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Intuitive Multifunctional Hand Prosthesis Control

Performance and Satisfaction

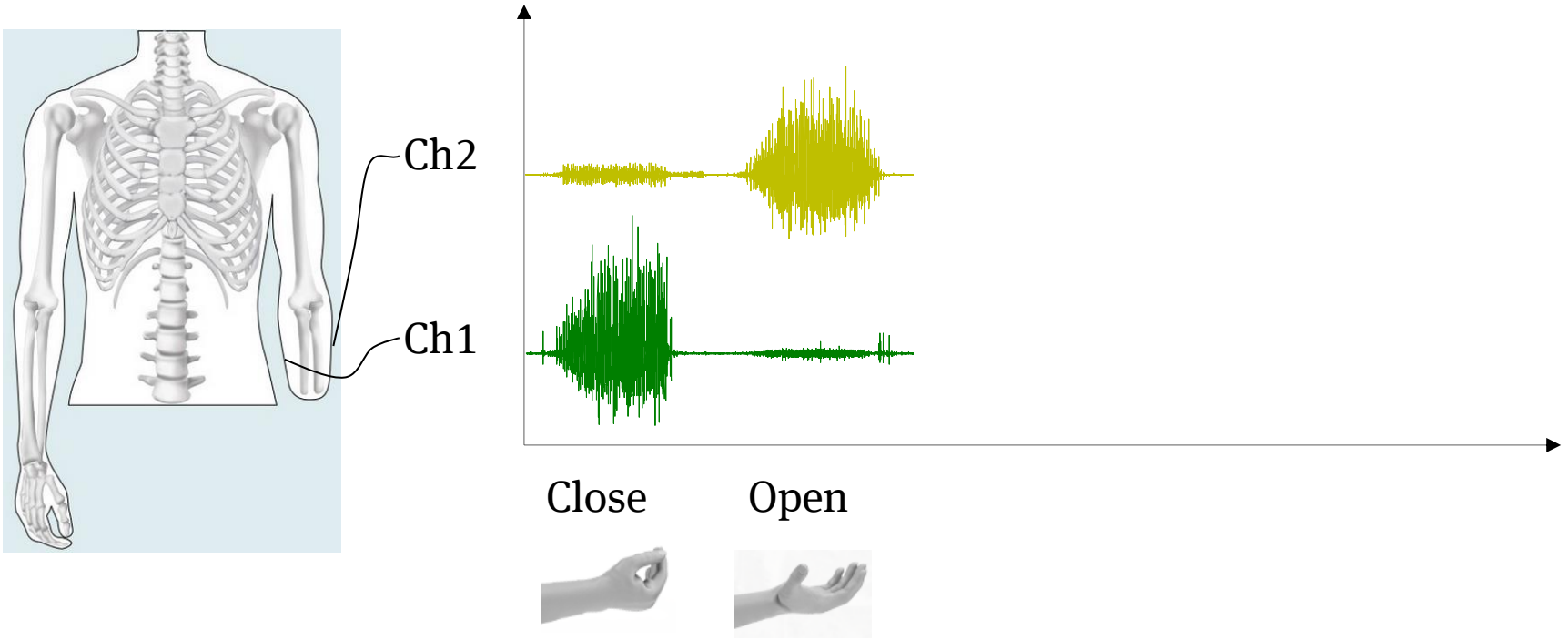
Sebastian Amsüss, PhD | BAPO 2018

Agenda

1. Introduction to intuitive multifunctional control
2. Results on performance and satisfaction
3. Outlook

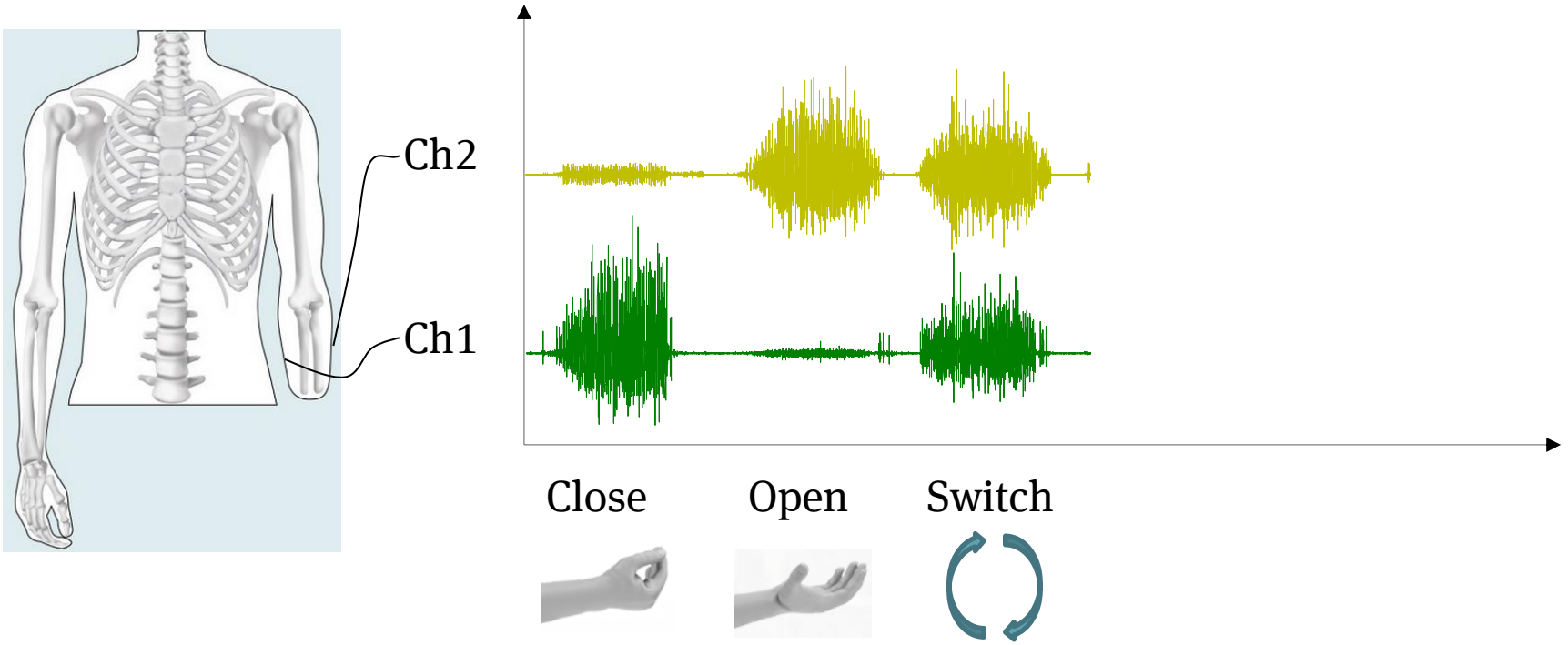
Conventional prosthesis control

2 channels for 2 functions



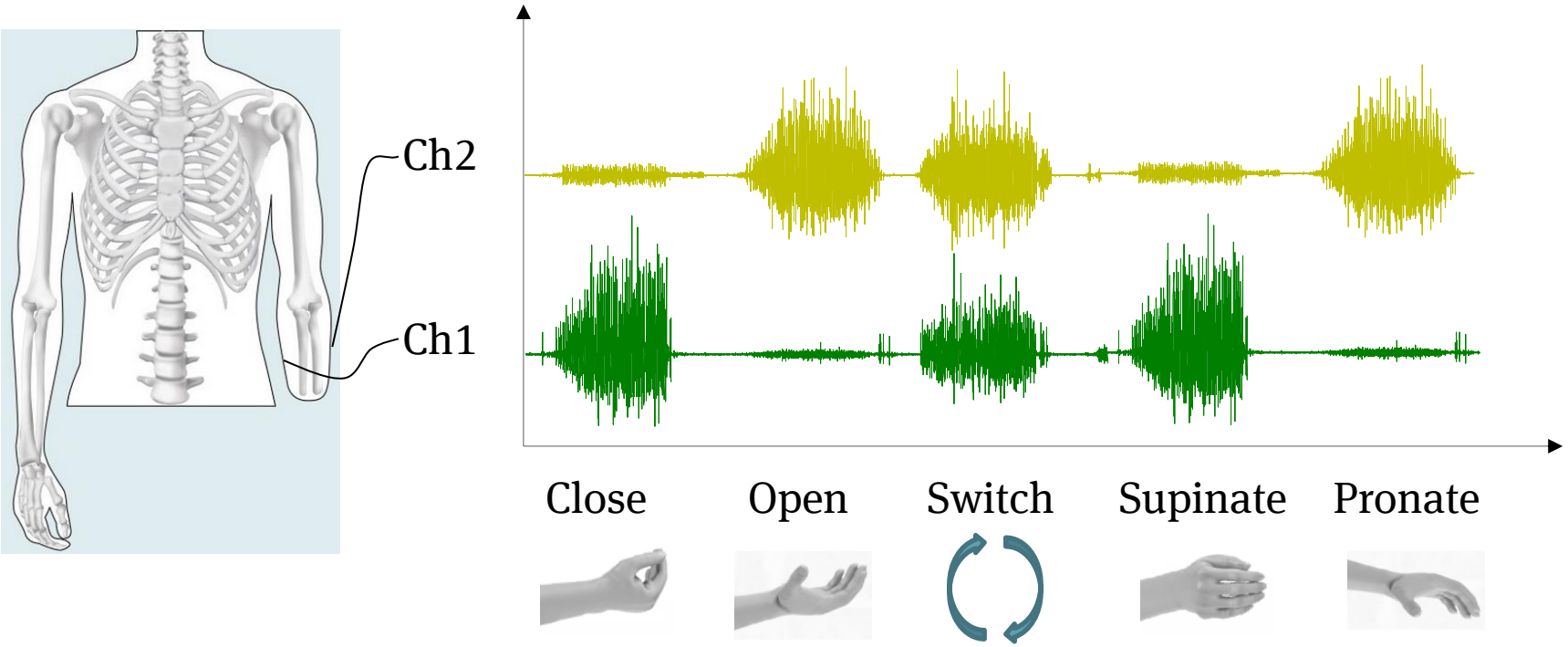
Conventional prosthesis control

2 channels for 4 functions



Conventional prosthesis control

2 channels for 4 functions



Conventional prosthesis control

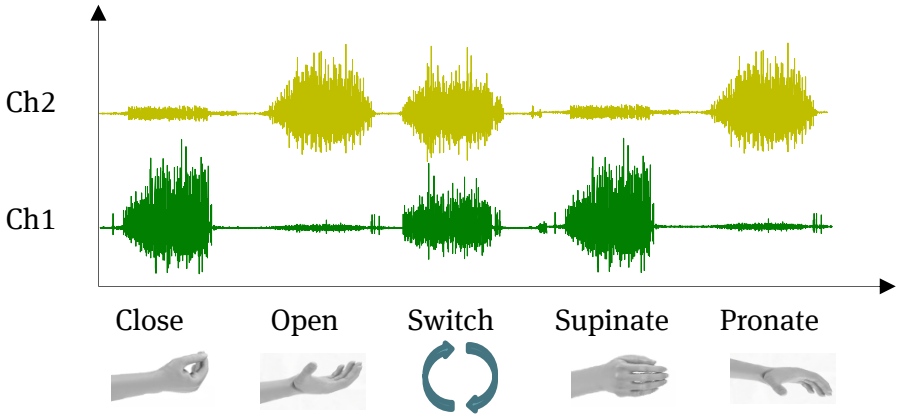
How does it extend to more functionality?

Belter et al.(2013), *JRRD 50*(5)

Conventional prosthesis control

Limitations

Feats of engeneering...



Conventional prosthesis control

Limitations

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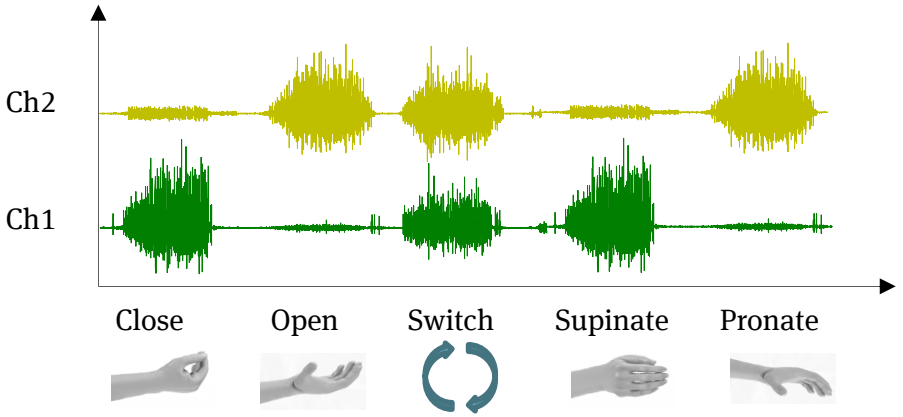
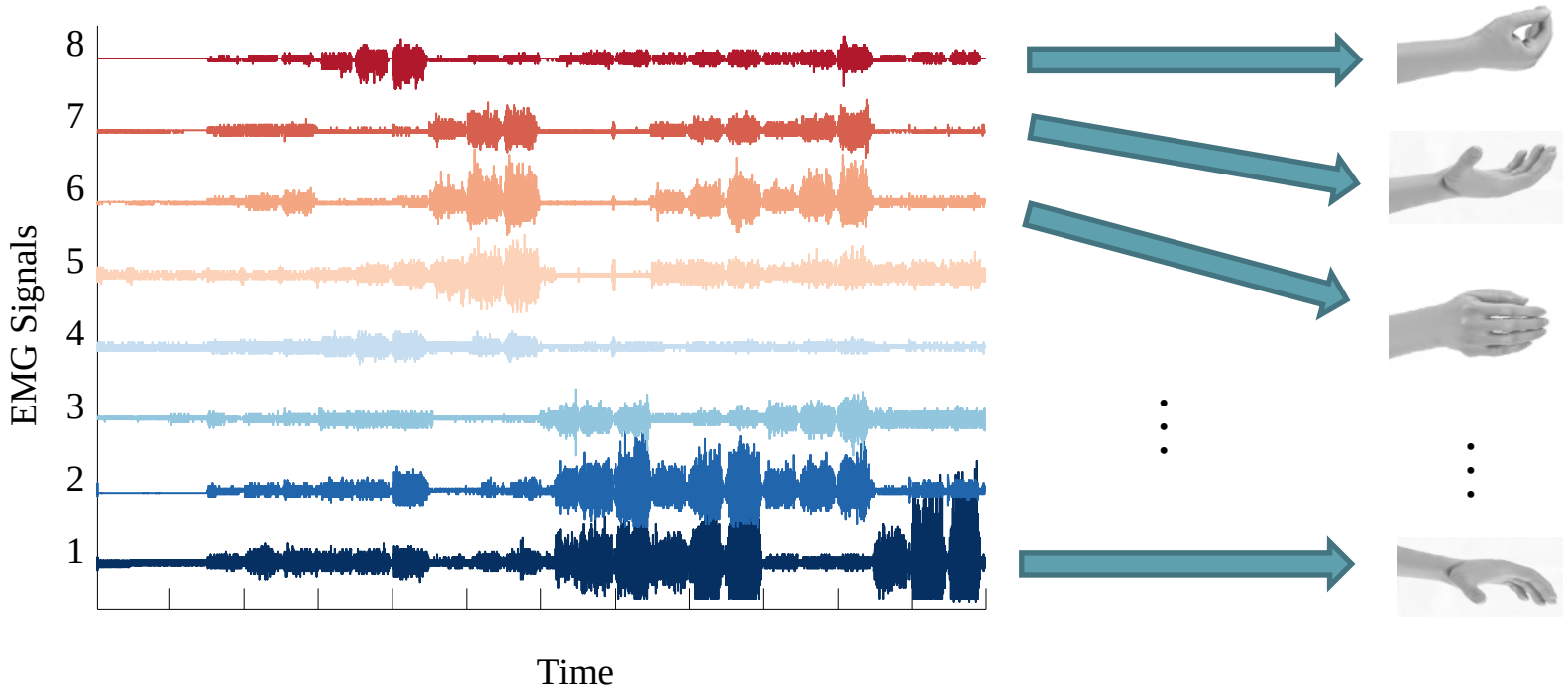


...driven with only two gears

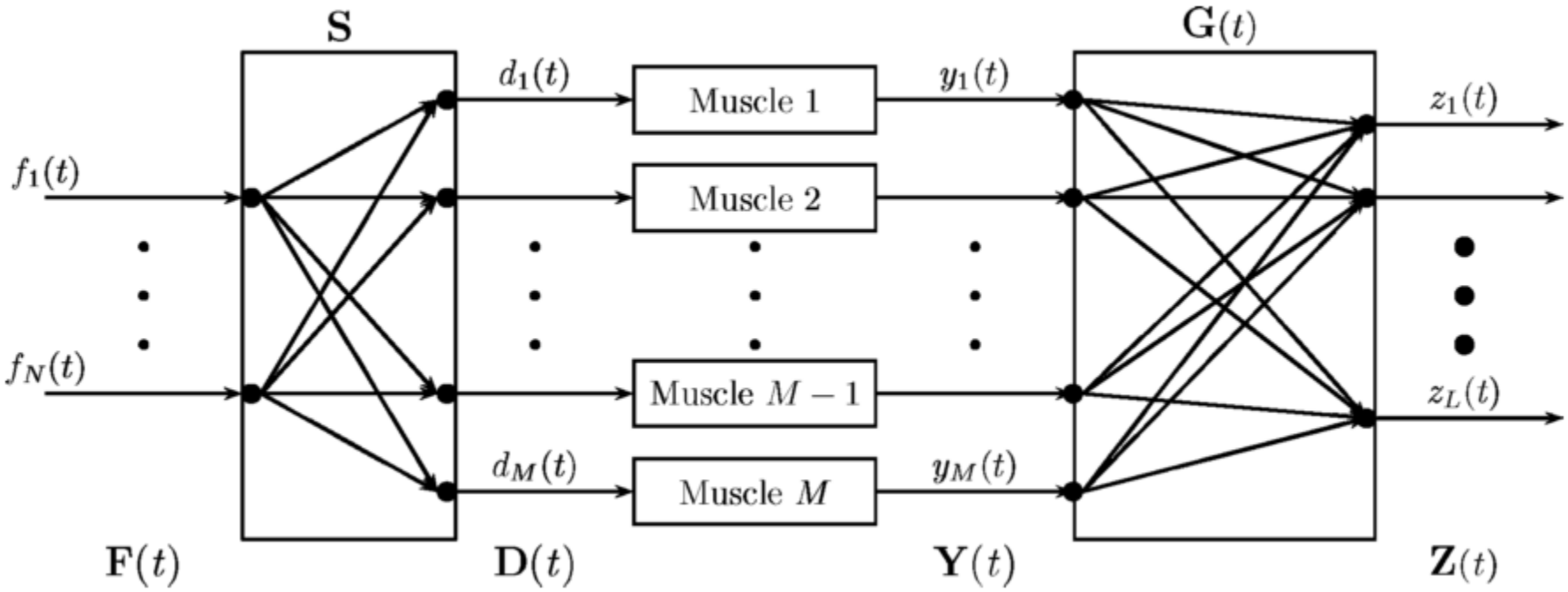
Intuitive multifunctional hand prosthesis control

Why not simply extend classic control to more channels?



Intuitive multifunctional hand prosthesis control

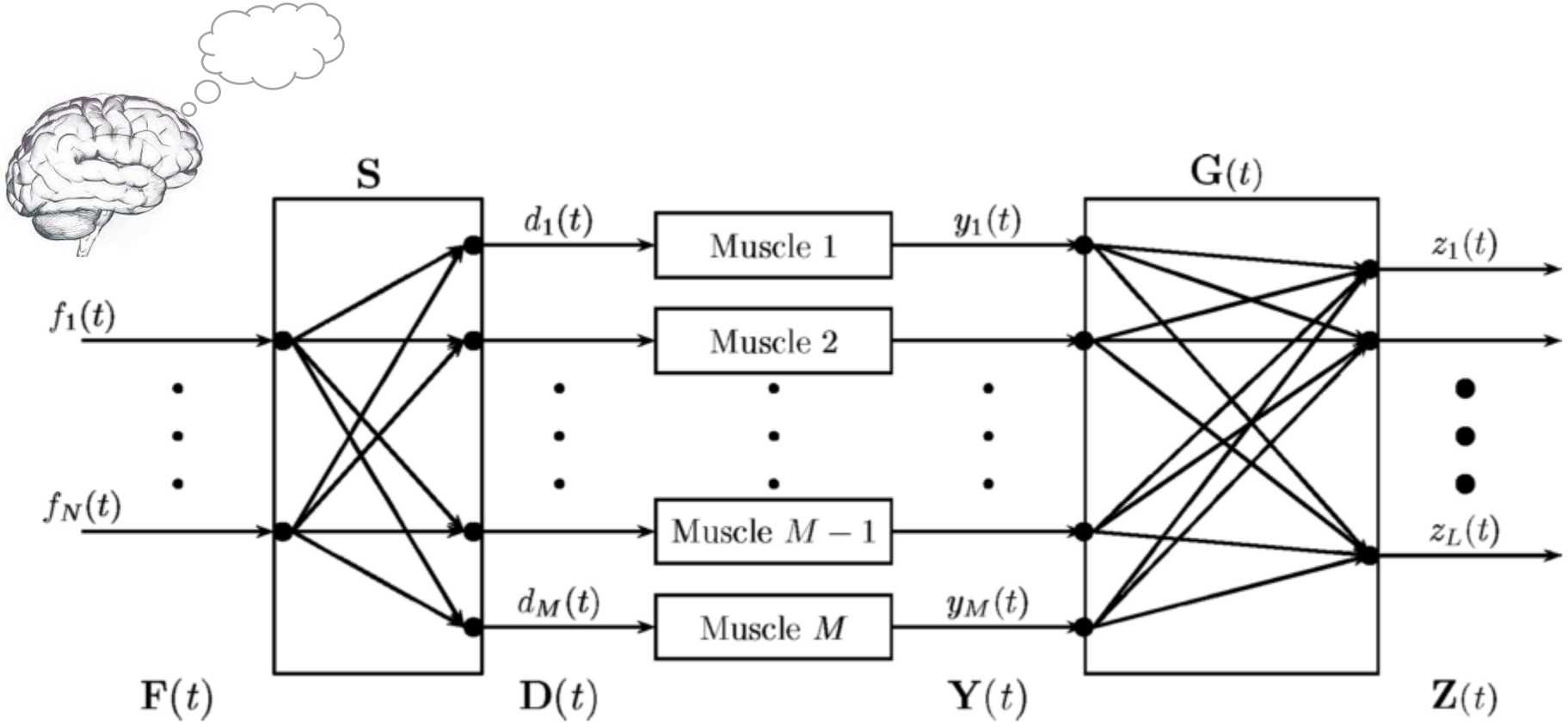
Muscle synergy and volume conduction



Jiang et al.(2008), *Univ. New Brunswick*

Intuitive multifunctional hand prosthesis control

Muscle synergy and volume conduction



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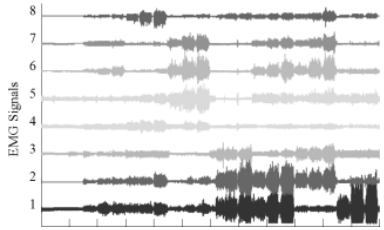
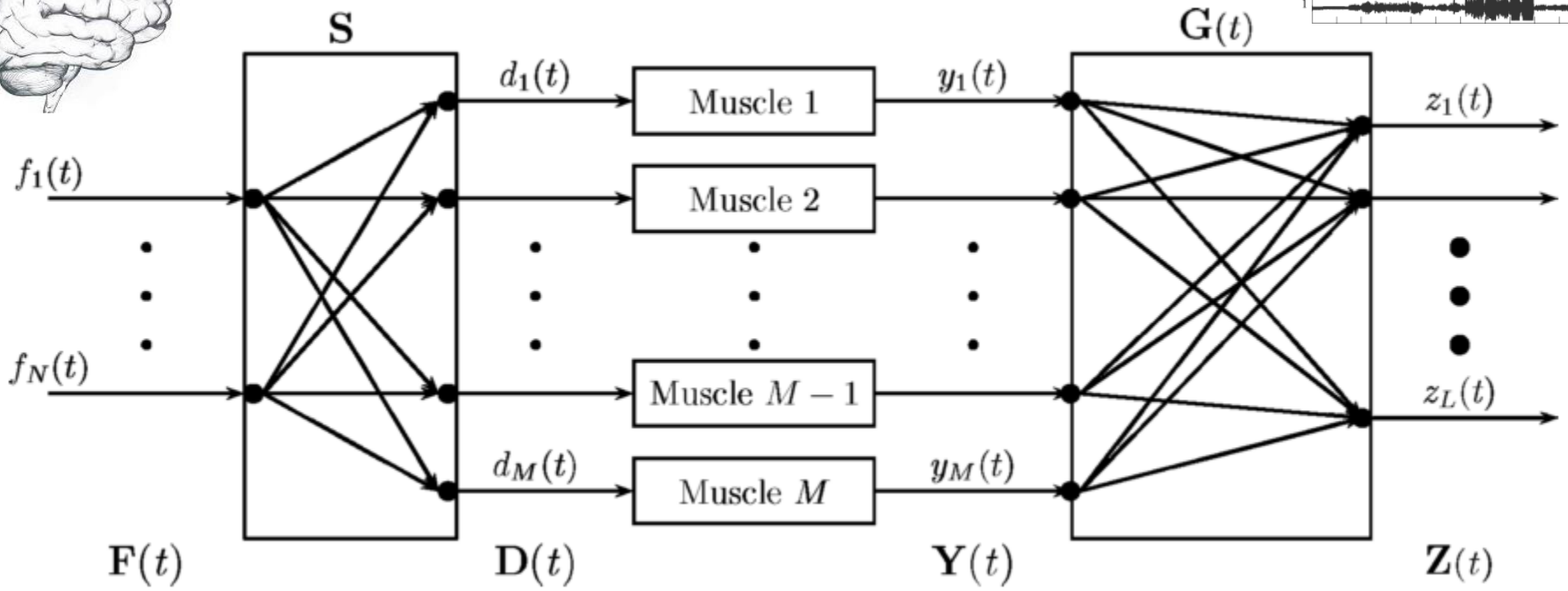
Intuitive multifunctional hand prosthesis control

Muscle synergy and volume conduction

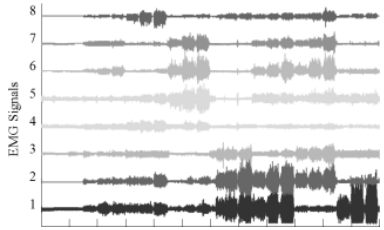


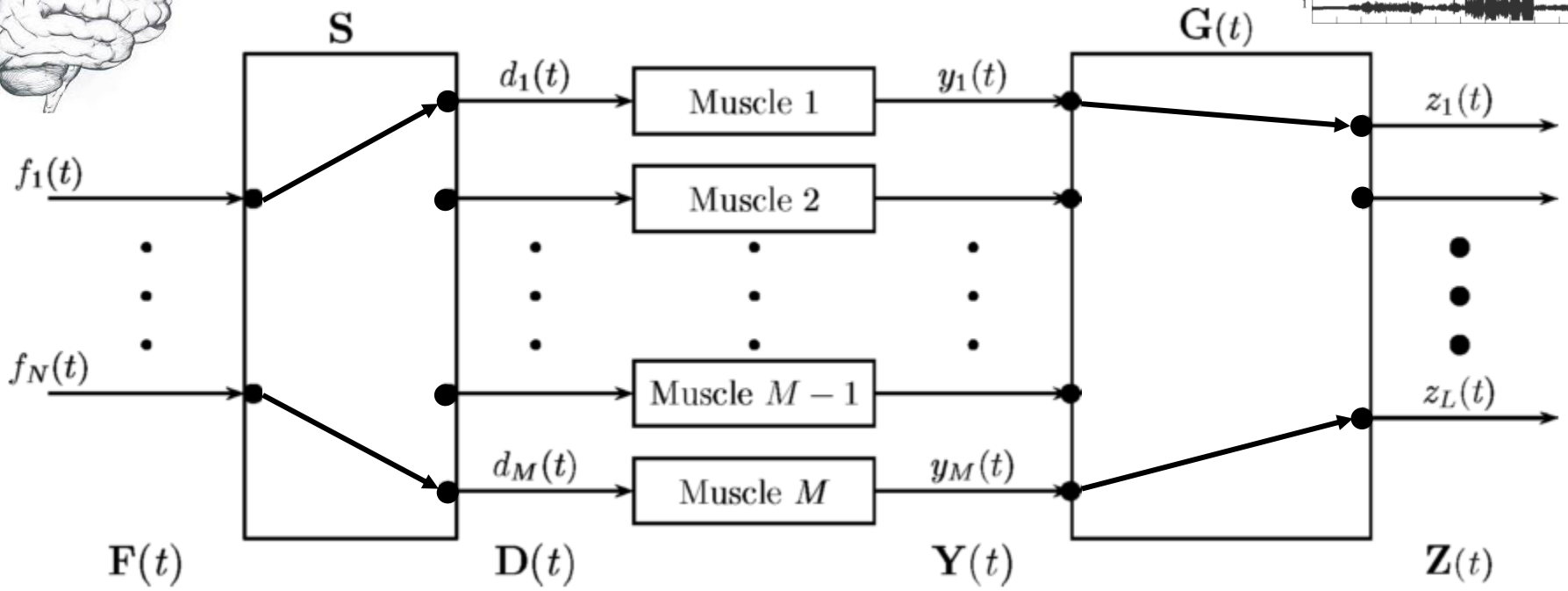


Jiang et al.(2008), *Univ. New Brunswick*

Intuitive multifunctional hand prosthesis control

Solution 1: TMR

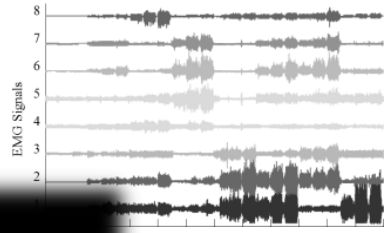


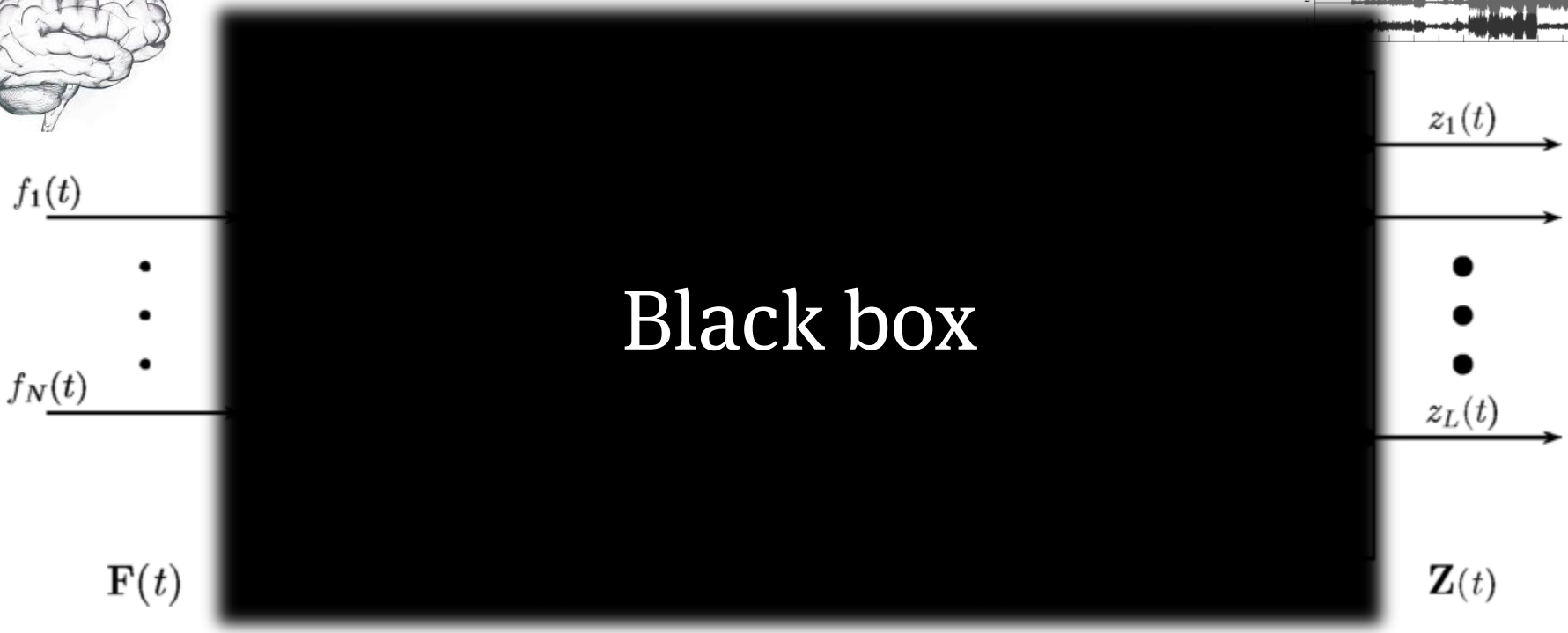


Jiang et al.(2008), *Univ. New Brunswick*

Intuitive multifunctional hand prosthesis control

Solution 2: Pattern recognition

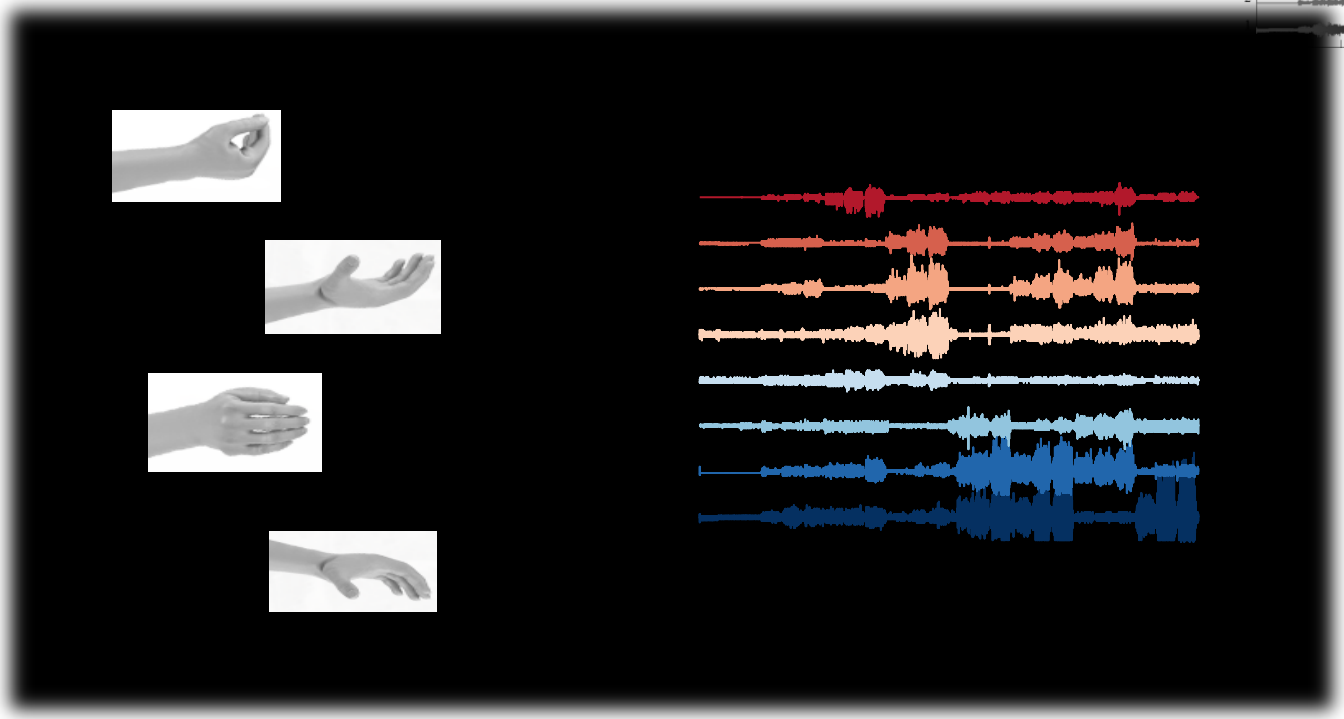


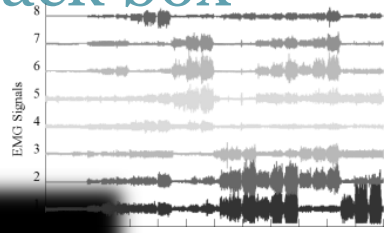


Jiang et al.(2008), *Univ. New Brunswick*

Intuitive multifunctional hand prosthesis control

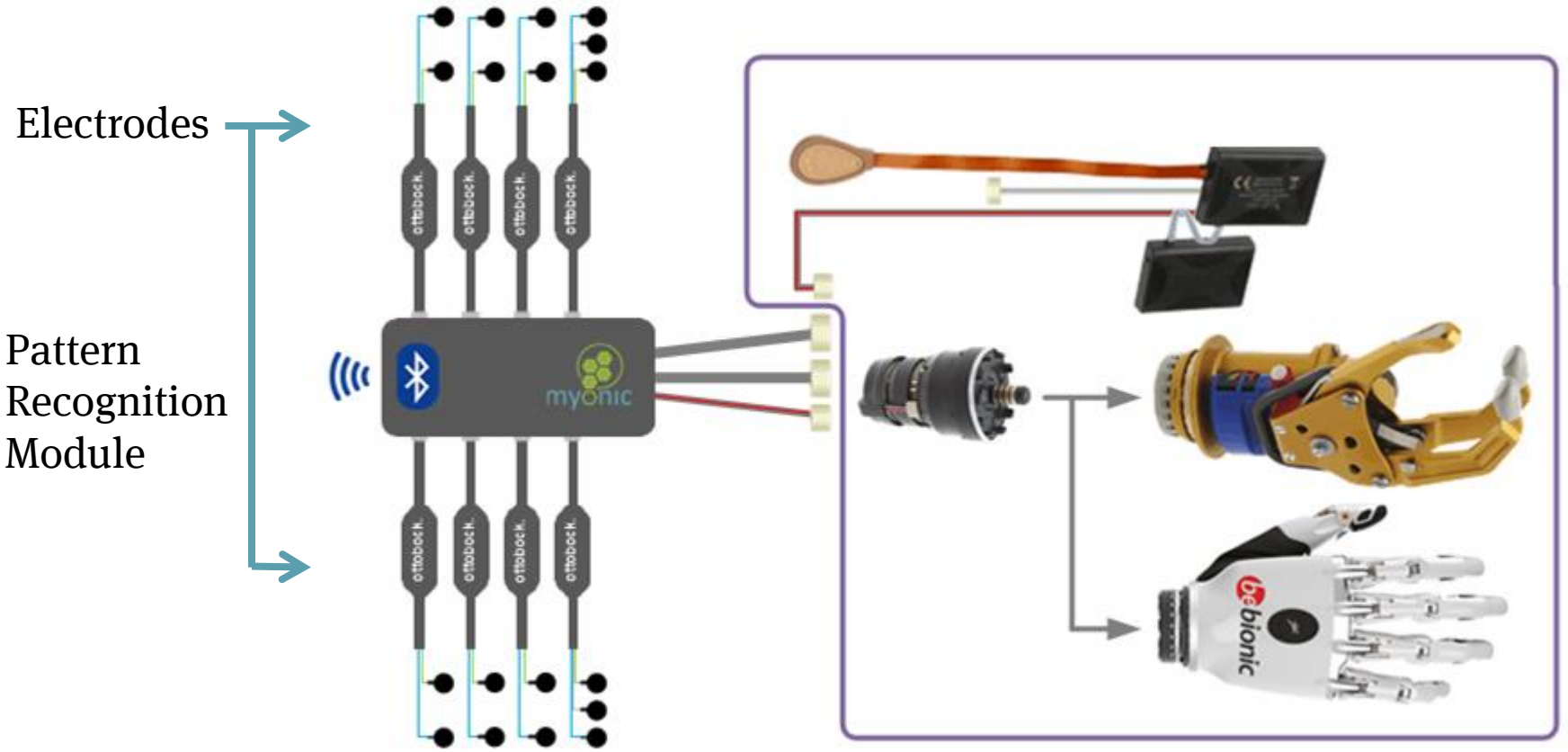
Solution 2: Pattern recognition - feeding the black box





Intuitive multifunctional hand prosthesis control

Pattern Recognition



Agenda

1. Introduction to intuitive multifunctional control
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Pattern recognition – home use study

Aim

(1) performance and satisfaction of **transradial amputees**
conventional control ⋯ PR control ⋯ conventional control

(2) feedback from **amputees, prosthetists and trainers**

(3) prolonged home-use

Study was approved by Ethics Committee BC Tubingen, Germany.

Pattern recognition – home use study

Study protocol

Visit #1
Recruitment

Visit #2
baseline measurement

Socket production

Visit #3
Test prosthesis
1st data collection

4 weeks home use

Visit #4 (1/2)
2nd data collection

Visit #4 (2/2)
original prosthesis
3th data collection

Original prosthesis:

1. transradial MYOBOCK hand prostheses and
2. MYOBOCK wrist rotator
3. conventional control

pattern recognition controller (in development)

Prosthetic control – home use study

Participants

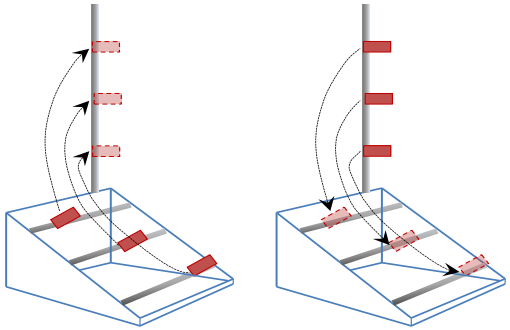
- 6 patients, 2nd follow-up for 5 participants

Demographic data	
age (year)	45 ± 16.0 (range: 22 - 68)
gender	83% male (5)
amputation cause	100% trauma (6)
time since amputation (year)	**7 ± 7.9 (range: 1 - 21)**
amputation side	83% left (5)
conventional control	33% co-contraction (2); **67% 4-channel control (4)**
hours of wearing a prosthesis / day	**8 ± 4.7 (range: 2 - 12)**

Pattern recognition – home use study

Clinical tests

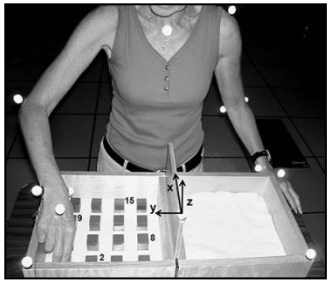
Clothespin Relocation Test

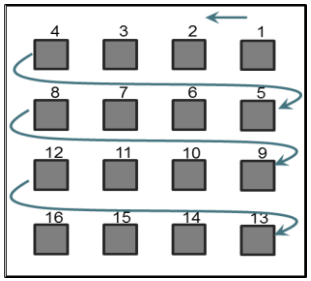


from horizontal to vertical bar

from vertical to horizontal bar

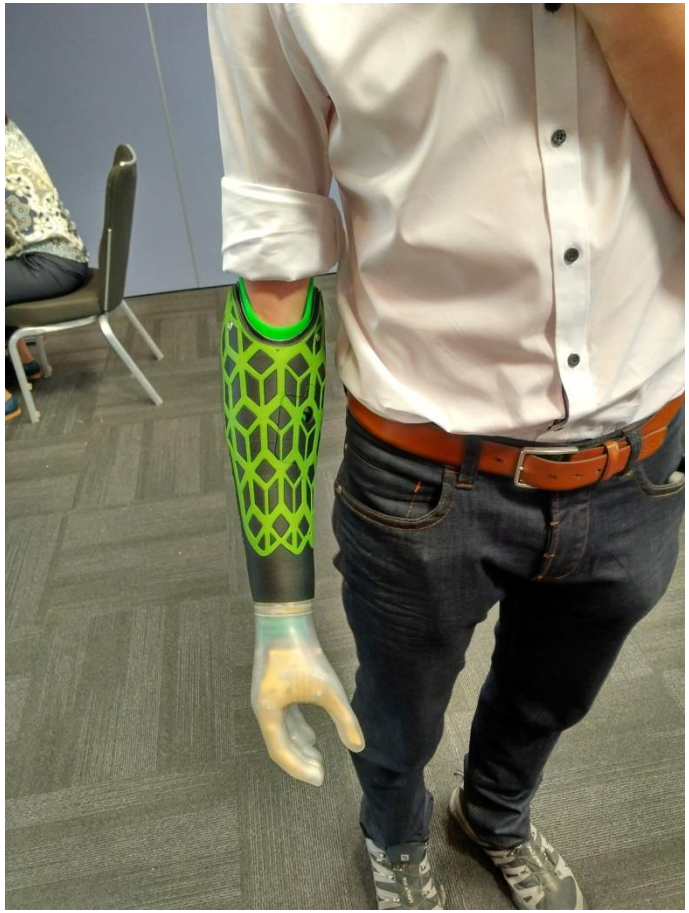
Modified Box and Blocks test





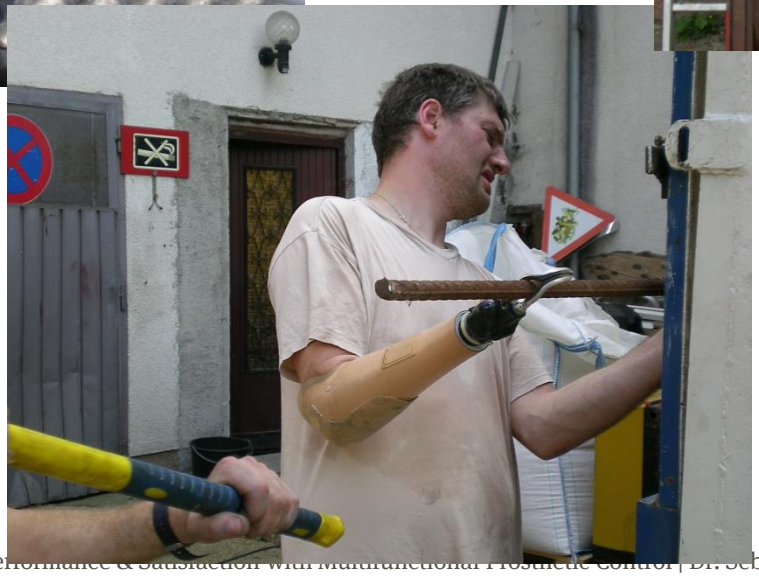
Pattern recognition – home use study

Socket examples (3D print)



Pattern recognition – home use study

Real-world use

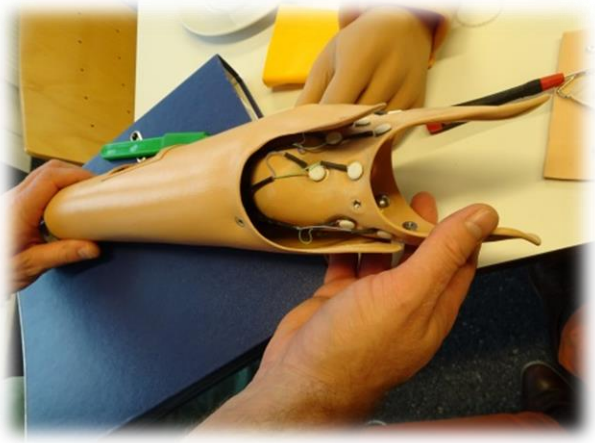


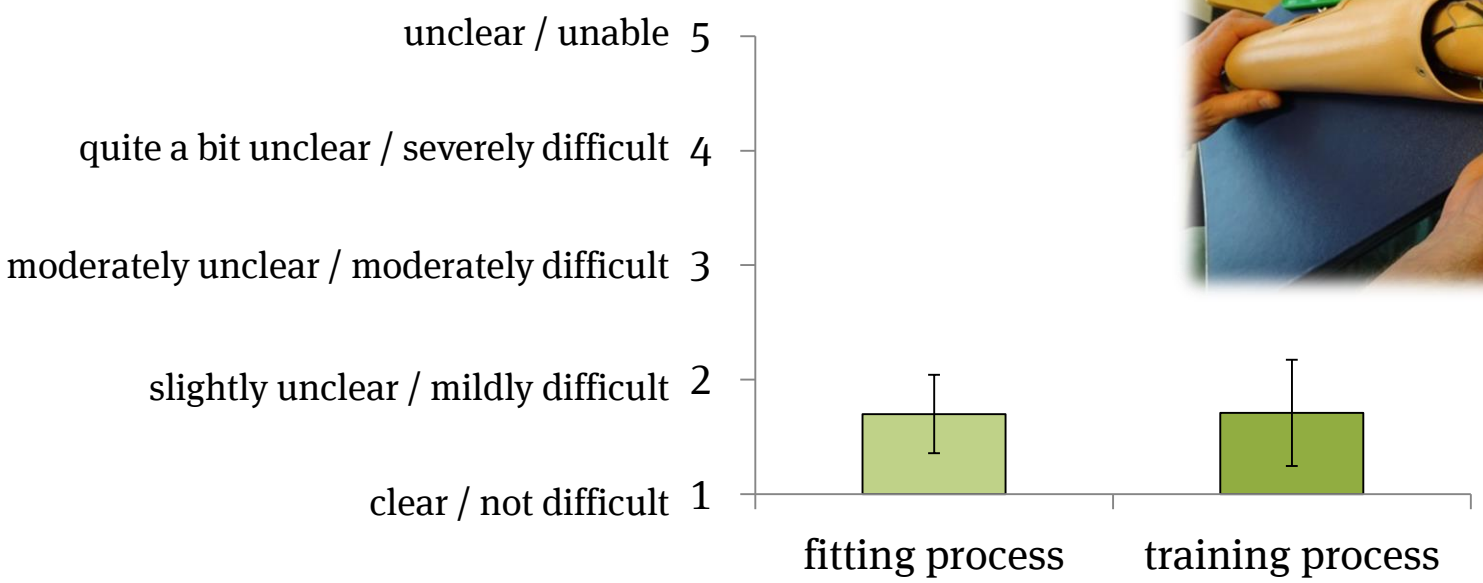
Pattern recognition – home use study

Results

CPO evaluation of training and fitting process

- all participants were satisfyingly fitted within the first visit



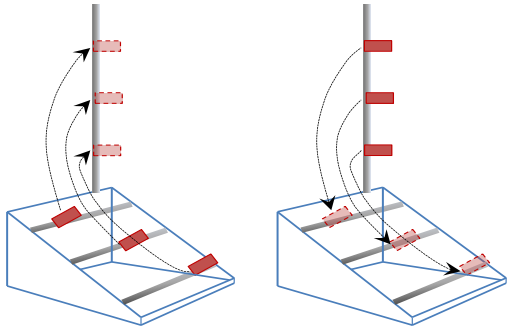


Pattern recognition – home use study

Results

Performance based tests

Clothespin Relocation Test



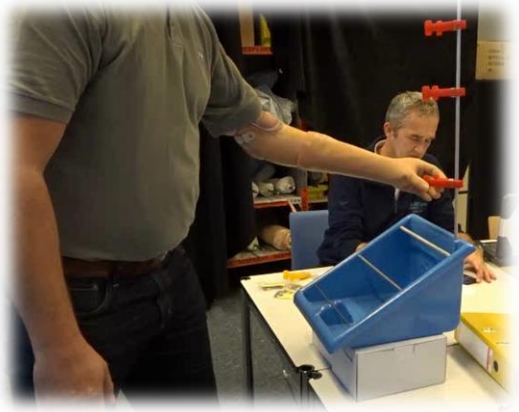
from horizontal to vertical bar

from vertical to horizontal bar

- The ability to control **<u>two degrees of freedom</u>** was tested with clothespin relocation test.

conventional control

pattern recognition control

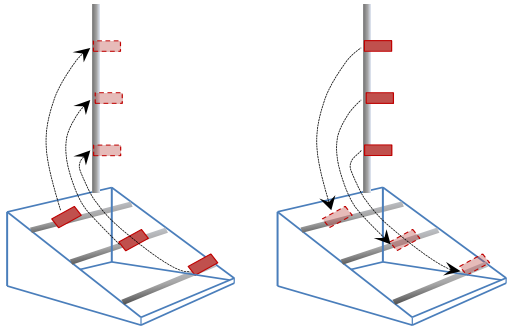


Pattern recognition – home use study

Results

Performance based tests

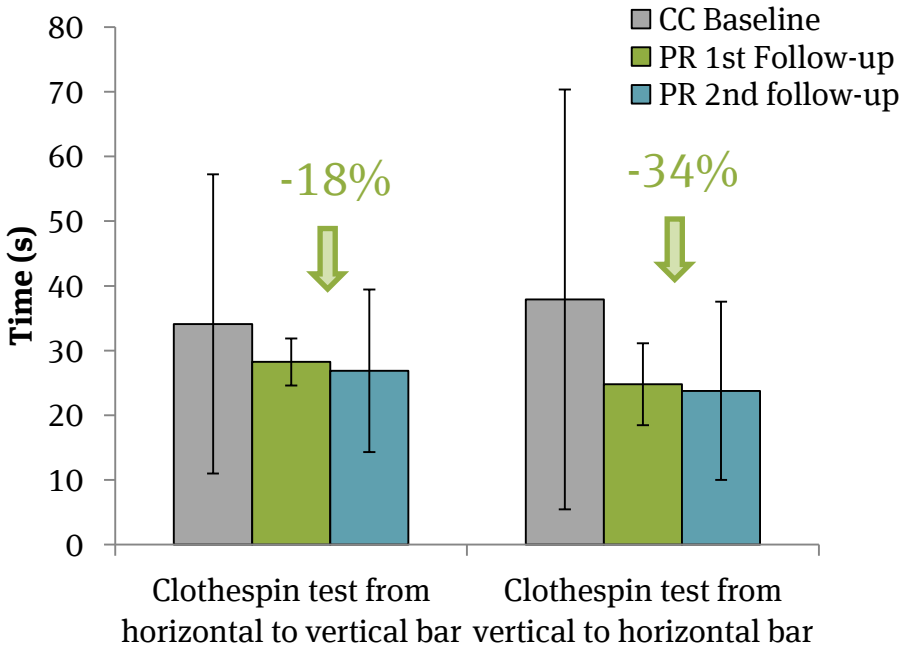
Clothespin Relocation Test



from horizontal to vertical bar

from vertical to horizontal bar

- The ability to control **<u>two degrees of freedom</u>** was improved immediately after pattern recognition fitting and remained consistent after 1 month of PR home use.
- Improvement in <u>5 of 6</u> patients.

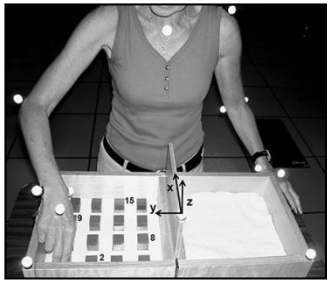


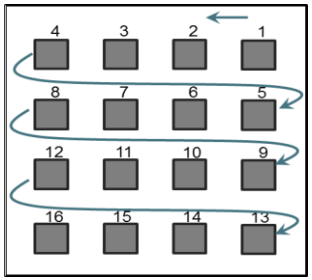
Pattern recognition – home use study

Results

Performance based tests

Modified Box and Blocks test





- The ability to control **<u>one degree of freedom</u>** was tested with mB&B test.

conventional control

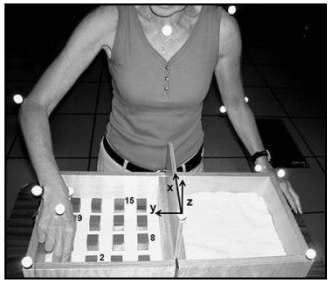
pattern recognition control

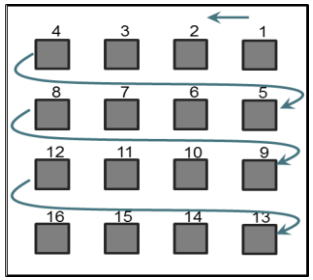
Pattern recognition – home use study

Results

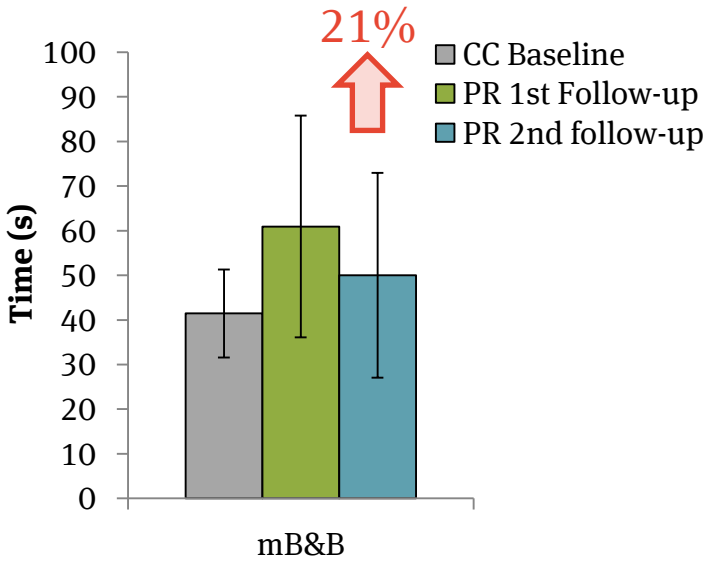
Performance based tests

Modified Box and Blocks test





- The ability to control **<u>one degree of freedom</u>** was prolonged after the fitting with PR, and after 1 month of PR home use when compared to the baseline.
- Improvement in **<u>1 of 6</u>** patients.



Pattern recognition – home use study

Results

Performance based tests

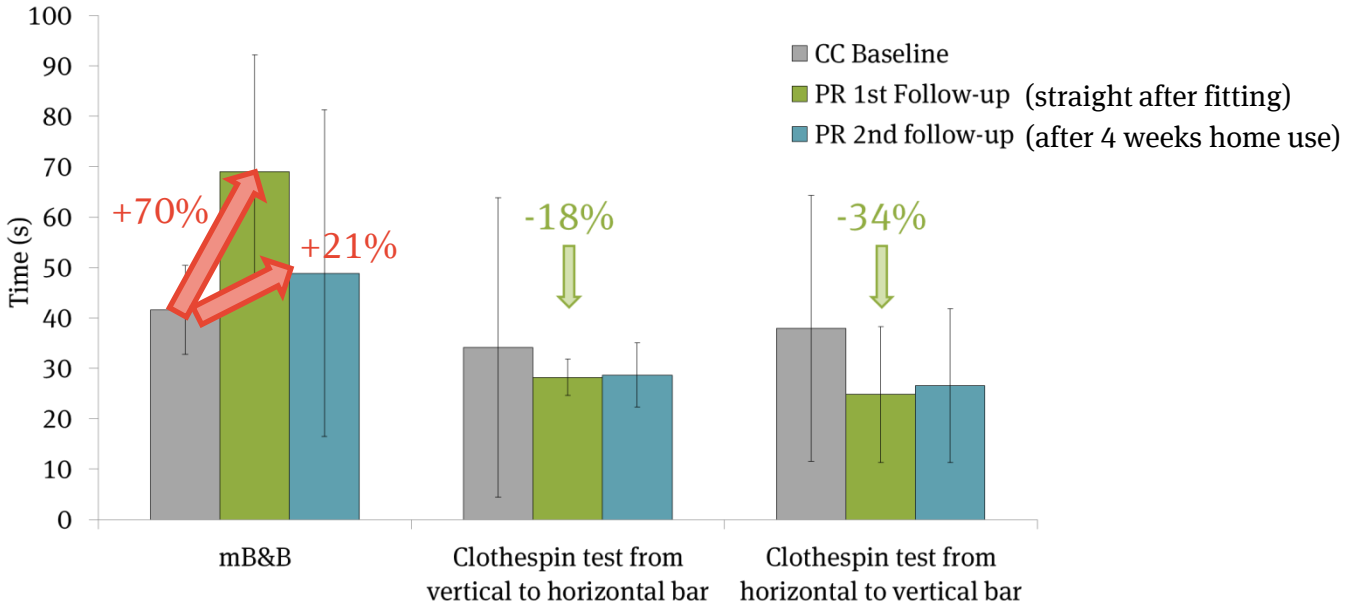
Proportional control test

- User´s proportional control was slightly improved with pattern recognition control.

	CC baseline	PR 1st follow up	PR 2nd follow up
Yellow clothespin (5N)	4.2 ± 1.15	5.2 ± 0.76	4.2 ± 1.30
Blue clothespin (30N)	4.1 ± 1.34	3.2 ± 0.27	3.0 ± 0.00

Pattern recognition – home use study

Results - Summary



Conclusion:

Simple open-close manipulations: Conventional Control (CC) is prefered

Complex, life-like manipulations: Pattern Recognition (PR) is prefered

Pattern recognition – home use study

Unstructured feedback from users

- Signal artefacts compromised control
- A software update during the run-time of the study fixed this problem

➢ Major outcome of the study for our product in development!

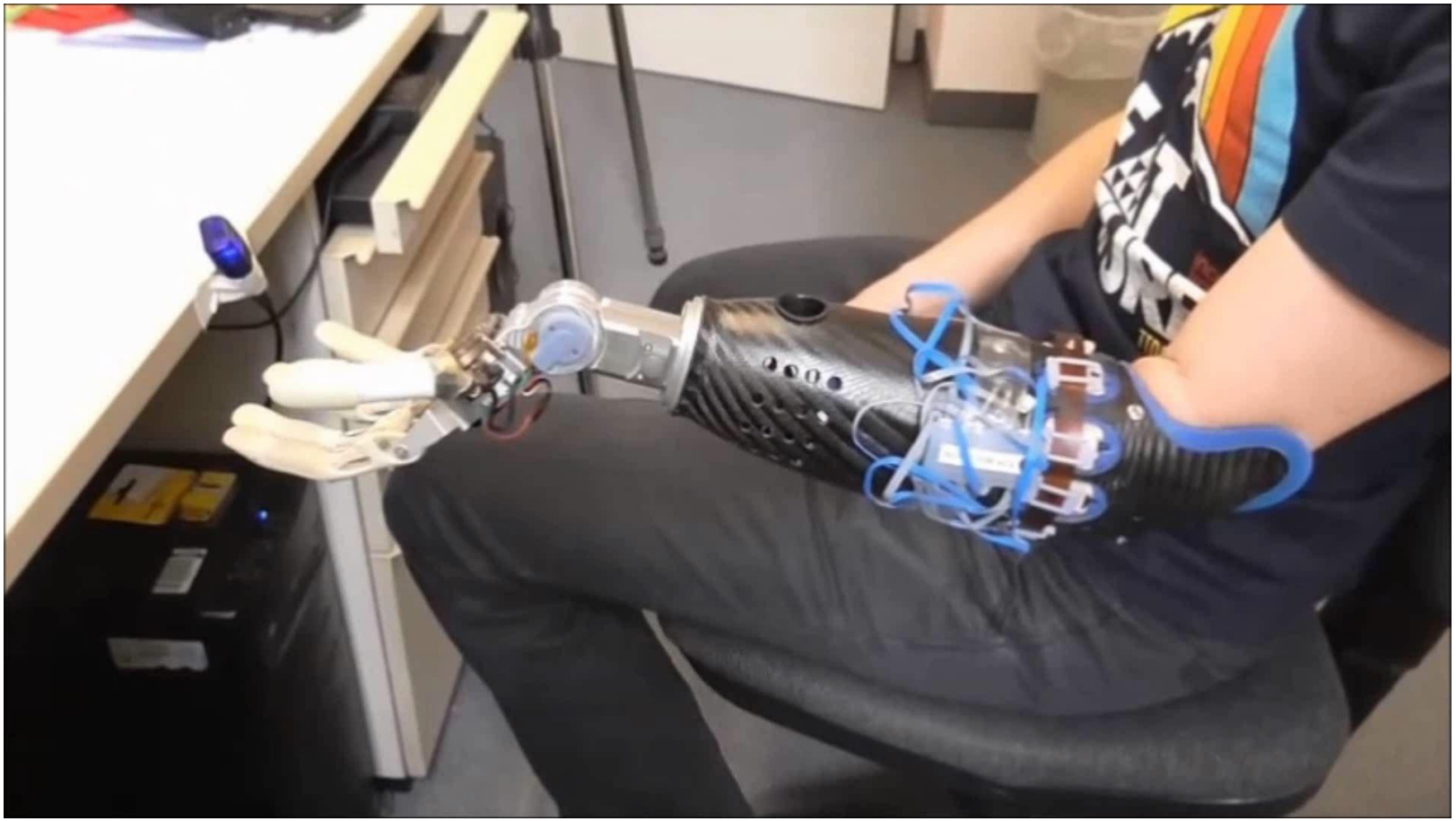
Pattern recognition – home use study

Unstructured feedback from users

Pattern recognition – home use study
Study limitations

- **Only one month of home use**
- **Only 2-DOF (Open/Close and rotation)**
- **No data recording for usage statistics**
- **SHAP or other more complex tests were too time consuming**

One step further
Simultaneous control



One step further
Simultaneous control

One step further – simultaneous control

User feedback

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Thank you very much for your attention!

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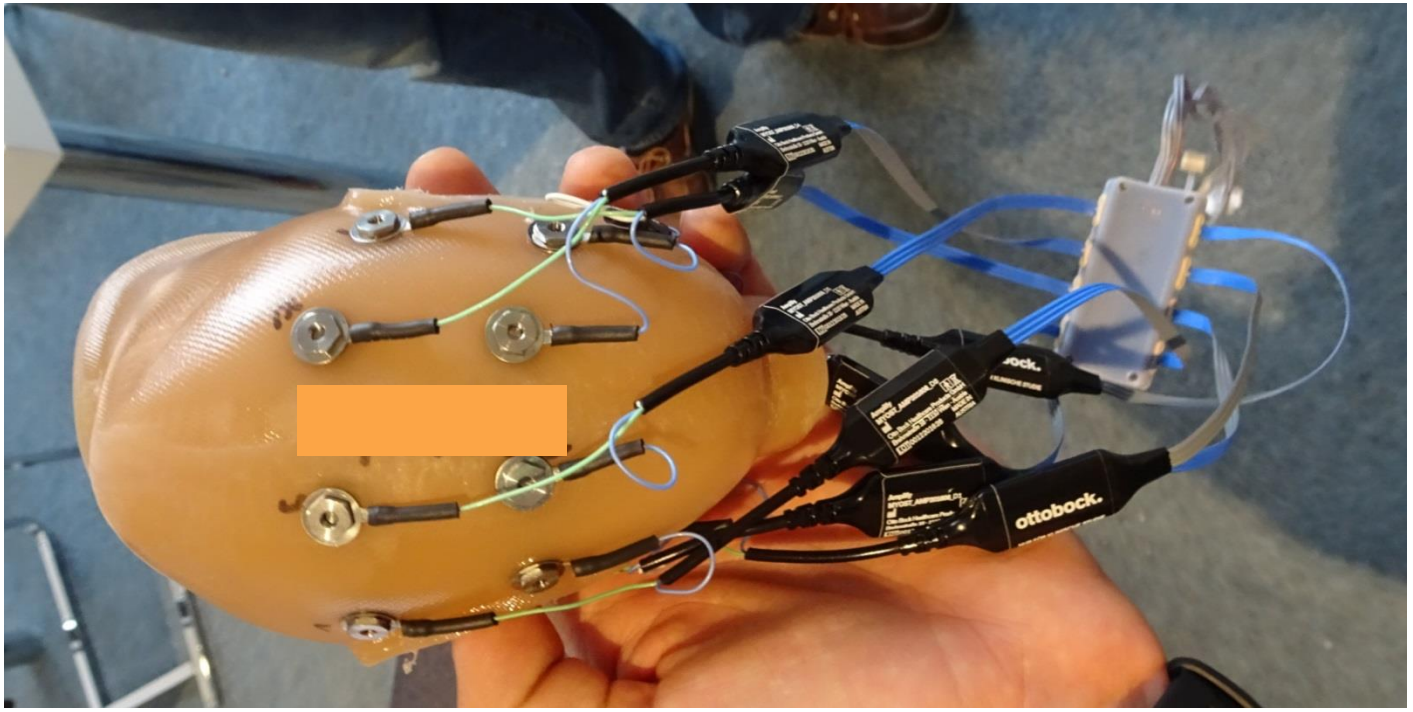
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Intuitive multifunctional hand prosthesis control

Early steps

Herberts & Caine (1978), *J Bone and Joint Surgery. British Volume, 60-B*(4)