

Nerve conduction velocity

Introduction

Electromyography (EMG) is standard electrophysiological method to evaluate the muscles and nerves function. The summation of muscle cells action potentials causes electrical activity, that is measurable on the skin. The loosening of muscle responses or prolonged response after nerve stimulation indicates the dysfunction of the nerves, that allows to reveal the localisation and size of damage.

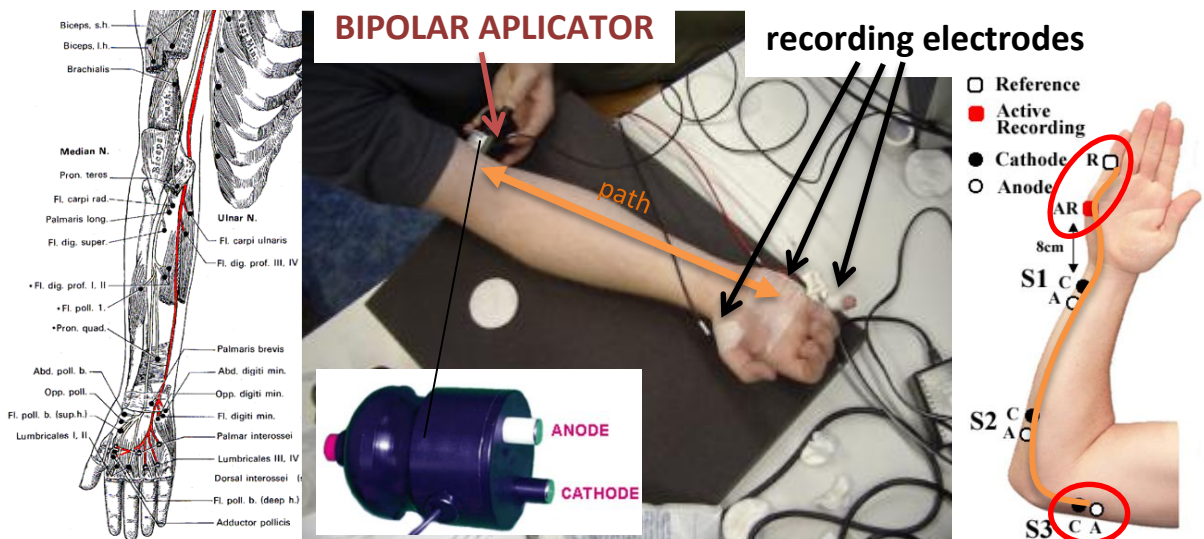
Stimulation of nervus ulnaris by short impulse (1 ms) through skin elicits the muscle responses (MEP) in little finger site of loof. Latency between stimulus and first EMG activity depends on nerve conduction velocity, that individually variates between 50-100 m/s. The maximal velocity obviously reflects the faster nerve of motor fibre.

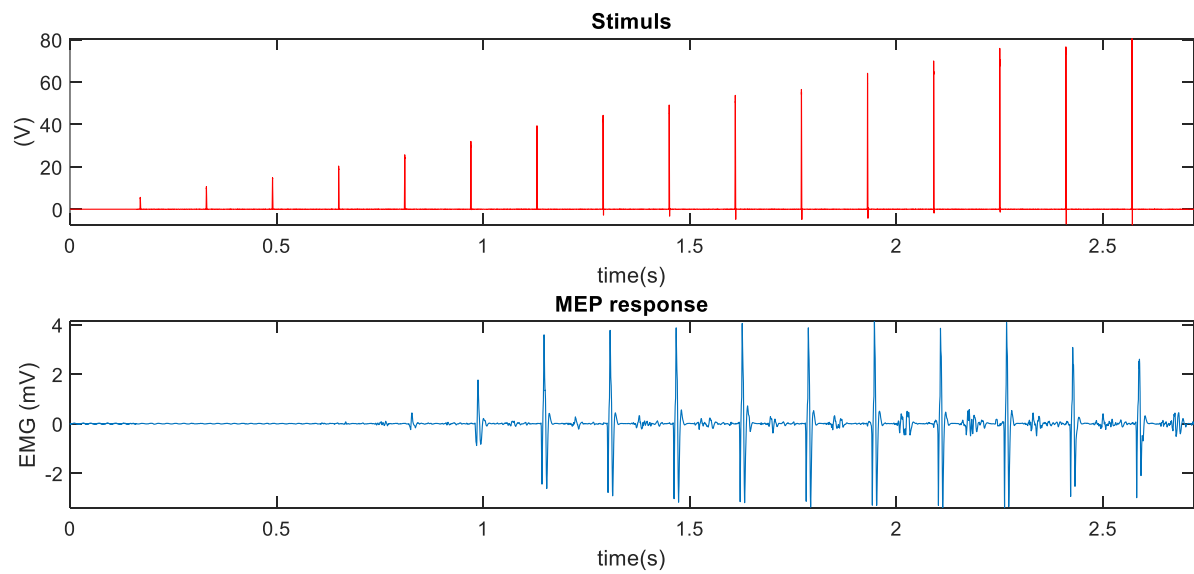
Notice: *Application of stimulation pulses (<100 V) causes feeling prick and muscle contraction with subsequent tingle. The voluntary measurement is fully safe, but can be light discomfort.*

Measurement:

Use the system Biopec with extended high-voltage stimulator BSLSTM Triger

1. Clean and degrease the skin of a hand loof, stick the electrodes on:
 - small finger – negative reference electrode (**white**)
 - edge of loof – positive active electrode (**red**)
 - back of the hand – ground (**black**)
2. Put the bipolar applicator 5 cm above inner side of elbow over the nervus ulnaris in a curve behind the medial epicondyle and volar to the triceps muscle (white anode proximally – to body)
 - Apply a small drop of electrode gel to each electrode, pay attention for the electrical short by the gel
3. Increase the stimulation voltage from 20V (5V steps) until first motoric responses.
4. Measure distance of the path





Aims:

- 1) Detect the muscle evoked responses to determine latency of the stimulus using:
 - thresholding of absolute raw signal
 - thresholding of power signal envelope
 - triangle detector
- 2) Calculate average nerve conduction velocity
- 3) Compare the results stability of detecting algorithms

Data:

```

fs=50 kHz
1. column ... time (s)
2. column ... stimulation pulses (V)
3. column ... EMG (0.5 - 5 000 Hz) (mV)
4. column ... EMG (30 - 1 000 Hz) (mV)

```

Note: Some files do not contain the first column. It can be generated by the fs.

Help:

Segment all trials to individual segments and analyse their separately:

```
segment=EMG(start:stop); % a trail
```

Simple thresholding

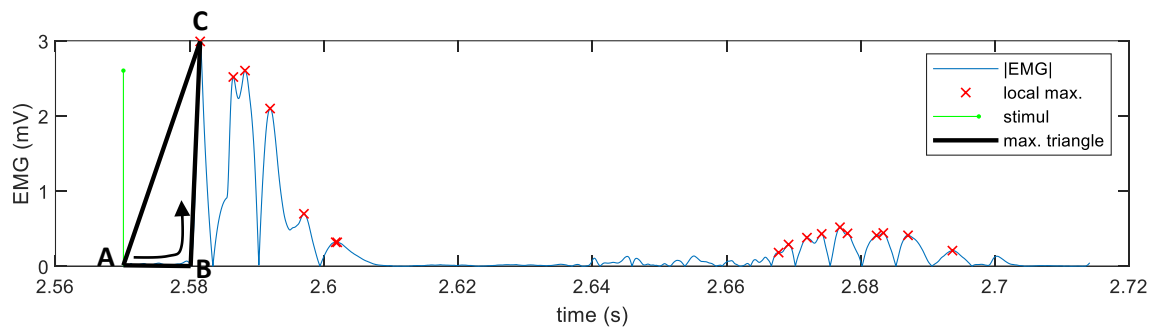
```
th=0.2; % threshold 0.2 mV
idx=find(abs(segment)>th,1);
```

Power envelope:

- power: $P = \text{segment}.^2$;
- simple integrator: $b=1$; $a=[1 \ z]$;
% $z \in (-1;0)$ find appropriate value e.g. -0.98
 $\text{envelope} = \text{filtfilt}(b, a, P)$;
- find the approximate start of muscle response by the appropriate threshold

Triangle algorithm:

- vertex **A** is in MEP in stimulation time $A=[a_x, a_y]$;
- find the first maximum of MEP, vertex **C**
- vertex **B** moves from **A** to **C**;
- area of triangle: $S = \frac{1}{2} |(c_x - a_x)(b_y - a_y) - (c_y - a_y)(b_x - a_x)|$;
- maximum argument of the space function $S(b_x)$ signalsizes the time position of **B** corresponding with muscle response.



```
% first local maximum
[amp,lmax]=findpeaks(abs(segment)); % all local maxima
lmax=lmax(amp>0.05*max(abs(segment))); % local maxima >5% of maximum
lmax=lmax(1); % the first local maximum

% triangle -----
ax=1; % x-coordinate of vertex A
ay=abs(segment(1)); % y-coordinate of vertex A
cx=lmax; % x-coordinate of vertex C
cy=abs(segment(lmax)); % y-coordinate of vertex C

% area of triangle S=f(B)
S=[];
for k=1:lmax % from A to C
    bx=k; % x-coordinate of vertex B
    by=abs(segment(k)); % y-coordinate of vertex B
    S=[S,0.5*abs((cx-ax)*(by-ay)-(cy-ay)*(bx-ax))]; % area of triangle
end
[~,bx_max]=max(S); % x-coordinate of vertex B with maximal area
```

Useful functions:

findpeaks, find, filtfilt, max