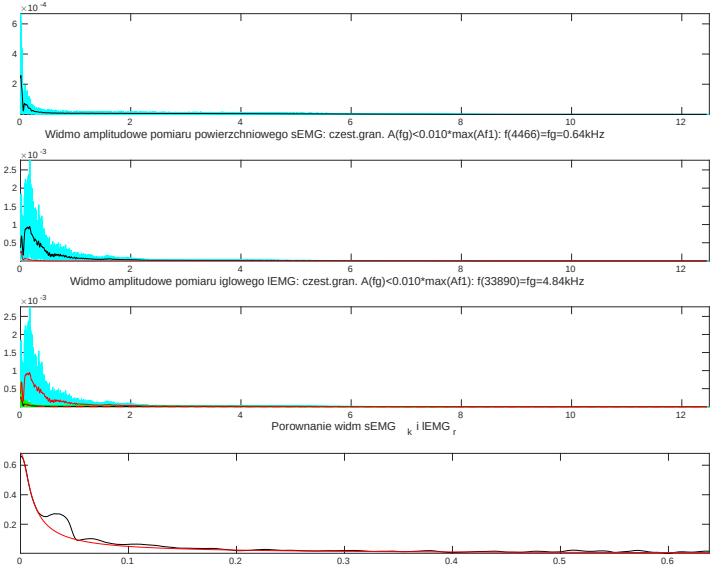

idenGMNK: Wyniki identyfikacji G(:,1) wg uImp
Odp.imp. G(t[ms]) w0 Filtr=2 mTu=25
nDty=1/0.2 NG=400/80 nTu=10/2 nTimp=10/2
Sygnał yg(t) yo(Uid) yob(uImp) i wejscia uImp i Uid
Blad modelu Er =yg-yo(Uid) i Ero =yg-yob(uImp): R =0.962 =0.09733 =0.09733

Fig. VIII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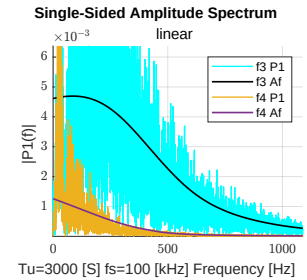
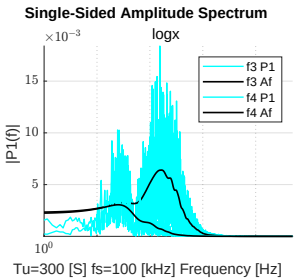
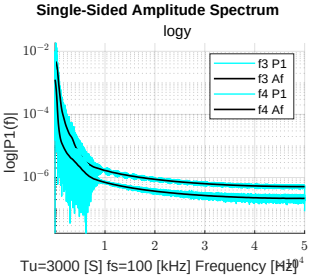
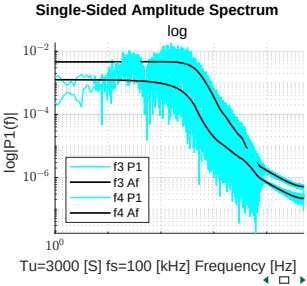
Curiosity

Ostateczne nagranie 100kHz, filtry w#a#czone

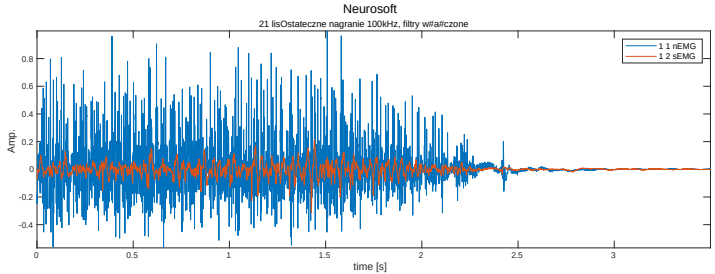


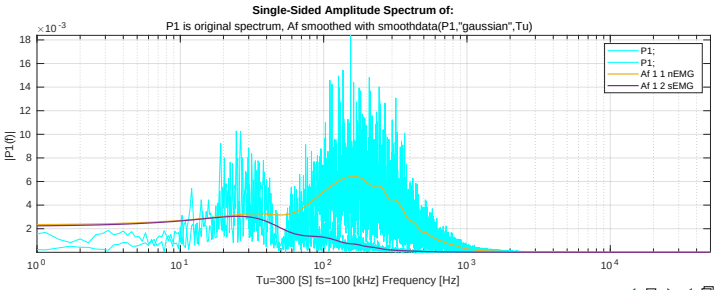






Curiosity continuation





Thanks for your attention

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