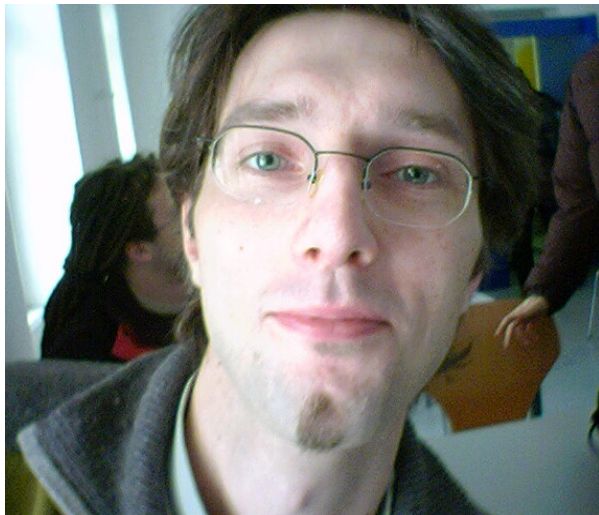


ICCHP – Young Researchers Consortium 2006

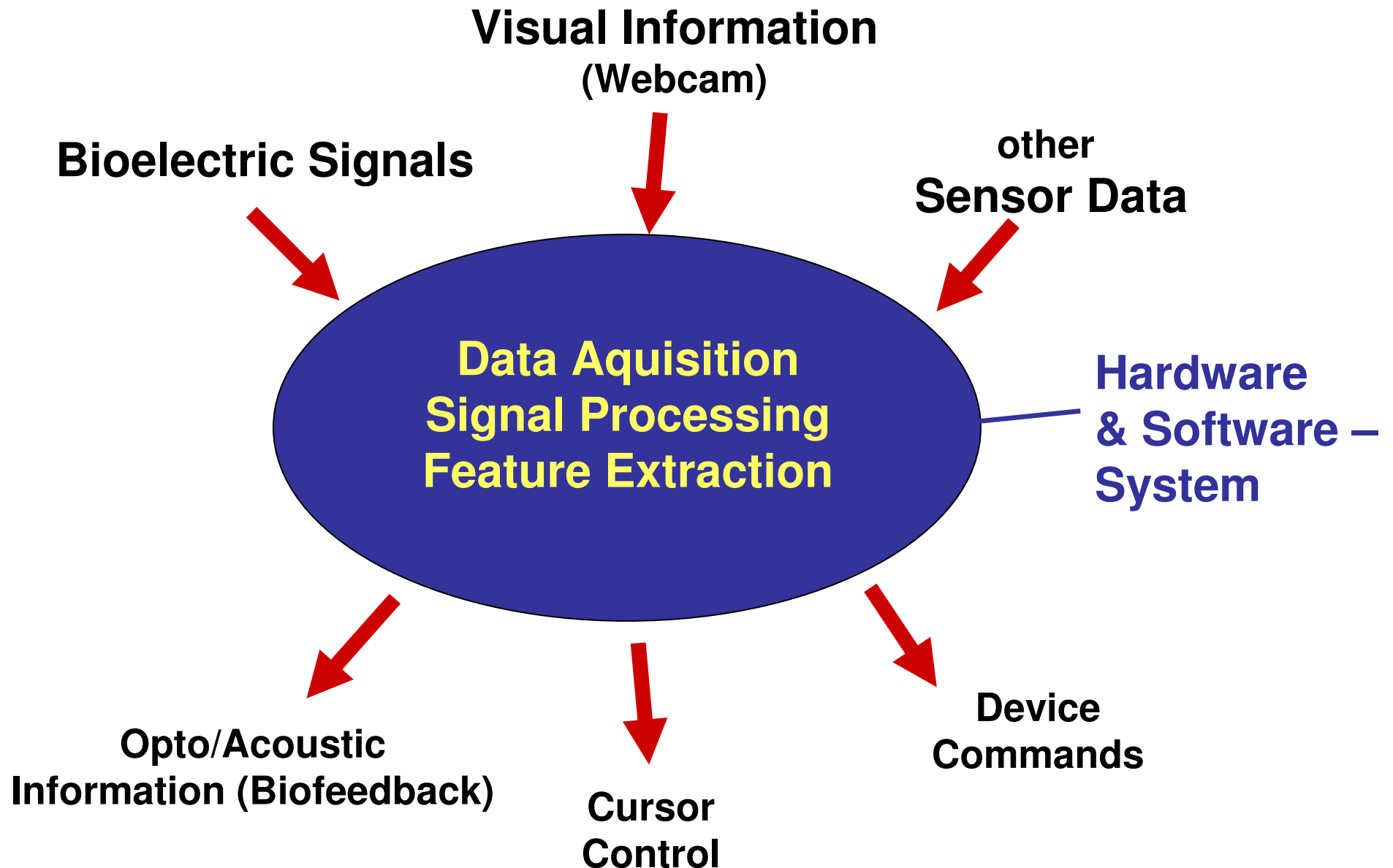
Christoph Veigl:

BrainBay - An Open Source Software
for Biosignal- and CameraMouse - Applications



Bacc. Software and Information Engineering,
Working on Thesis for Medical Informatics,
Institute “Integrated Study”,
Technical University Vienna

Basic Idea:



System Components:

Biosignal Amplifier + Electrodes

Mesurement and Digitalisation of Electric Body Signals

Digitalisation of Analog Sensors

(Movement, Temperature, Force, ..)

Webcam

Digitalisation of Real-Time Image

Software for Signal- and Image Processing,
Hardware-Communication, File Operations,
User Interface

Laptop or Desktop Computer

What can be measured:

Muscle Activity (**EMG**)

Heart Activity (**EKG**)

Brainwaves (**EEG**)

Eye Movements (**EOG**)

Breathing, Temperature, Skin resistance (**GSR**)

Movement (Acceleration)

Electrically

Position of Body Parts (eg. FACE)

Movement of Body Parts

Gaze Estimation (limited)

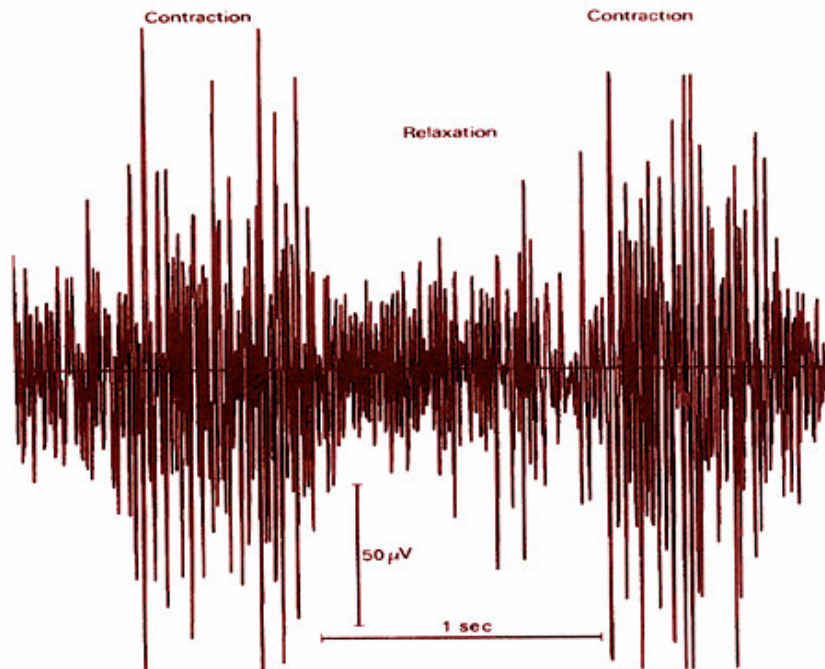
Pose estimation (limited)

Visually

EMG-Electrodes and recording

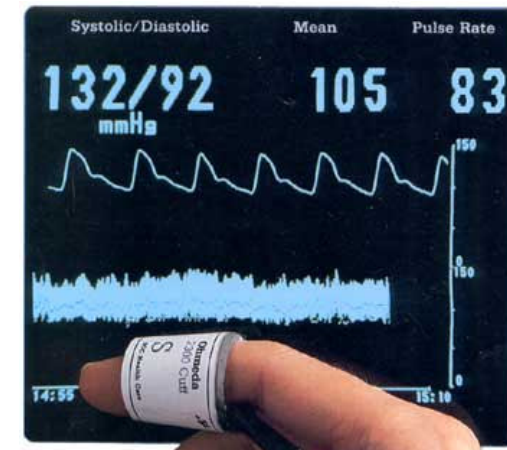
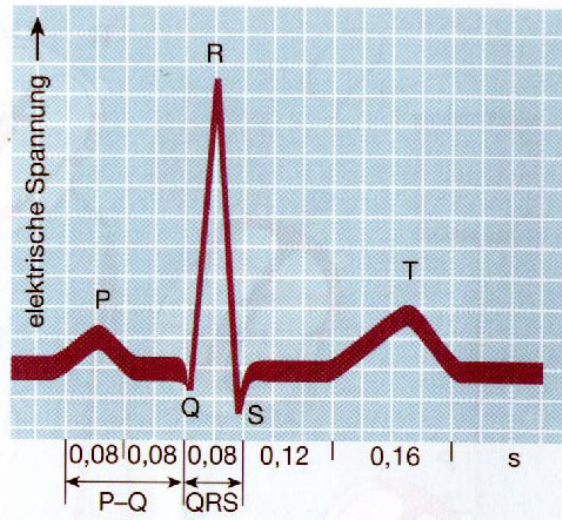
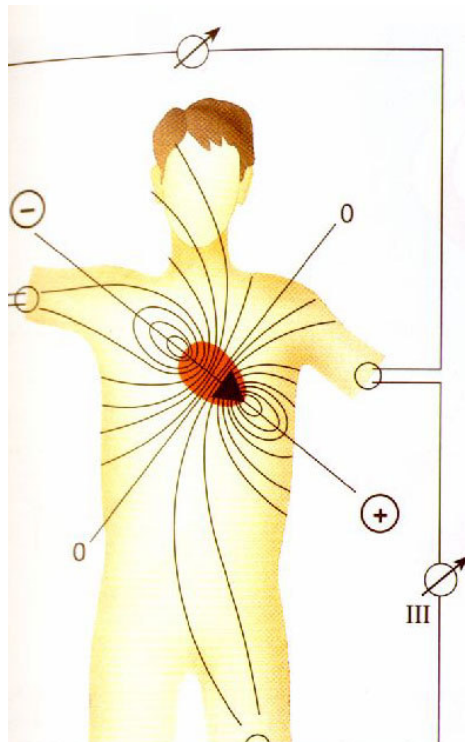


Passive Electrodes



Active Electrodes

EKG, Pulse, Heart-Rate Variability (HRV)



Recordings with Electrodes / Pulse Sensor

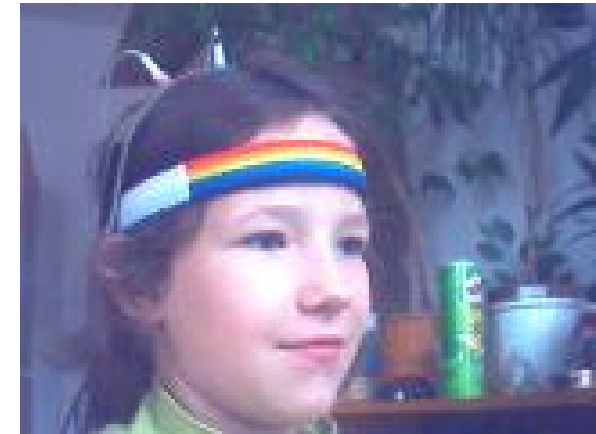
DIY – EEG-Electrodes, Alpha BrainWaves



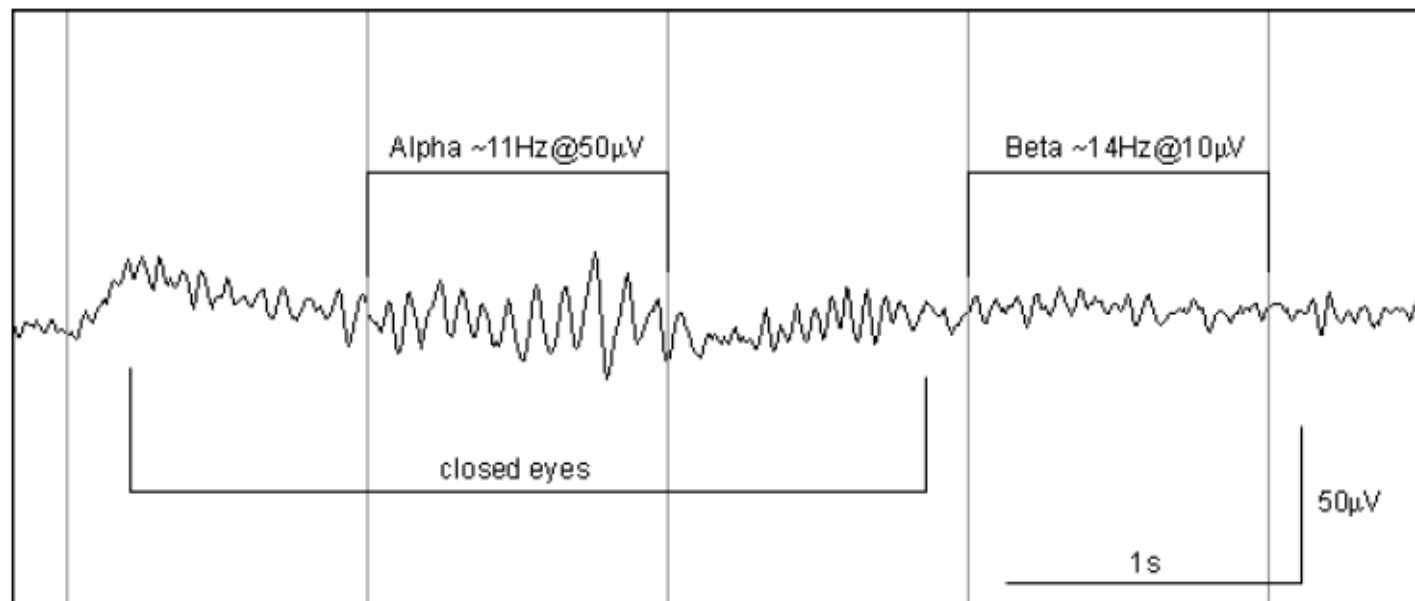
Material: Silver



Contact-Gel



Headband



possible Applications:

Biofeedback and Neurofeedback-Therapy
Rehabilitation Training

Training

Realtime–Telemetry of Bodysignals
Patient Monitoring
Online and Offline Data Analysis

Monitoring

Control of Mouse-Cursor + Clicking-Functions
Typing via an On-Screen Keyboard
Control of Home Appliances
Control of a Wheelchair,
Control a Prothesis or Robot
Brain Computer Interface

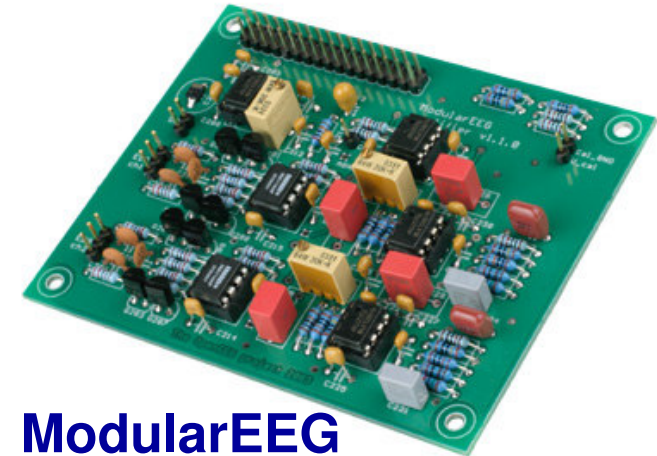
Interaction-Aid
(for motor-disabled Persons)

Building a Bio-Amplifier: The OpenEEG-Project

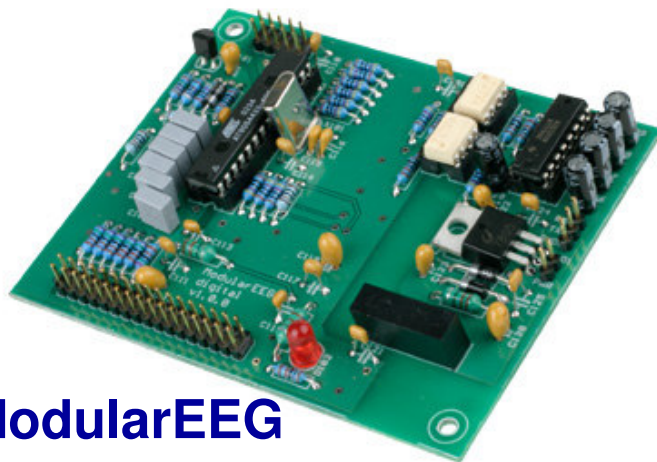
Online since 1999

Two Major Hardware Designs :
ModularEEG (6 Chn, non-SMD, Kit)
MonolithEEG (2 Chn, SMD, USB)

Resolution: 10bit, Samplingrate: 1kHz
AVR-Microcontroller (RISC)



ModularEEG
(analog board)



ModularEEG
(digital board)

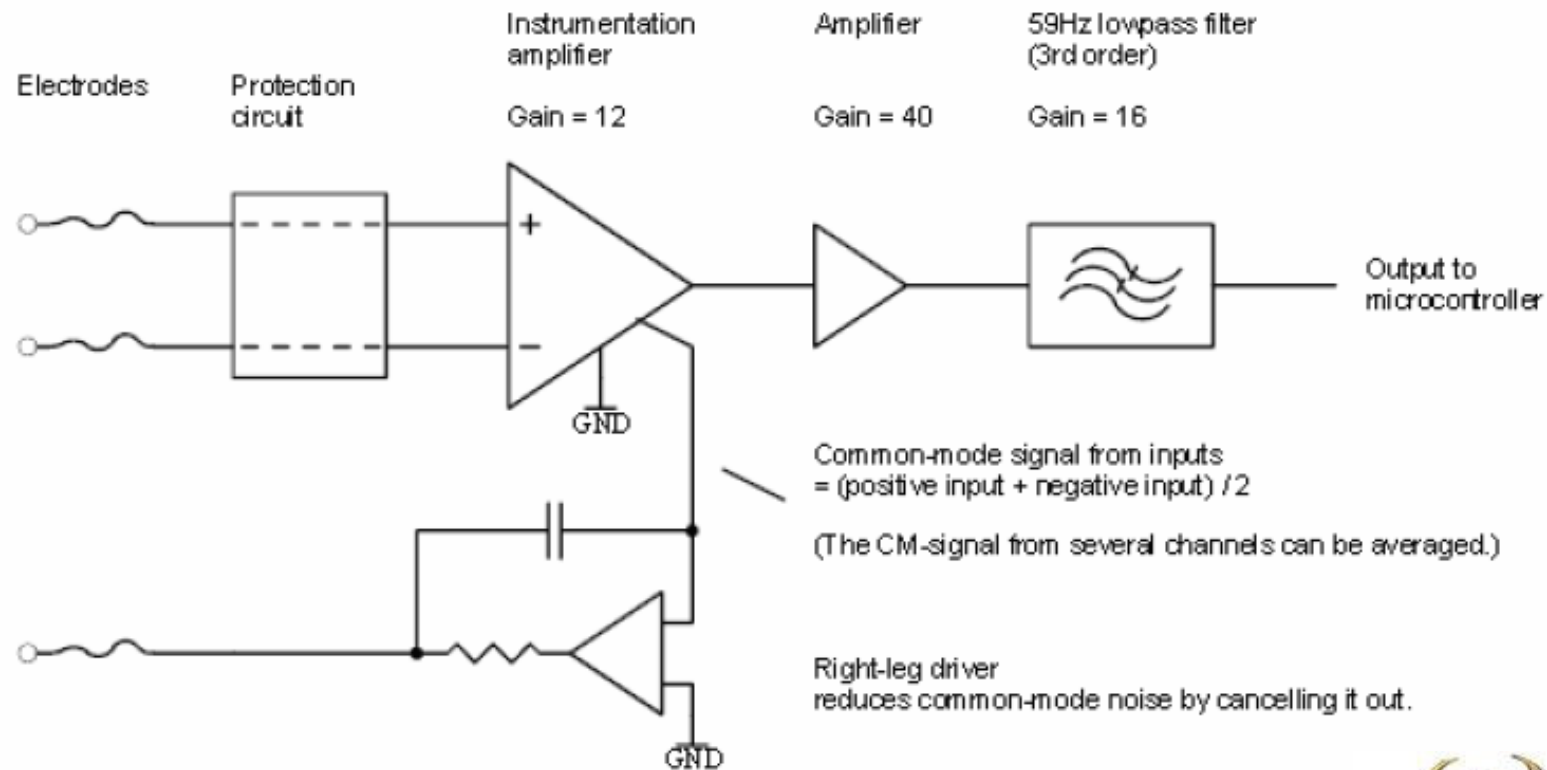
Protocol / Software available
Material Cost about 150.- Euros

Community Support (Mailing-List)
Hardware well documented, extensible
not certified as Medical Equipment

Amplifier-Hardware:

MODULAR EEG

by Jörg Hansmann



Simplified block diagram of the ModularEEG amplifier



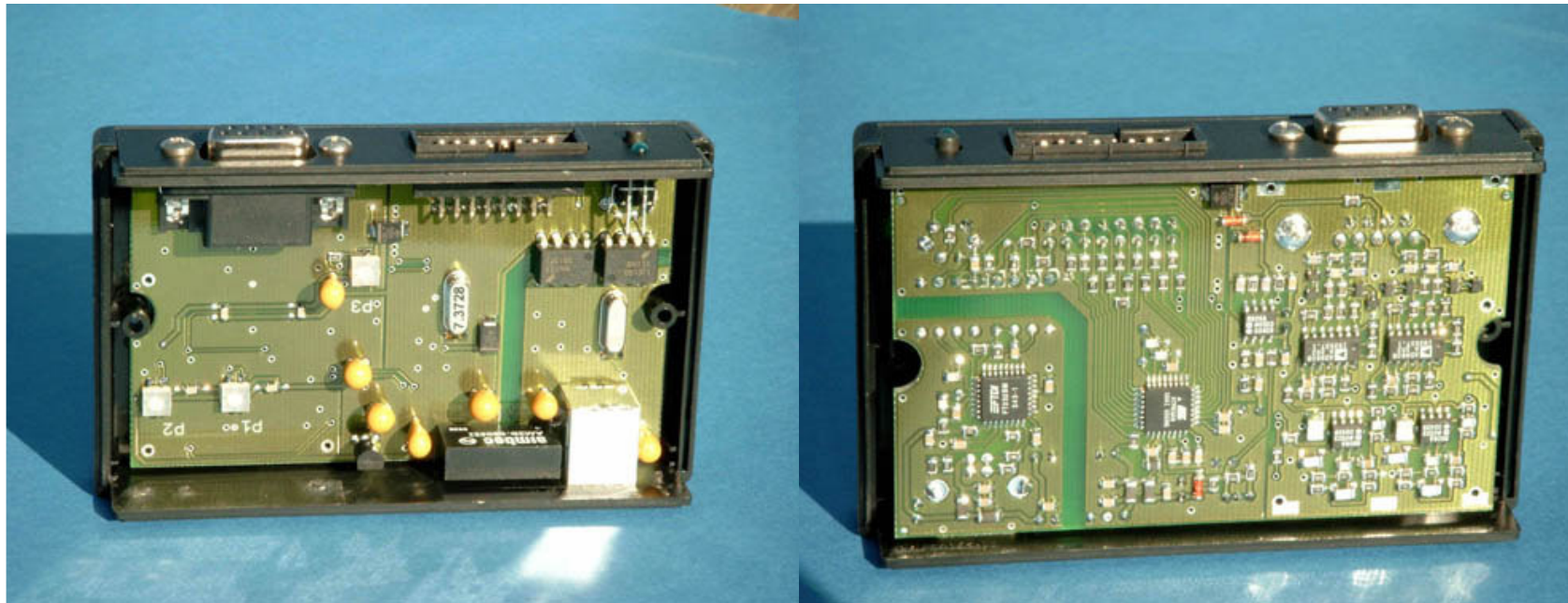
Amplifier-Hardware:

Small and lightweight
USB-powered
one double-sided SMD-board
works with unshielded cables

Bluetooth in development (User safety improvement)

MONOLITH - EEG

by Reiner Münch



Software Design Goals

Universal system with easy adaption to individual needs

Graphical „Drag-´n´-Drop“ design of configurations

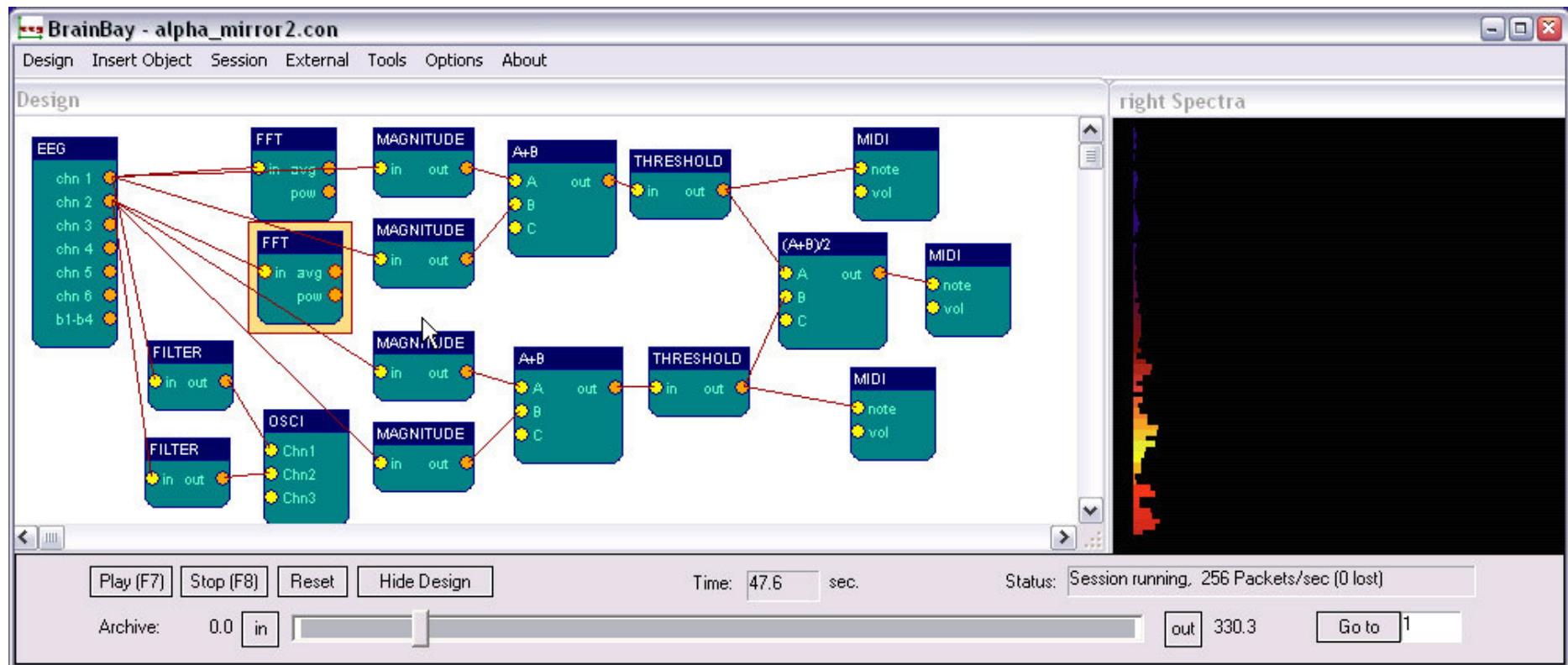
Real Time and Background operation

Network and Multimedia support

Offline analysis of the data, read and store EDF - format

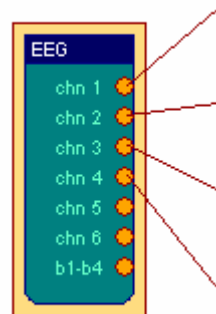
Open Source and extensible

BrainBay – Implementation Screenshots



Configuration Design: Input-, Processing- and Output-Elements

BrainBay – EEG Signal Source

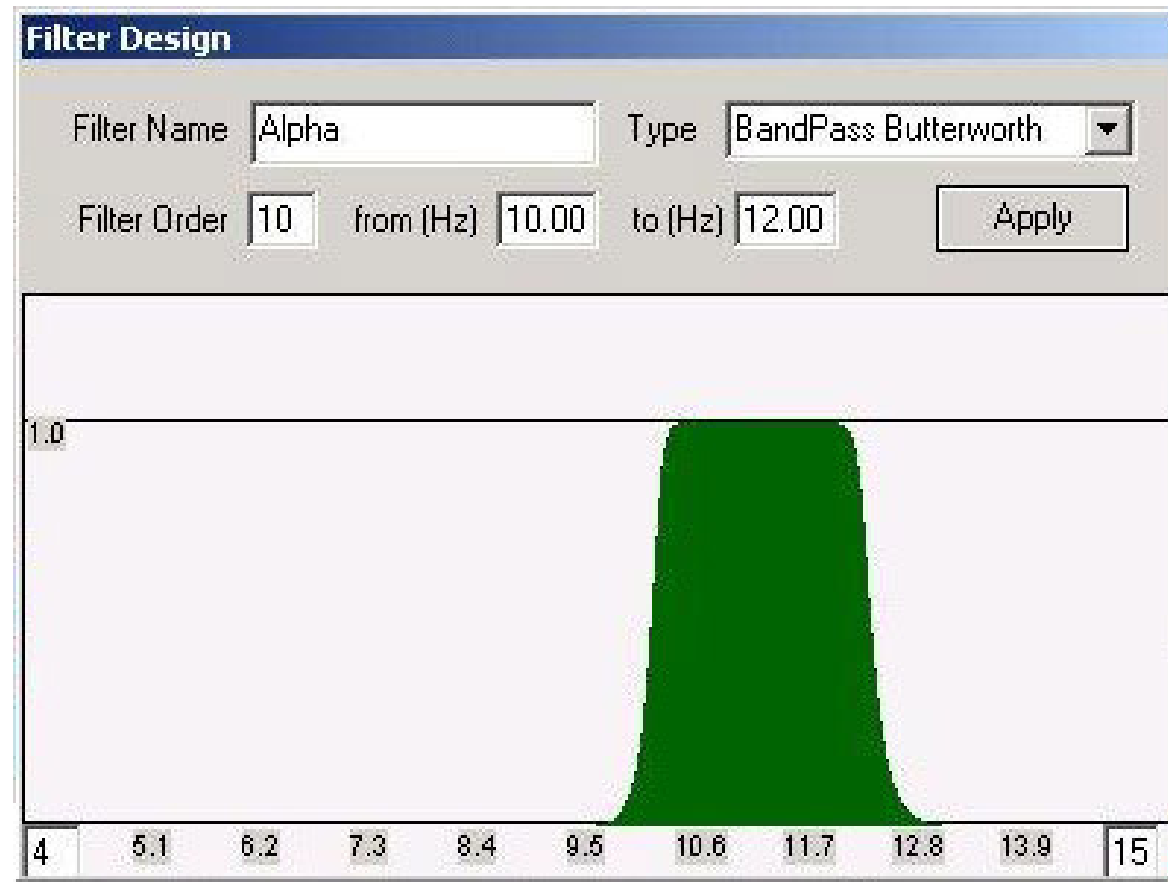
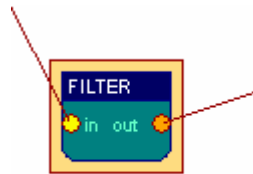


The screenshot shows the 'EEG' software window with the following settings:

- Com Port: COM5
- connected: ☐
- bi-directional: ☐
- Baud Rate: 57600
- Sampling Rate: 256
- Device: ModularEEG P2
- Ch1: ☒ Ch2: ☒ Ch3: ☒ Ch4: ☒ Ch5: ☒ Ch6: ☒
- Buttons: Record Archive, Close Recording
- Archive File section:
 - Filename: c:\works\eeeg\brainbay\debug\ARCHIVES\test.arc
 - Buttons: Open Archive, Close Archive
 - Filetype: Integer Values
 - Position: (range 0 to 1)
 - initial Delay: 0.00 seconds
 - Button: Apply

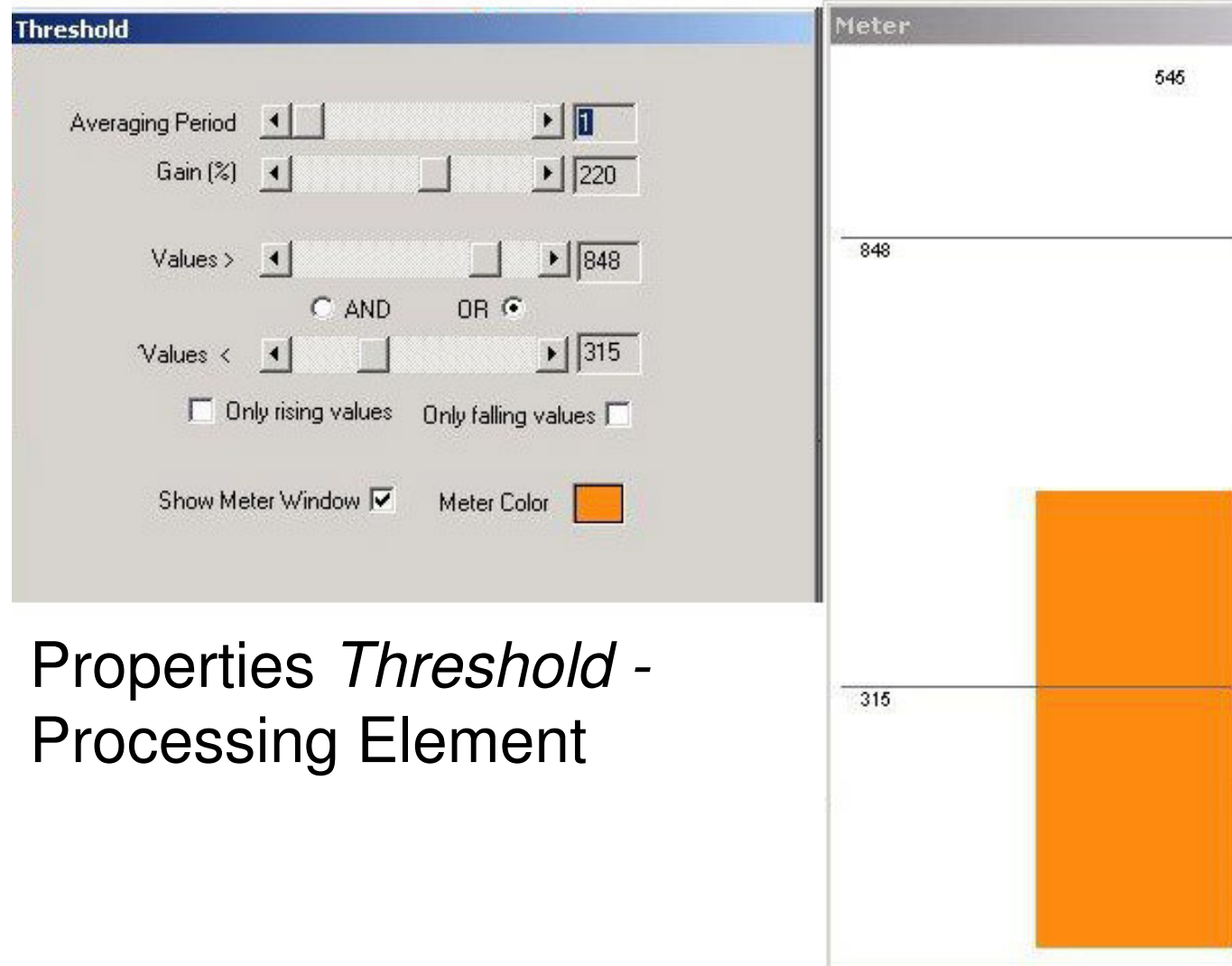
Properties *EEG-Amplifier* Signal Source

BrainBay – Digital Filter Element



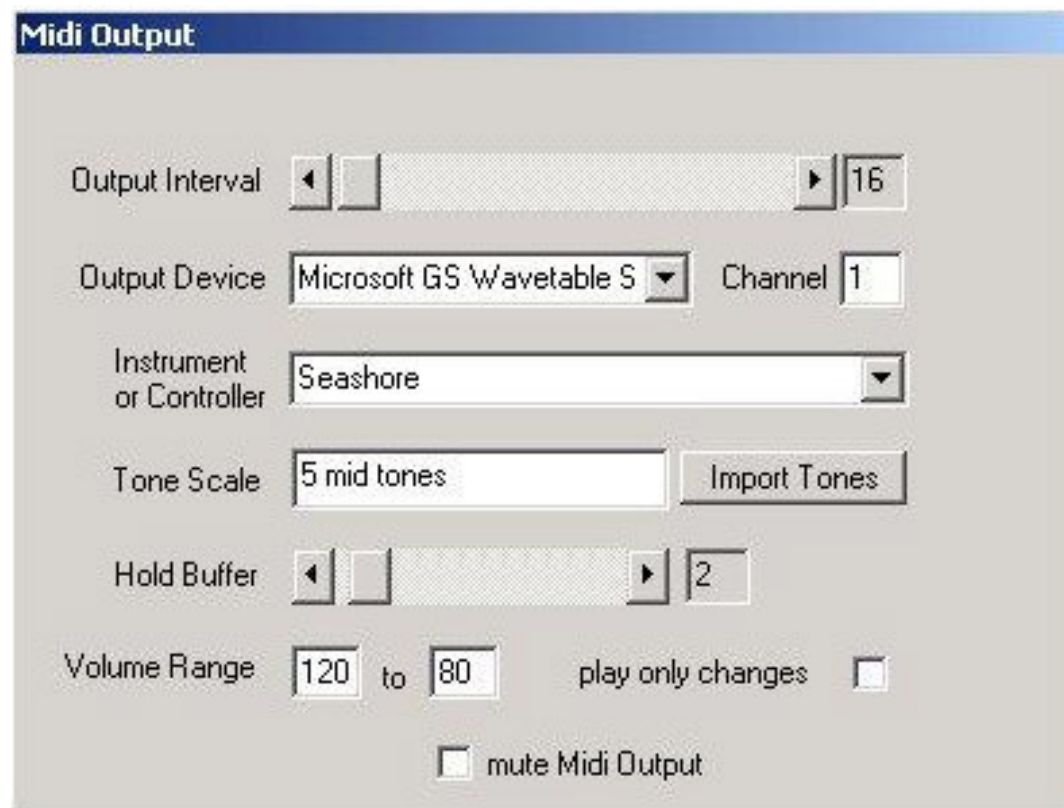
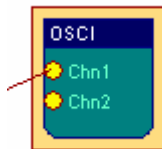
Properties *Digital Filter* Processing Element

BrainBay – Threshold Element



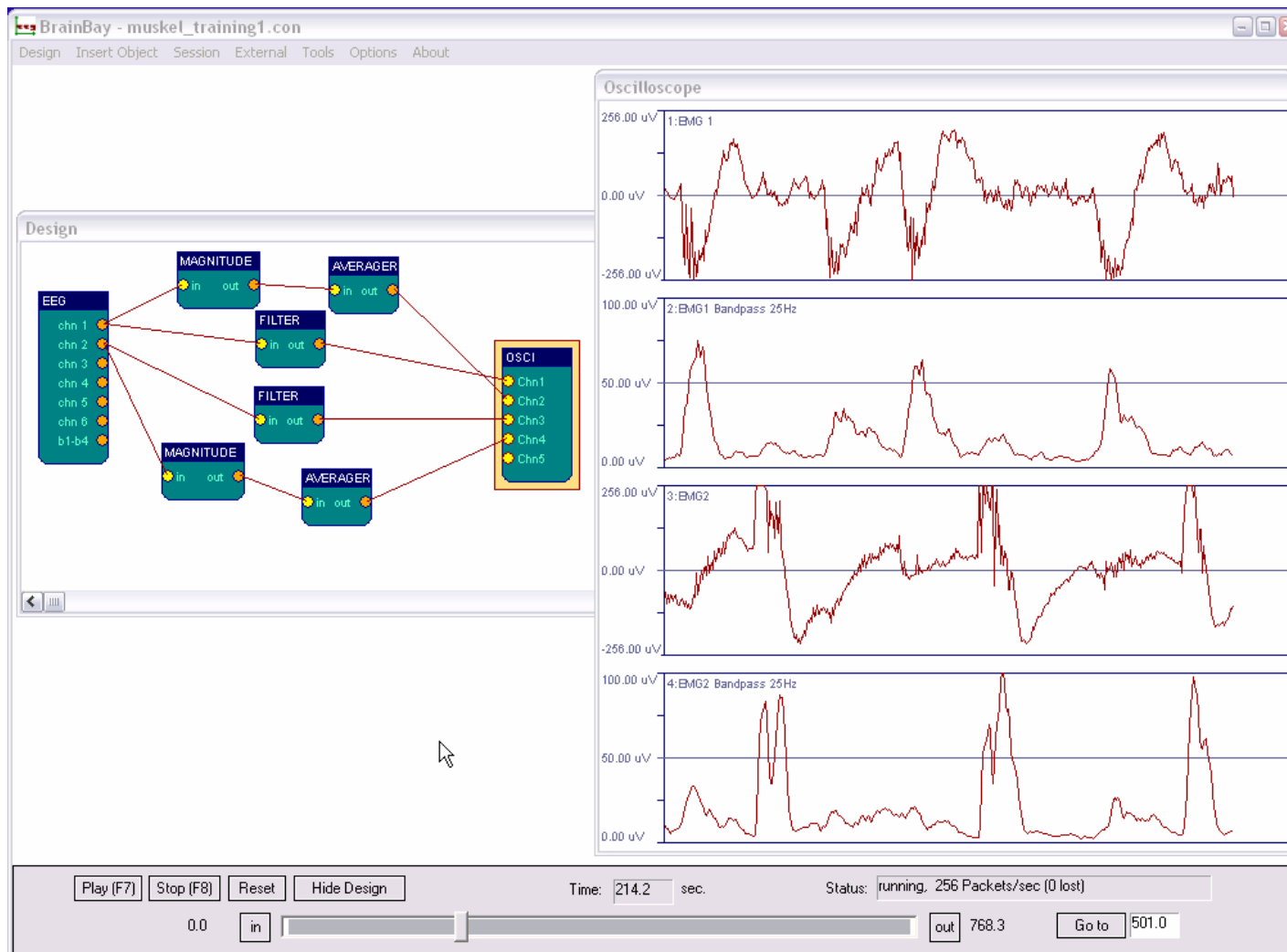
Properties *Threshold* -
Processing Element

BrainBay – Element Midi-Player



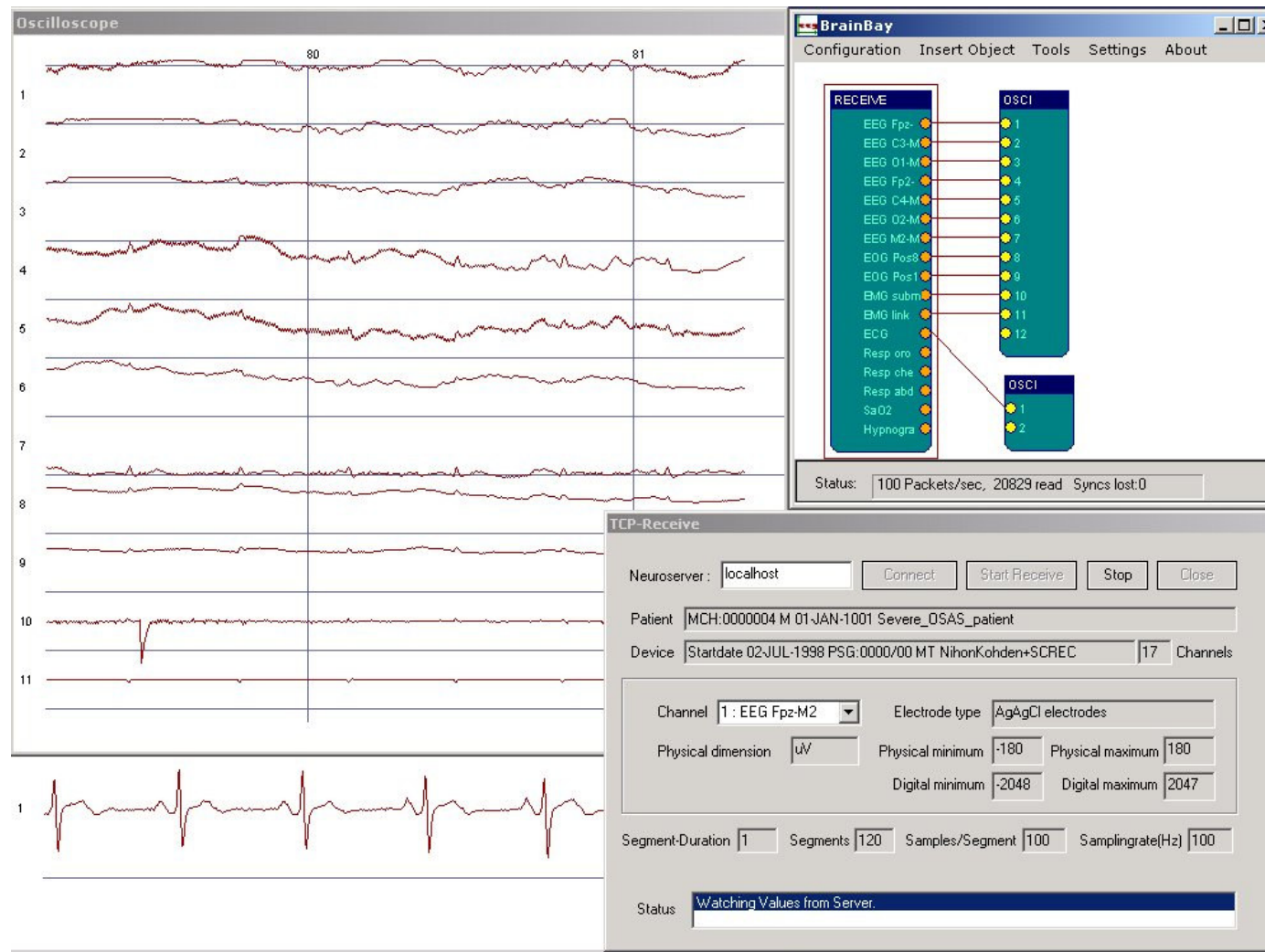
Properties *Midi-Audio* Output Element

BrainBay – Feature extraction from EMG



Bandpass-Filtered EMG-Signals, Magnitude

BrainBay – Reading Data via TCP / IP



21 Channel EDF- File, transmitted via TCP/IP

Other BrainBay – Elements:

Input + Output

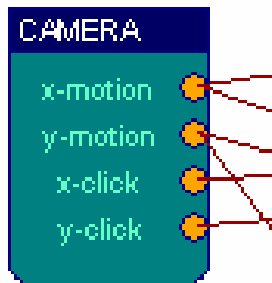
Signal Generator
File Reader / Writer
TCP-Reader / Writer
Camera-Tracking
Mouse-Controller
3d-Display
Particle Generator
AVI-Player
Ballgame
Wav-Player
Midi-Player

Processing

Fourier Transformation
Expression Evaluator
And, Or, Not
Counter
Coherence
Integrate
Average
Debounce
Mixer
Pattern Matching
Matlab transfer

BrainBay – Camera Element

using the *Open Computer Vision – Library*



Outputs:
Nose and Chin-Movement

**Initialisation
Phase**

- 1) Haar – Classifier Cascade detects the Face-Position
- 2) Estimation of Nose and Chin Positions

**Tracking
Phase**

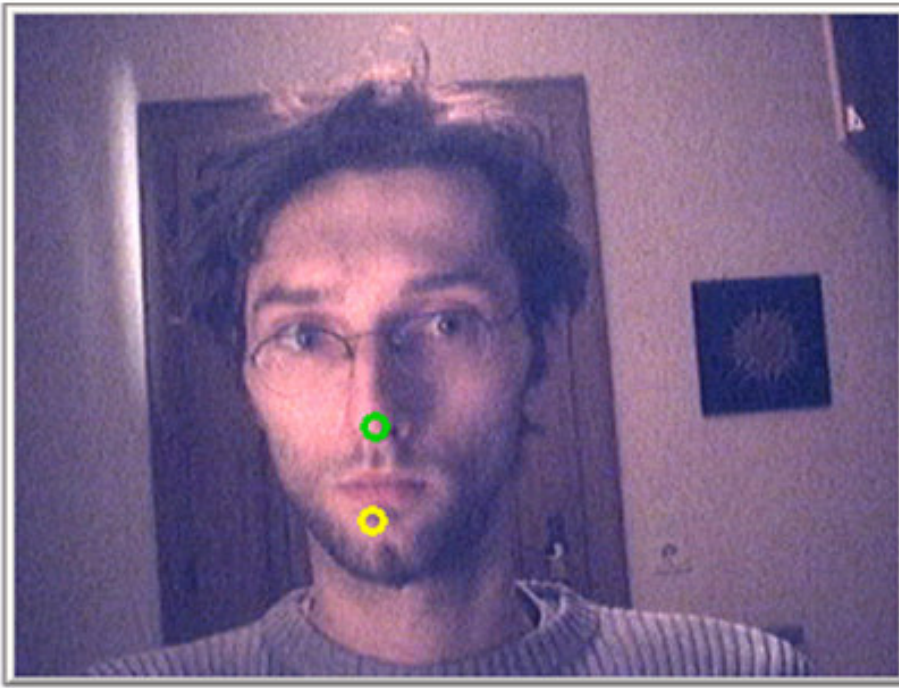
- 3) Lukas – Kanade Optical Flow Tracking
Drifting Error -> Re-Initialisation

BrainBay – Camera Mouse Control

Nose Position -> **Mouse (X/Y)**

Relative Chin-Movements -> **Mouse (Click)**

Autostart-Function, HotKeys



Normal operation



Re-Initialisation

BrainBay - Programming Methods

Visual C++ Programming Language, Win32-API
(Compilation under Linux possible with *WINE*)

OpenGL – Graphics and 3d-Visualisation

Intel Open Computer Vision Library (OpenCV)
for Camera Image – Processing

SDL-Library for TCP and Sound Functions

Timer Interrupt Routine, Threads

Hardware: 1,6 GHz Pentium-IV Laptop, 256MB Ram

Creating new Elements: the Object Base Class

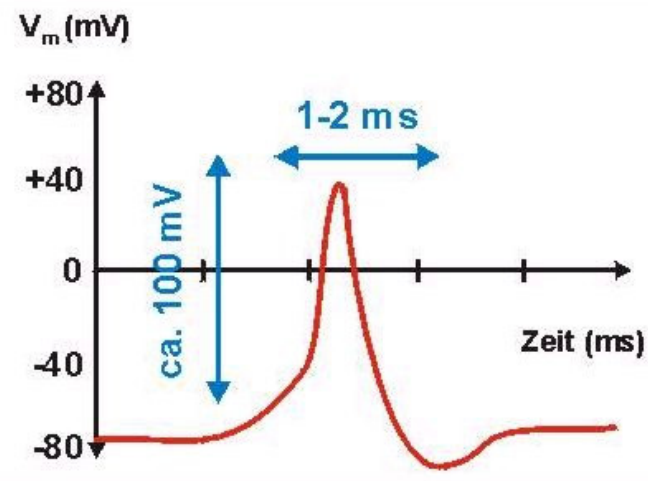
```
BASE_CL (void)
{
virtual void init (void) {}
virtual void make_dialog (void) {}
virtual void update_inports (void) {}

virtual void session_start (void) {}
virtual void session_stop (void) {}
virtual void session_reset (void) {}
virtual void session_pos (long pos) {}
virtual long session_length (void) { return 0; }

virtual void load (HANDLE hFile) {}
virtual void save (HANDLE hFile) {}

virtual void incoming_data(int port, float value) {}
virtual void work (void) {}
void pass_values (int port, float value) {}
};
```


Practical Tests / Field research



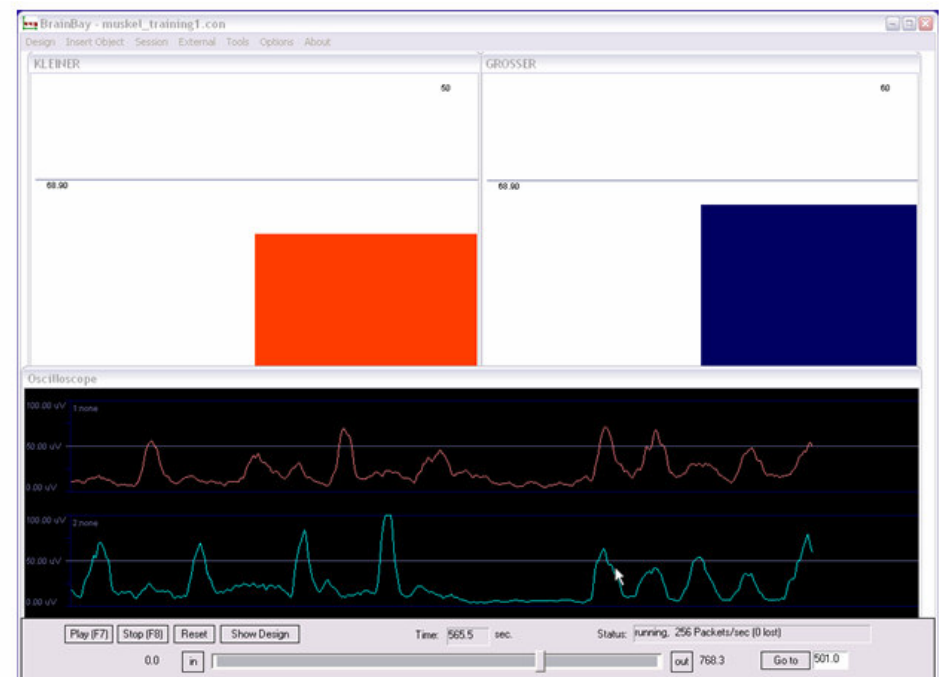
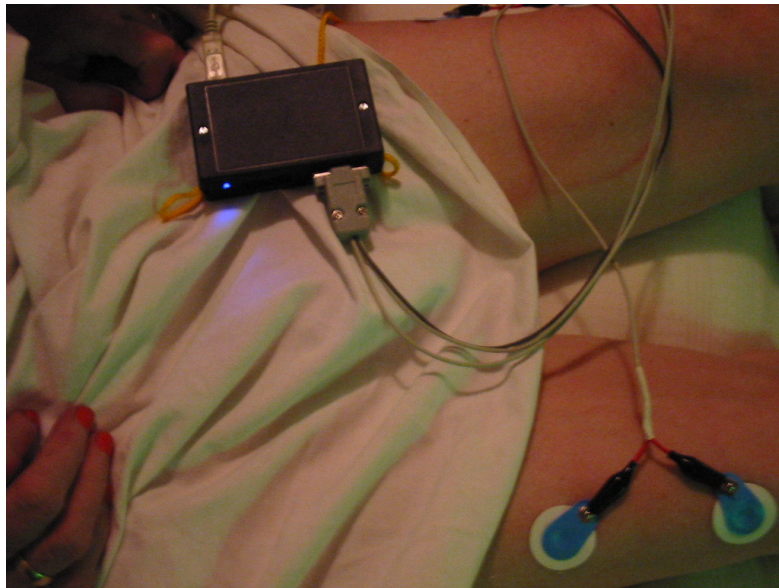
Setting: Biofeedback for Muscle Rehabilitation



Gerda, doing her first Biofeedback-Session

Muscle Rehabilitation: EMG- Biofeedback

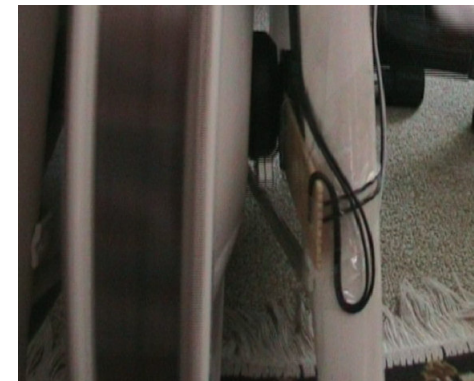
BlueSensor Electrodes, Monolith-EEG-Amplifier
Bandpass-filtered EMG-Signals with Threshold
Acoustic feedback via Midi-Tones
Optical Feedback via Meter-Bars



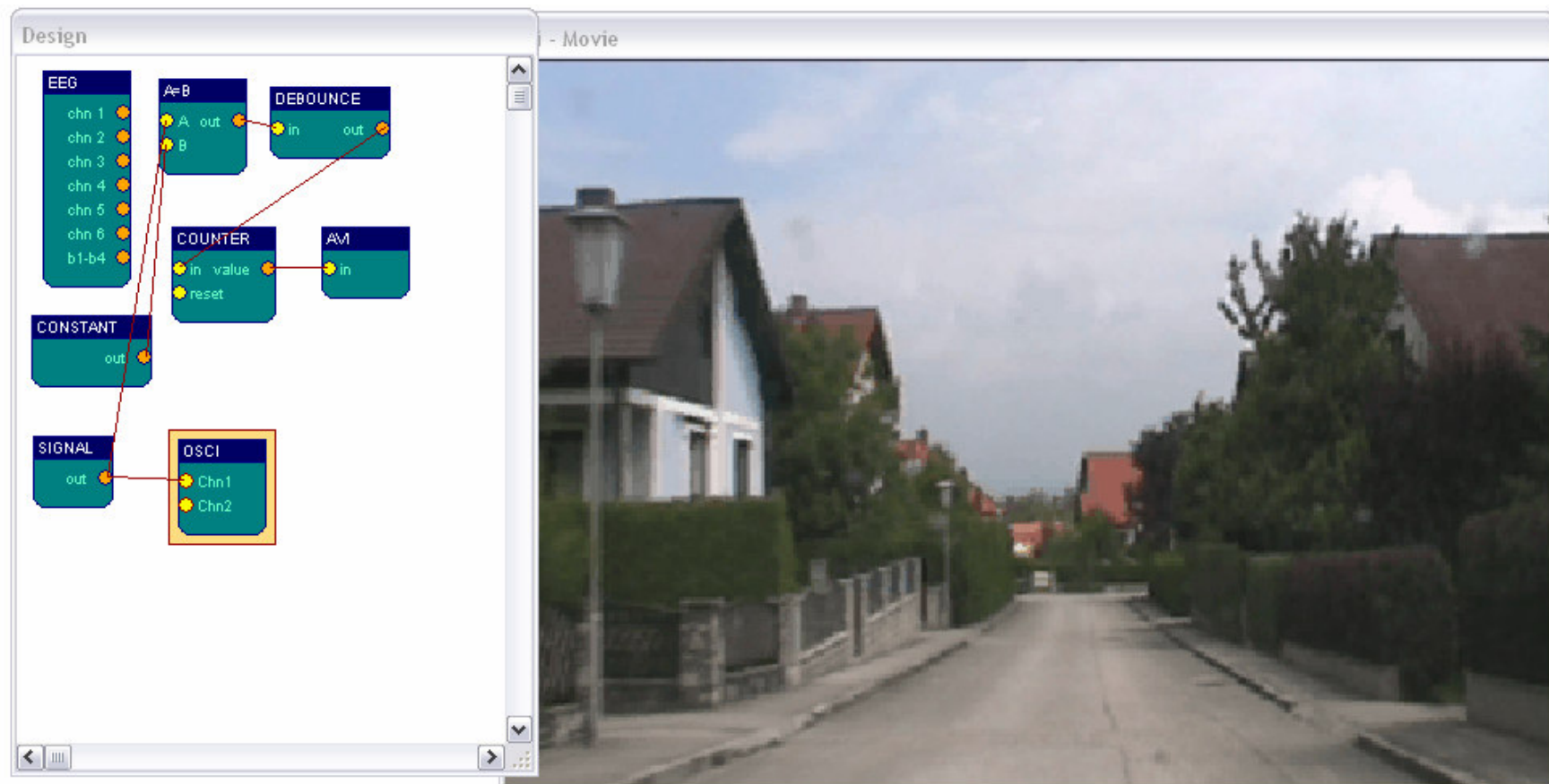
Muscle Rehabilitation - using external Devices:



Home-Trainer as BrainBay-Input
(using a Reed-Switch)



Muscle Training – watch a Movie per Bike



Results for Biofeedback / Muscle Rehabilitation

the System can support (not replace)
conventional Muscle Training / Physical Therapy

Feedback Games and Optoacoustic Settings
enhance motivation to do excercises, if well designed

Quantitative Information is useful to
monitor training successes

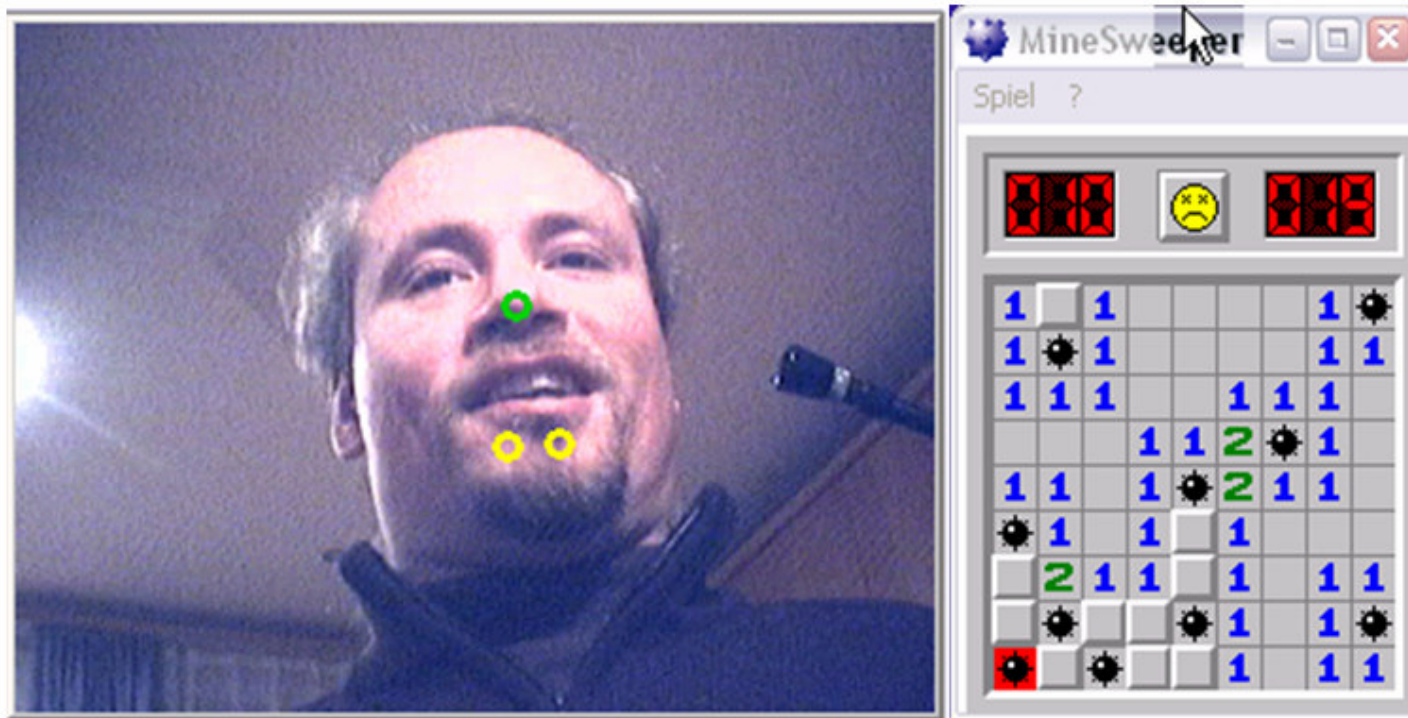
Computer + Training Assistance is needed
but not always available

Setting: Camera-Mouse as HCI - Support



Alex, controlling his computer mostly per mouth-stick

Setting: Camera-Mouse as HCI - Support



CAM-MOUSE - Game (Minesweeper)	Test Person C	Test Person A
Overall clicks	125	100
Overall time	5 min	5 min
Missed Clicks	10	17
Correct hits	92 %	87%

Setting: Camera-Mouse as HCI - Support



CAM-MOUSE – <u>Typing</u> (10 min)	Test Person C	Test Person A
Total Characters	337	250
false Characters	7	15
Missed Clicks	2	5
Characters per Minute	30	23,5

Results for Camera-Mouse Setting

Cursor Control worked intuitively and without prior training

Training enhanced the results in speed and accuracy

No markers were needed, Mouse-Click functions could be accessed by Face & Chin – Movements

Feature Tracking needs improvement

Alex continues to use the system for tasks like web-browsing or playing games

Improvements and Future Work

Add a **dynamic GUI-Component** for the User that allows easy adjustment of Key-Parameters

Write a **Manual** which includes examples

Improve the stability of **Camera-Feature Tracking**
use Active Shape Models instead of Lukas Kanade-Tracking

Work on **Gesture Recognition** for the Camera-Mouse

More Real-World Tests, Documentation, Homepage Updates

Internet Links

<http://brainbay.io-res.org>

(Project download)

<http://fortec.tuwien.ac.at>

(Research Group on Rehabilitaion Technology)

email contact

chris@shifz.org

**Your Questions + Suggestions
are welcome !**

Thanks for your Attention !