BIORAZGRADLJIVI NANOSENZORJI, KOMUNIKACIJA ČLOVEK-STROJ-ČLOVEK IN DRUŽABNA OMREŽJA PRIHODNOSTI

Univerza v Mariboru
Fakulteta za elektrotehniko, računalništvo in informatiko

Aleš Holobar
Fakulteta za Elektrotehniko, Računalništvo in Informatiko, Univerza v Mariboru
ales.holobar@uni-mb.si

10. Nanotehnološki dan
Gospodarsko razstavišče, Ljubljana, 18. april 2013

NeuroTREMOR
SEVENTH FRAMEWORK PROGRAMME
REPUBLIKA SLOVENIJA
MINISTRSTVO ZA IZOBRAŽEVANJE, ZNANOST, KULTURO IN ŠPORT
OBRTNO-PODJETNIŠKA ZBORNICA SLOVENIJE

Pregled predavanja

- komunikacija
  - človek-človek
  - človek-stroj
  - možgani-stroj-možgani
- nano- in biosenzorji
- protetika
  - napredno krmiljenje protez (MUV, Ottobock, UMG, UM FERI)

© Tokyo University, http://www.robaid.com

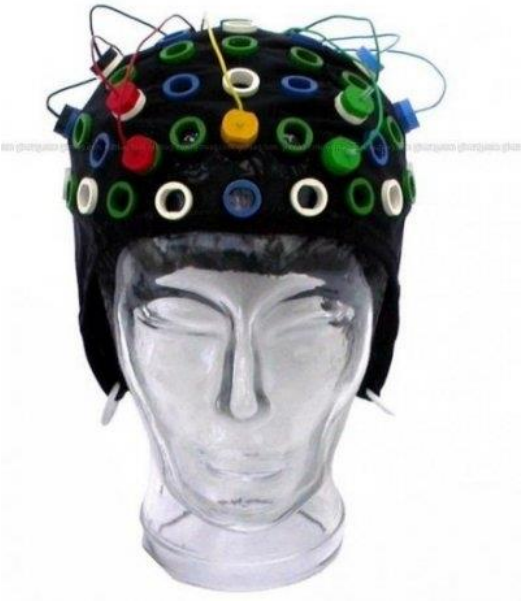
vir: http://www.multitouch-barcelona.com

vir: http://www.openthemagazine.com

Neverbalna komunikacija

http://esciencecommons.blogspot.com/2011/03/key-facts-about-nonverbal-communication.html
http://cwrite1.wordpress.com/tag/digital-communication/

Komercialni vmesniki možgani-stroj

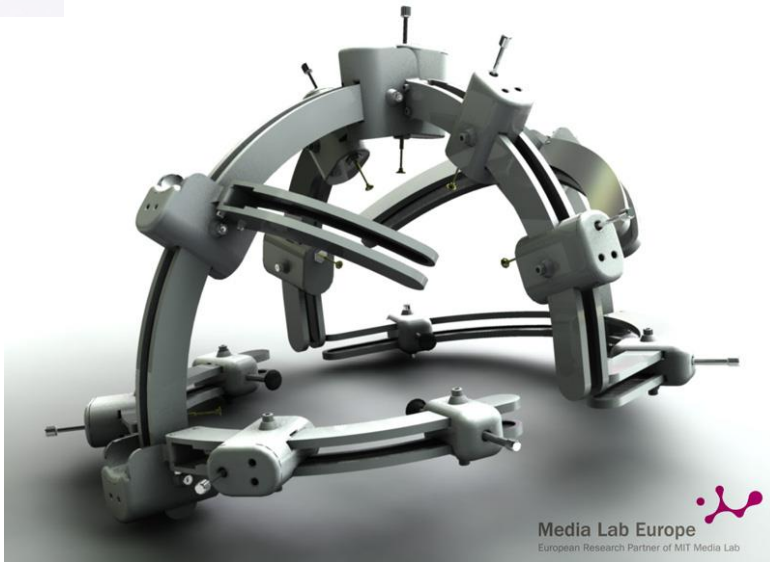


g.tec

Berlin BCI

Emotiv

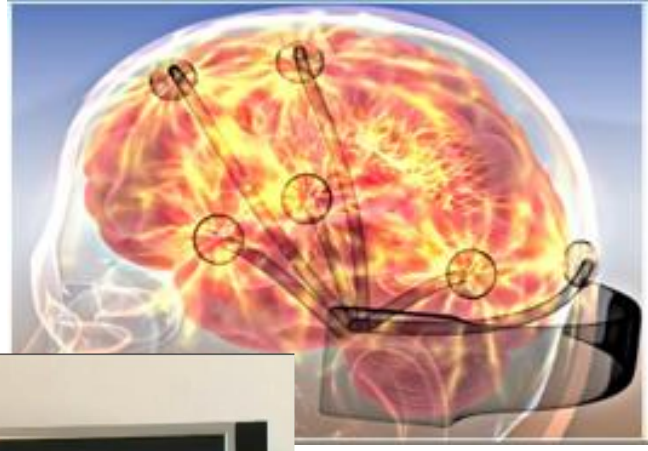
Emotiv Systems



Media Lab Europe

Vmesniki možgani-stroj

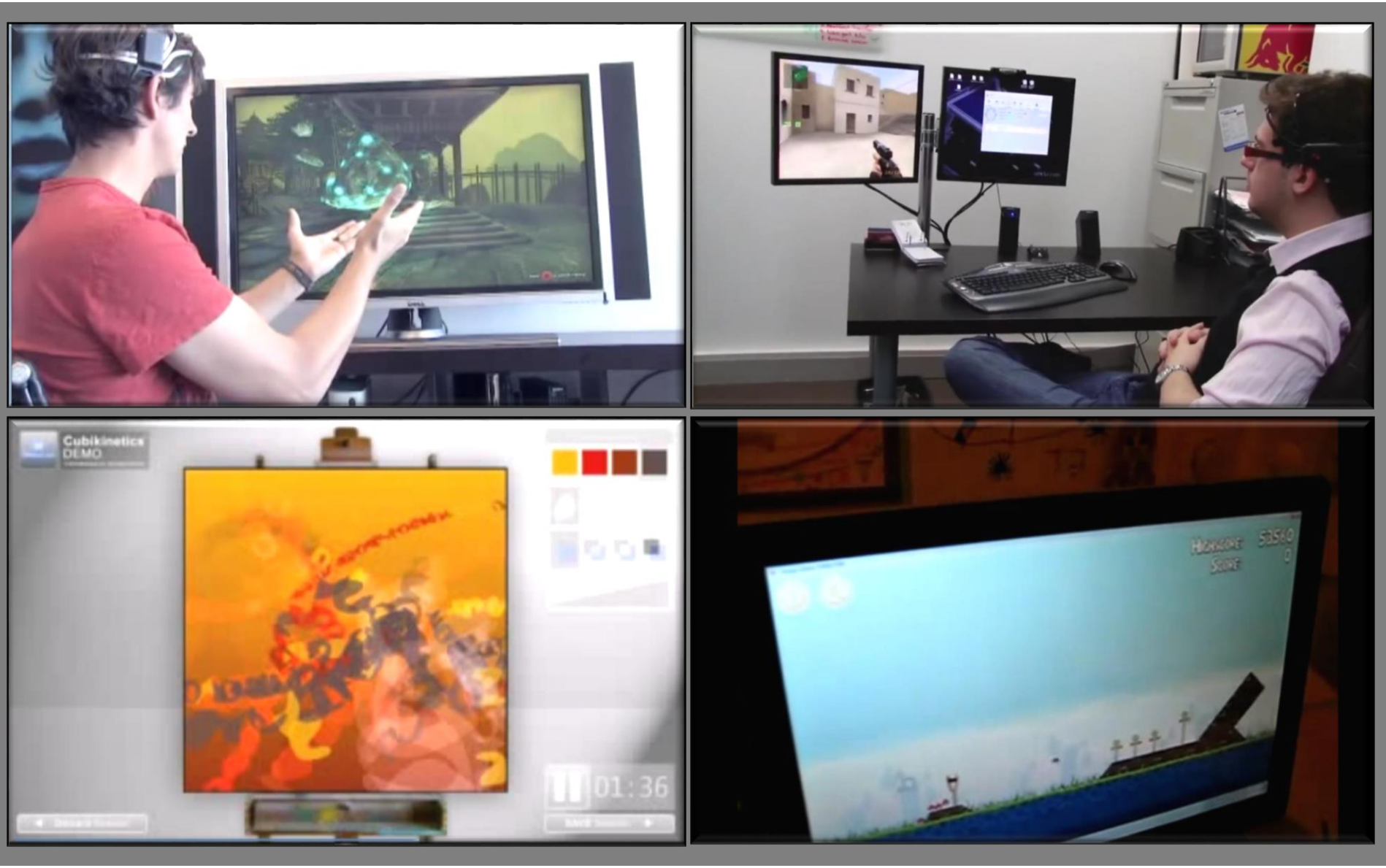
- realnočasovno zaznavanje uporabnikovih odzivov na dražljaje in razpoloženja
- zaznavanje miselnega sodelovanja
- prilagajanje virtualnega okolja in bivalnih prostorov razpoloženju uporabnika
- prilagajanje in personalizacija grafičnih vmesnikov
- igranje računalniških iger (igra, ki se odziva na uporabnikova čustva)
- neverbalna komunikacija na daljavo



© http://www.emotiv.com/

© http://milab.imm.dtu.dk/eeg

Vmesniki BCI: aplikacije



vir: http://www.emotiv.com

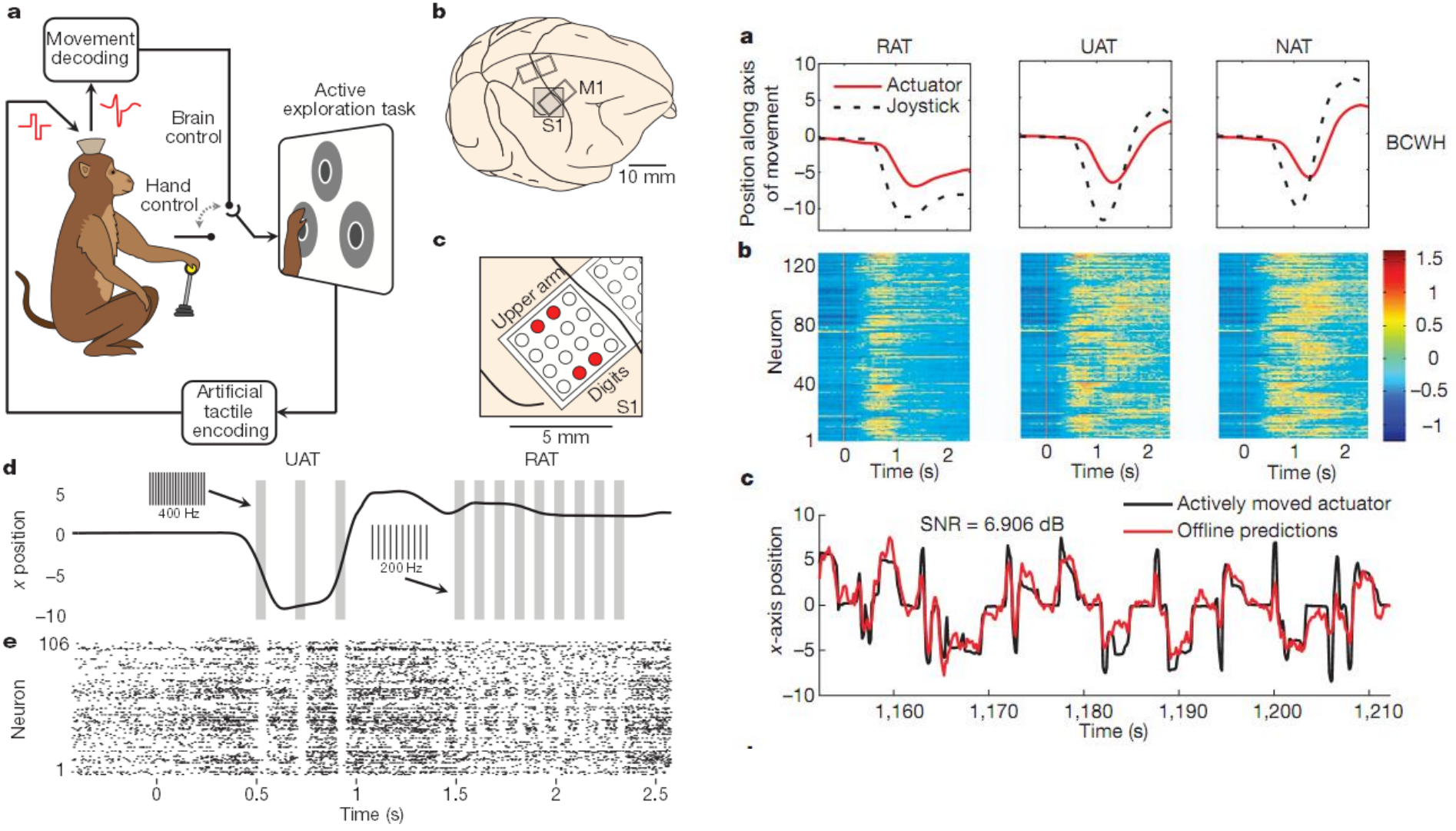
Branje kodov vizalnega korteksa

Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies

S. Nishimoto et al. Current Biology 21(19): 1641-1646

Taktilni vmesniki možgani-stroj

Active tactile exploration using a brain–machine–brain interface



J. E. O'Doherty et al. 228 | NATURE | VOL 479 | 10 NOVEMBER 2011

Vmesniki možgani-možgani

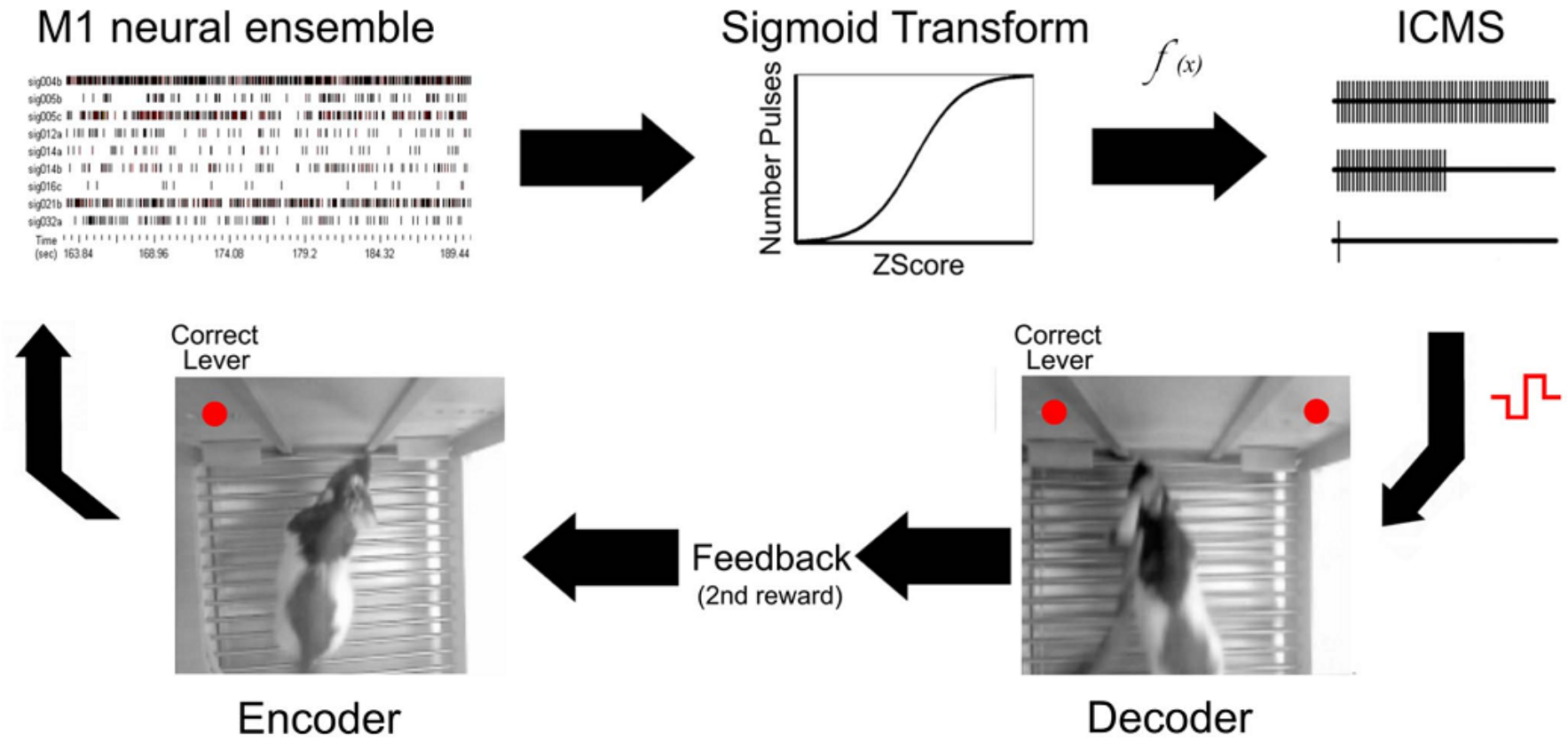
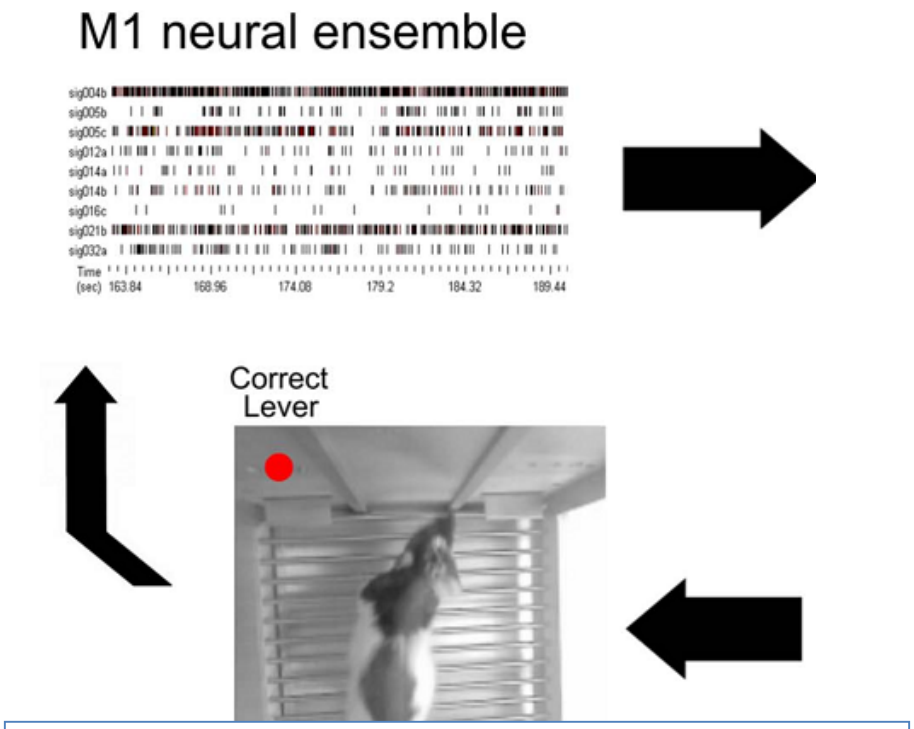
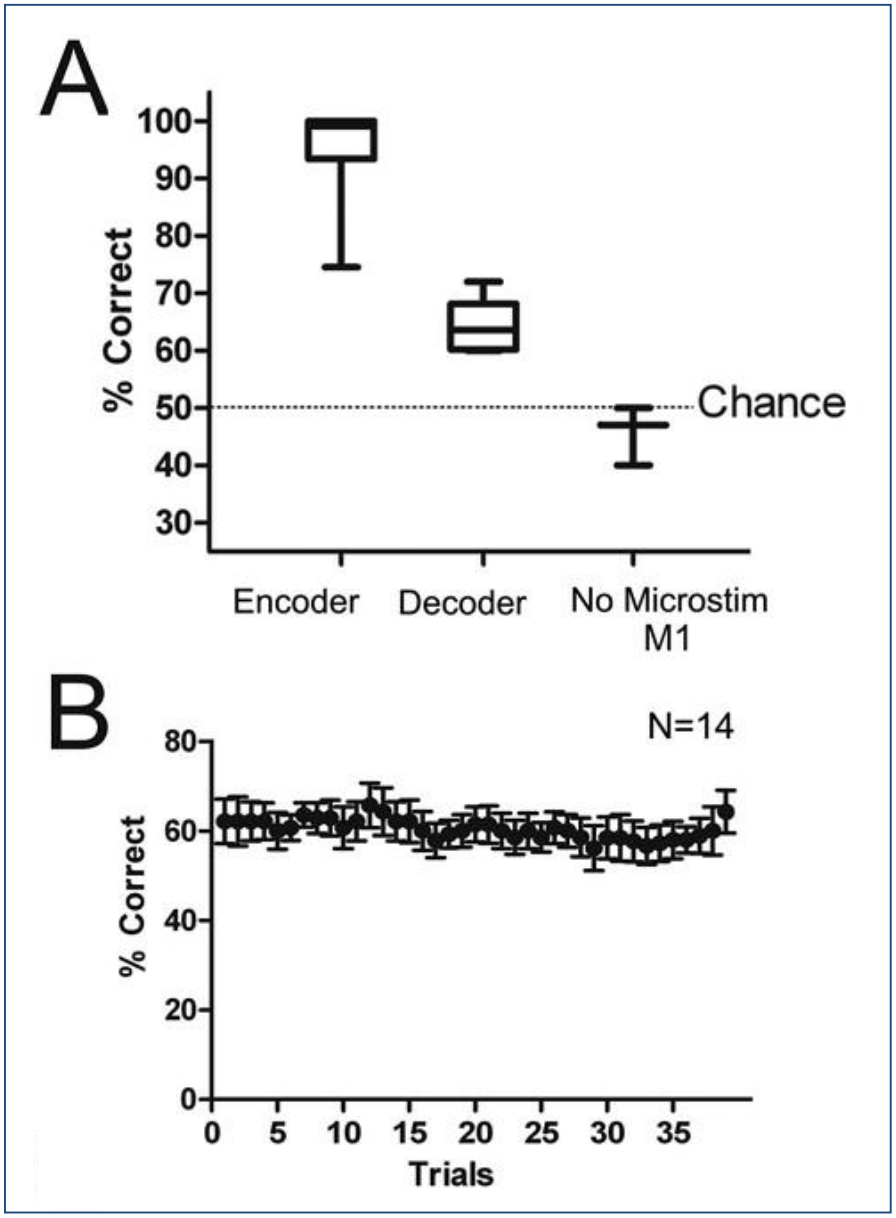


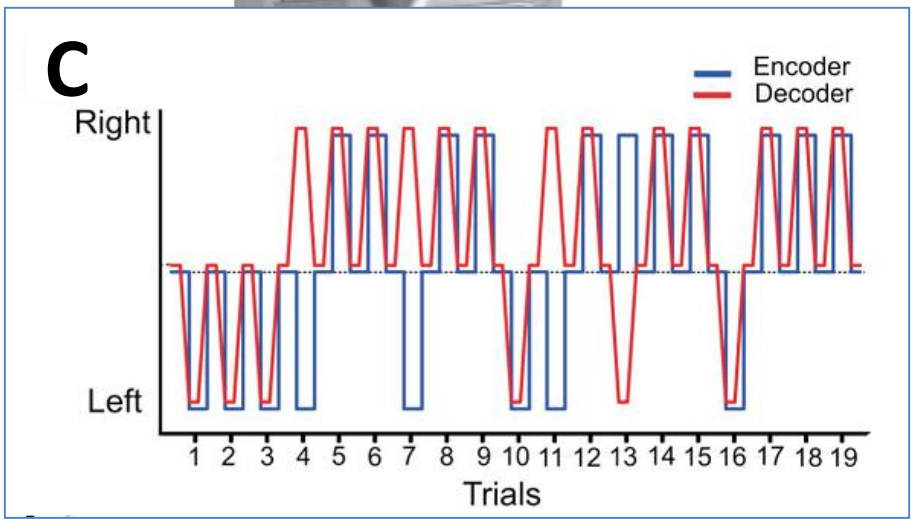
Figure 1 | Experimental apparatus scheme of a BTBI for transferring cortical motor signals. Arrows represent the flow of information from the encoder to the decoder rat. In the motor task, the encoder rat has to identify a visual stimulus, signaled by an LED (red circle), and then press one of two levers to receive a small water reward. Meanwhile, M1 neural activity is recorded from the encoder rat and transmitted to the decoder animal, by comparing the pattern of the encoder's M1 to a template trial (previously built with the firing rate average of a trial sample). The difference between the number of spikes in a given trial and the template trial is used to calculate a Zscore. The Zscore is then converted, through a sigmoid function centered on the mean of the template trial, into an ICMS pattern. Thus, the microstimulation patterns varied in real time, according to the number of spikes recorded from the encoder rat's M1, on a trial by trial basis. Once microstimulation is delivered to the M1 cortex of the decoder rat, this animal has to select the same lever pressed by the encoder. Notice that the correct lever to press is cued only by the pattern of the decoder's M1 microstimulation. If the decoder rat pressed the correct lever, both rats were rewarded. Thus, when the information transfer between the brains of the two rats was successful, the encoder rat received an additional reward that served as positive reinforcement.

vir: M. Pais-Vieira et al. Nature, Scientific reports | 3 : 1319 | DOI: 10.1038/srep01319

Vmesniki možgani-možgani





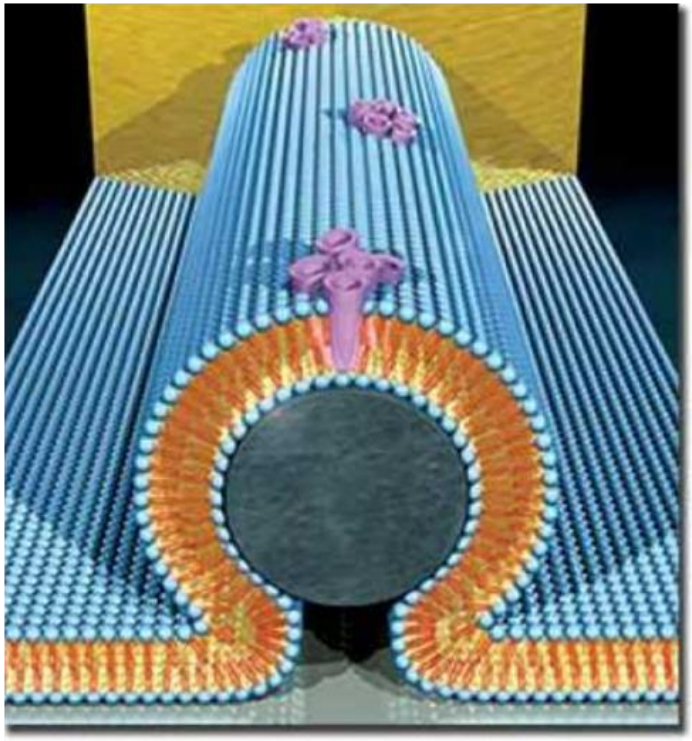


vir: M. Pais-Vieira et al. Nature, Scientific reports | 3 : 1319 | DOI: 10.1038/srep01319

Nanoelektronika in biološke komponente

Nanoelectronic transistor combined with biological machine

- elektronika: električna polja in tokovi
- biologija: množica receptorjev, membranskih kanalov, aktivnih črpalk…
- bio-zaznava in diagnostika



<u>Nanožice, prevlečene z lipidi</u>

- v sredini je nanožica
- okoli nje membrana - stabilna, samo-obnovljiva, neprehodna ovira za ione in molekule.
- pore v membrani lahko odpiramo/zapiramo s pomočjo električne napetosti
- membrana lahko vsebuje tudi biološke receptorje in proteinskih vezij.

vir: http://www.robaid.com/tech

Samorazgradljiva elektronska vezja

transient electronics

Biokompatibilna vezja, ki po določenem času delovanja (nekaj minut, dni ali tednov) razpadejo, okolje pa jih resorbira.

- ultratanka (nekaj deset nanometrov),
- običajni materiali (silicij in magnezij), nanesena na svilo
- se razgradijo v vodi ali telesnih tekočinah
- nanotehnologija omogoča nadzor nad časom delovanja (koliko časa potrebujejo vezja/svila za svoj razpad)

vir: http://www.robaid.com/tech

Epidermalna elektronika

Epidermal Electronics

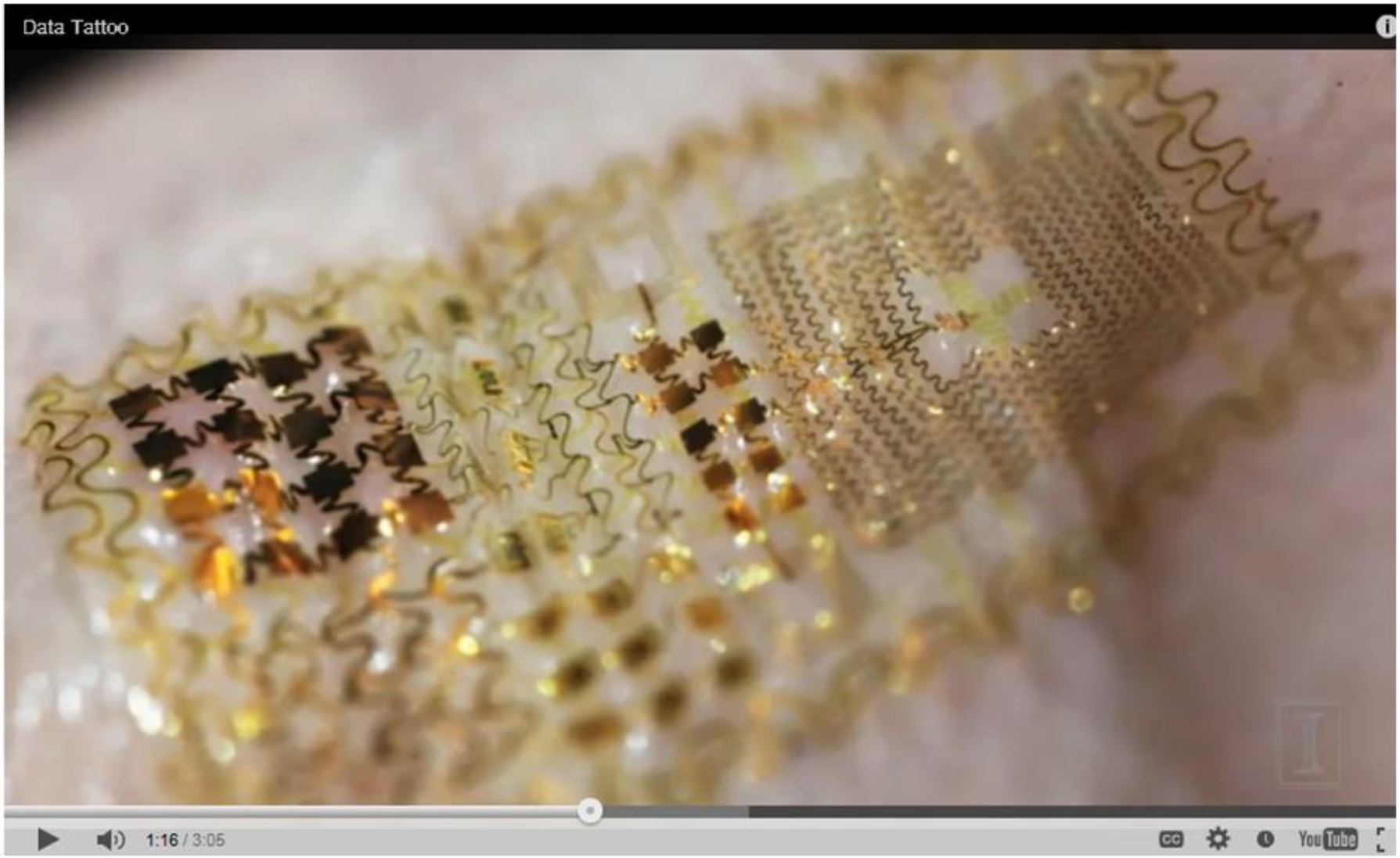
- tanka fleksibilna vezja, ki se namestijo na površino kože
- omogočajo zaznavo bioloških električnih potencialov: EMG, EKG, EEG
- uporabnost: vmesniki človek-stroj, komunikacije, diagnostika…
- načrtovana nadgradnja s komponentami Wi-Fi -> sistemi senzorjev

- upogljiva in raztegljiva vezja, ki sledijo mehaniki kože
- na kožo jih namestimo s pomočjo vode, tako kot samolepljive tatuje.
- povezave in senzorji so serpentinastih oblik, naneseni so na gumijasto podlago.
- napajanje preko indukcijskih tuljav in solarnih celic.

Kim et al. Science, 333 (6044); 838-843, 2011

Epidermalna elektronika

Epidermal Electronics



vir: http://www.robaid.com/tech

Elektronska koža

E-Skin

- združuje prevodnost kovin in fleksibilnost gume/polimerov
- taktilni senzorji, zaznava potenja, telesne temperature, svetlobe, vlažnosti, ultrazvoka…
- široko področje uporabe: v robotiki, avtomobilski industriji, nevroprotetiki…

© Prof. T. Someya, Tokyo University

- elektronska koža iz organskih tranzistorjev in ogljikovih nanocevk, nanesenih na polimere.
- razteg za faktor 1.7 brez izgube prevodnosti
- razteg za faktor 2.3 ob polovični izgubi prevodnosti

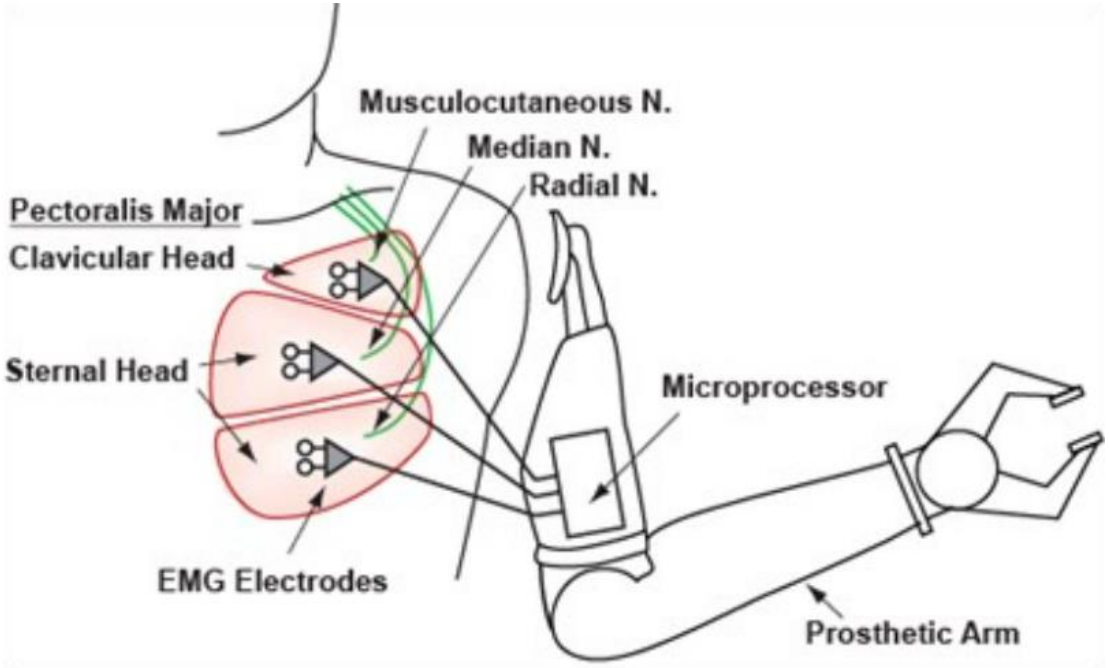
vir: http://www.robaid.com/tech

Bionika in nevroprotetika

ottobock.

Presaditev živca in reinervacija mišic

Targeted Muscle Reinnervation



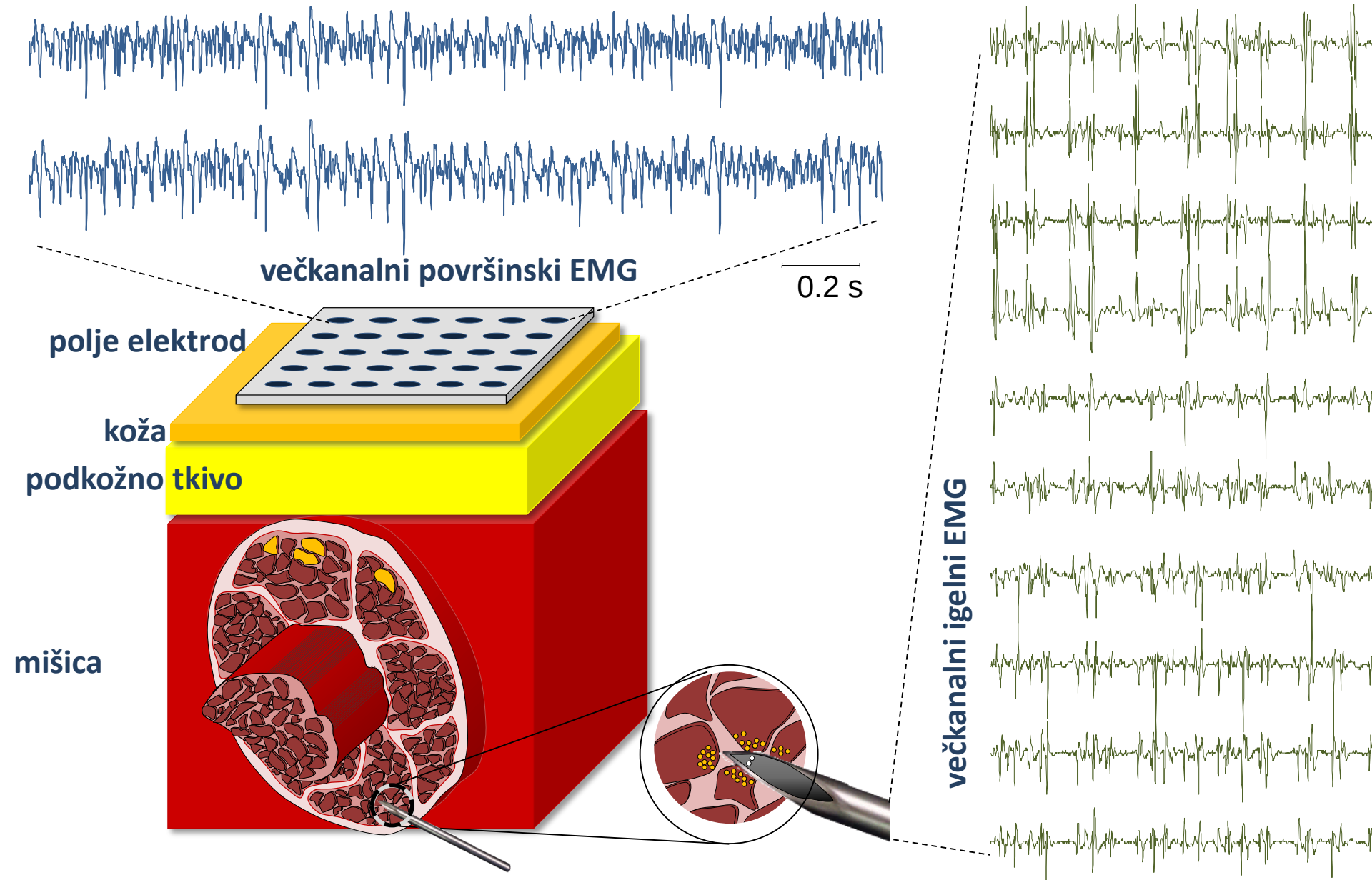
T. A. Kuiken et al. :Targeted Muscle Reinnervation for Real-Time Myoelectric Control of Multifunction Artificial Arms, JAMA 301, 619–628

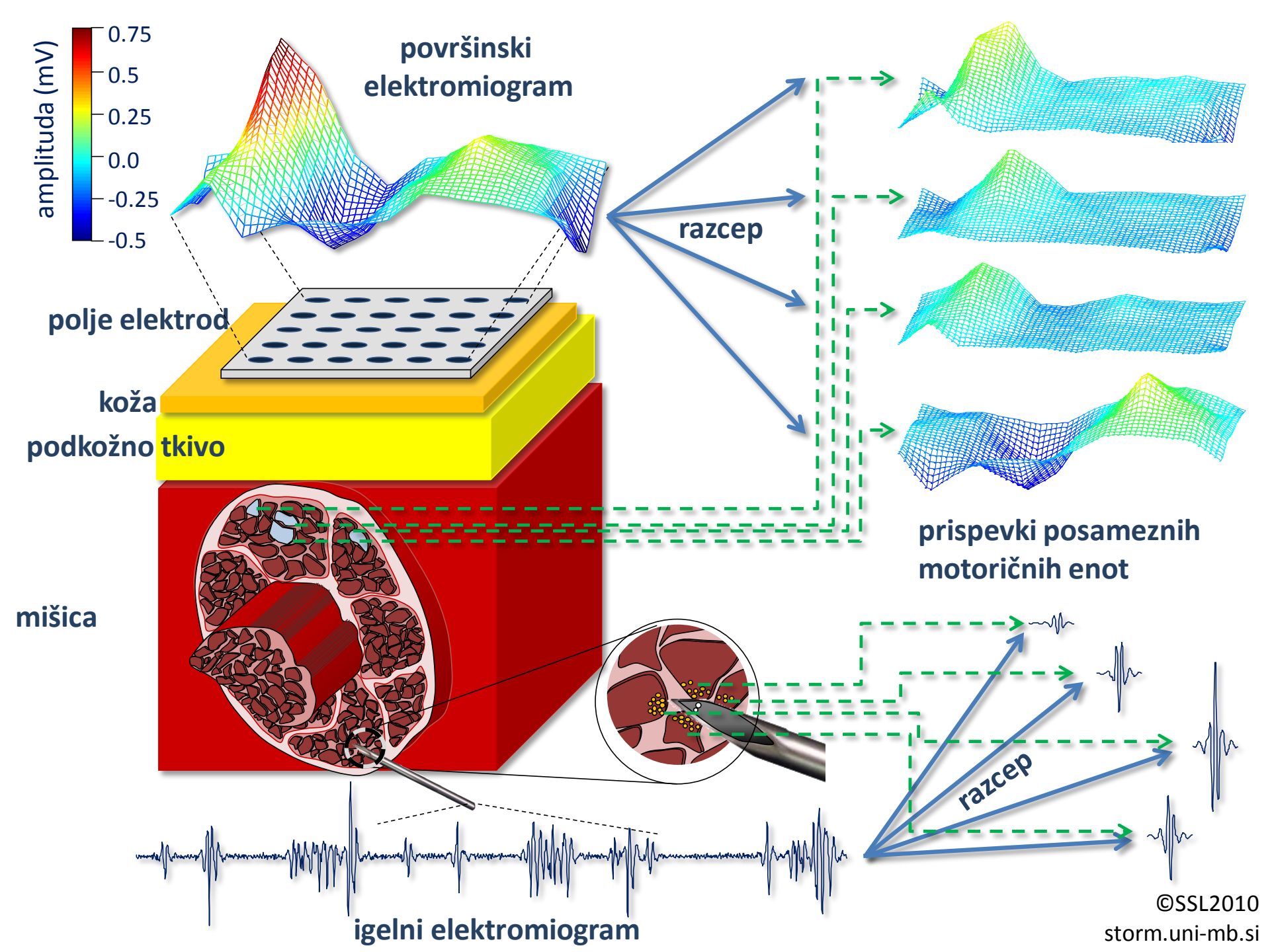
Rehabilitation Institute *of* Chicago

Reinervacija mišic

ottobock. MEDICAL UNIVERSITY OF VIENNA UMG Univerza v Mariboru

Večkanalni elektromiogrami (EMG)

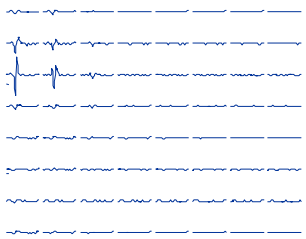



amplituda (mV)
0.75
0.5
0.25
0.0
-0.25
-0.5
površinski elektromiogram
razcep
polje elektrod
koža
podkožno tkivo
mišica
prispevki posameznih motoričnih enot
razcep
igelni elektromiogram
©SSL2010
storm.uni-mb.si

Reinervacija mišic

fleksija komolca - matrika M1

ME 1

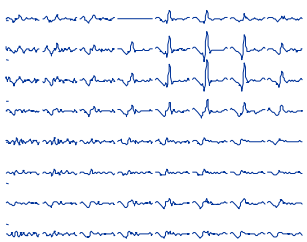


ME 2

ME 3

ME 4

ME 5



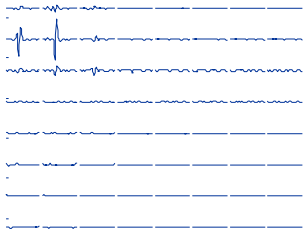
ME 6

ME 7

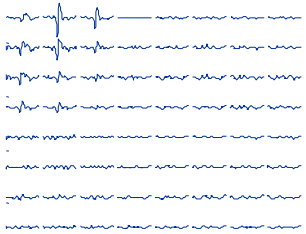
ME 8

ME 9

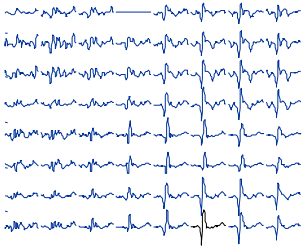
ME 10



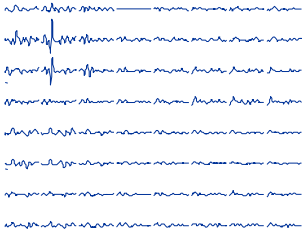
ME 11



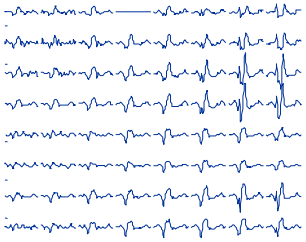
ME 12

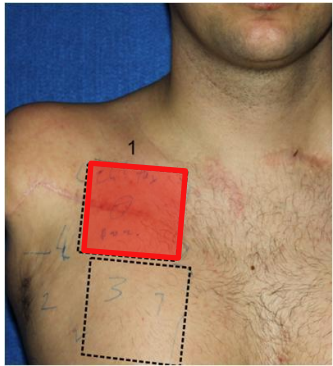


ME 13



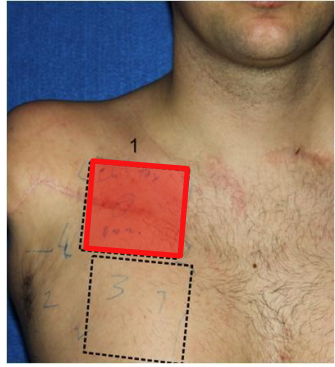
ME 14





Reinervacija mišic

fleksija komolca - matrika M1



fleksija

fleksija

frekvenca proženja motoričnih enot (Hz)

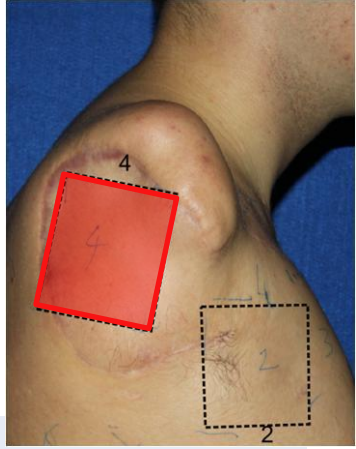
0 5 10 15 20 25 30 35 40 45

0 2 4 6 8 10 12 14 16 18

čas (s)

Reinervacija mišic

fleksija komolca - matrika M4



fleksija

fleksija

frekvenca proženja motoričnih enot (Hz)

0
5
10
15
20
25
30
35

0
2
4
6
8
10
12
14
16

čas (s)

Zaključek

Nanotehnologija odpira številne nove možnosti v komunikaciji človek-stroj-človek:

- biorazgradljivi nanosenzorji: zaznava električnih potencialov človeškega telesa
- fleksibilni nanosenzorji toplote, električnih potencialov, ultrazvoka, pritiska, gibanja…
- taktilni vmesniki in intuitiven/naraven nadzor aktivnih mehanskih protez, ortotičnih oblačil
- zaznava čustev in človeškega odziva na izbrane dogodke
- miselna (neverbalna) komunikacija na daljavo
- nove oblike druženja, komuniciranja

NeuroTREMOR
SEVENTH FRAMEWORK PROGRAMME
REPUBLIKA SLOVENIJA
MINISTRSTVO ZA IZOBRAŽEVANJE, ZNANOST, KULTURO IN ŠPORT
OBRTNO-PODJETNIŠKA ZBORNICA SLOVENIJE

Zahvala

- Department of Surgery, Division of Plastic & Reconstructive Surgery, Medical University of Vienna, Vienna, Austria
- Department of Neurorehabilitation Engineering. Bernstein Focus Neurotechnology Göttingen, University Medical Center Göttingen, Georg-August UniversityGöttingen, Germany
- Otto Bock Healthcare Products GmbH, Vienna, Austria
- Otto Bock Healthcare GmbH, Duderstadt, Germany

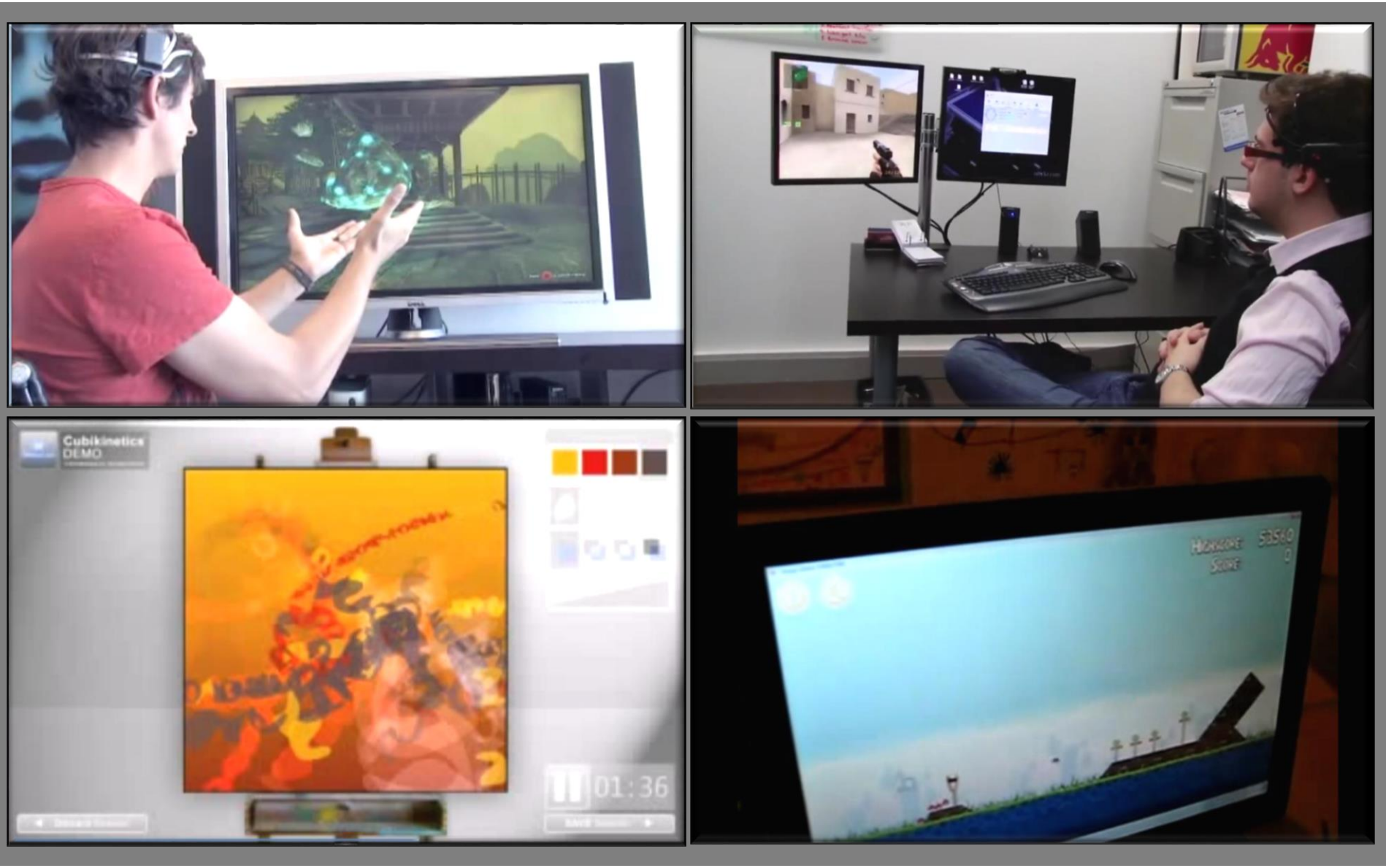
NeuroTREMOR PROJECT

A novel concept for support to diagnosis and remote management of tremor

http://www.car.upm-csic.es/bioingenieria/neurotremor/

This project is funded by the Commission of the European Union, within Framework 7, specific ICT Challenge 5 "ICT for Health, Ageing Well, Inclusion and Governance", Target outcome 5.1 ”Personal Health Systems (PHS)”, under Grant Agreement number ICT-2011.5.1-287739, "NeuroTREMOR: A novel concept for support to diagnosis and remote management of tremor."

Vmesniki BCI: aplikacije



vir: http://www.emotiv.com