

BIOS

Bidirectional Input/Output System

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Short description: BIOS uses a custom built apparatus, which consists of modified HMD (head mounted display) surround sound system, EEG device and a computer. Immediate brain reaction to audiovisual stimulation are analyzed and fed back to eyes and ears as re-created images and sounds. Thus second exterior audiovisual perception path is generated, which forms a closed loop with the natural one. The viewer is invited to dive into his own (physiological) perception.

On one side BIOS is an investigational prototype for neuronal research dealing with brain signals correlated to the audiovisual perception, which could lead to a kind of a "neuronal camera" and on he other side - it is a slightly ironic 'homage' to the popular sensationalism of the contemporary industry.

Background

In history, there had been many attempts to understand the way images are processed, until they appear as an "impression" in mind. Because of the unavailability of sufficiently sensible sensors (and maybe because of pragmatism) one of the first tries to do this, was to show a certain picture to a makkake monkey and to shock freeze him afterwards, in order to cut out his brain in the 'same state' as in the moment of this discreet perception. Having injected him a radioactive fluid, an x-ray exposure could be done, that showed a distorted version of this picture, found on an area at the rear part of his brain. Other experiments of perception capturing were done with a cat. The result was a very noisy black and white video with a very low resolution, but with undeniable origin. It was achieved by using invasive electrodes, which were directly attached to the retina of the cat's eyes.

These a re only two examples showing the "normal" methods, that neurologists are using up to nowadays. Therefore we did not want a clean, high-polished appearance of our apparatus, like industrial companies would do. The visitor should get a certain sensation of how one of the countless test-monkeys could have felt, before he was taken his life in order to create the theoretical basics, we are using for this machine.

But as already said, this apparatus was not only built because of protest. In a way it has a deep connection to the old philosophic problem of reality, or better to say, of distinction between the "real" and the "hallucination".

The transformation of light energy into the language of the brain takes time, so this process leads to the fact that our seeing is always delayed. If visual and aural impulses are emitted from an object near by, both signals arrive at different times in our brain. Thus, objectively simultaneous events are subjectively shifted against each other, because of the different time pe rformance of our sensory organs. In addition, these effects are very small for human relations; the term "simultaneous" can not be justified, in neither a physiological nor a quantum-mechanical sense. One always sees, hears, smells, and feels something that already occurred, or in other terms, one "scans" reality, similarly to the frames of a film. The clocking of this scanning, the density of registering modifications, generates a feeling of time. The dependence of perception on the biological condition of the corresponding creature can be seen very clearly. A cold lizard perceives time more slowly than a warm one does, and being in a stress situation time seems to pass faster than e.g. while staying at a quiet place.

Apart of that, one runs into real, not only linguistic difficulties, trying to answer the question - if it would be possible to distinguish between a simulation of all senses (by some kind of machine not yet investigated) and the "real" world. At the moment we are far away from building such a machine, but we suppose that at least a few of our readers had had dreams, in which they touched, heard, saw or even smelled things the same way, as if they were awake.

One possibility of getting a feeling of what perceptional interpretation means, would be to amplify it. That means, if there would be a way to tap the perceived signal after it has been transformed, it could be "fed back" to be transformed again, the re-transformation would be done for an undefined number of times and thereby be amplified. This is, what BIOS basically does.

The apparatus

A second exterior audiovisual perception path is generated, which forms a closed loop with the natural one. The viewer is invited to dive into his own (physiological) perception.

The attached electrodes transfer signals from the three sensory areas of the brain cortex: the visual cortex V1 and both auditive cortices to an electroencephalograph (EEG). A custom built interface translates the voltage curves of the EEG into binary data. Thus it is possible to algorithmically translate this information 'back' into audiovisual signals. As output media - the HMD, and the headphones represent the electromechanical part of the cycle. The output runs continuously (back) into the biological perception apparatus; a feedback develops.

The neurological term Retinotopie describes the pattern of projection, how the x/y position of one point in the visual field is represented on the surface of the first visual cortex.

The computer calculates the X/Y position and the color of a pixel in the resulting image from the X/Y position of an electrode and its frequency. The time flow is represented by the Z (depth) value. Missing intermediate values are interpolated (synthesized). The accompanying image shows the system of conversion (i.e. basic principles). For BIOS, we allowed us some artistic freedom to visualize 'output' as subtle colored pulsations and waves of light. In the stereoscopic HMD these trembling, breathing, flowing flares sometimes raise visual associations of fire, smoke and liquid. It also somewhat resembles images one sees, when pressing with fingers on one's own eyes.

The pattern of the auditive cortex is similar, but somewhat simpler. The hearing snail forms a spiral structure behind the ear. Sounds







are translated to the biological cognition system by the movement of finest villi, which are sending neuronal impulses. Each villi has a nerve connection leading to the acoustic cortex also structured as a spiral. Imagining the hearing snail directly put on top of the auditive cortex, the connections would be parallel. Three signals are received, corresponding to basses, middles and trebles. The conversion corresponds to a Fourier (algorithmic) analysis, which is interpolated to the original width and resynthesised afterwards.



Possible future scenarios and experimental BIOS prototypes:

A basic scheme, where 2 identical, or alternatively 2 different biofeedback systems in dialogue. A public interface and public display (e.g. as dynamic, amplified audiovisual / VR installation)

more possible interface sketches: www.BIOS.x-i.net/prototypes

Production background:

Involved participants of the project met during their studies at KHM, Academy of Media Arts, with interest in various areas of interactive audiovisual and technological disciplines, and having experience or several common projects. Thomas Tirel had his largest competence with diverse video equipment, software / Norman Muller with projection and sound hardware / Sven Hahne with sound design and programming / Jaanis Garancs with interactive 3D and audiovisual Virtual Reality – where all have been relying much on self-developed techniques.

Willing to experiment biofeedback technologies, in 1999 Thomas Tirel finally obtained a functioning EEG device, which was partially donated by some hospital that was upgrading its equipment. Since then, with help of Norman Muller and Sven Hahne, during 1999-2001 they made several experimental set-ups with this device. converting analogue EEG output to various electronic devices (such as video - and sound generators and computer interfaces, trying to integrate with external computing) for aesthetic experiments. Fighting with many technical problems and as - undeniably - beginners in brain research - acknowledging their ignorance, they were doing intensive research through literature, personal correspondence and meetings with some specialists (medics, scientists), Gradually a deepened understanding of possibilities vs. limits evolved and the idea of loop-back system got crystallized as concept (more extended scientific background notes is accessible from BIOS website). That got submitted in late 2001 for the support from the KHM for additional project funding. Some of the necessary technological prerequisites got solved in early 2002 and Jaanis Garancs joined the team more actively (concentrating on real-time visualizations for stereoscopic HMD), to present the project in an upcoming conference and art exhibition in autumn. Only shortly before the exhibition, for first time it was possible to roughly connect the 'missing chain links' and create the feedback loop. Some of the results were disappointing, and certain aspects of the concept had to be adjusted or in some cases, made much less ambitious for the time being.

Current state of the project:

Despite of many development obstacles, nevertheless, in November 2002 the 1st version of BIOS had its premiere as a functioning set-up. Experiencing much of (flattering) interest and enthusiasm from many visitors, we have also realized some limits and weak sides of the set-up. The current main hardware component: EEG (obtained in 1999) is in fact build in 1982 and can not use many of the recent advancements in brain research, necessary for BIOS to get closer to its utopia: read the sight and hearing information as 'accurate' as possible, just by monitoring brain activity. The current setup e.g. is very sensitive to various kinds of electrostatic and electromagnetic 'noise' around it, and is somewhat awkward for demonstration (e.g. only 1 person at a time, needs assistance). In addition, the HMD at our disposal in 2002 with its relatively low light contrast, resolution and unsatisfactory construction would need to be improved. Another, not less important aspect is necessity for much more advanced brain activity pattern analysis – which can be done only with much stronger computing power – a dedicated computer for specific task(s) – and of course, more research expertise. We have applied for additional funding and hope to develop the projects further in 2003.

Intended outcome:

The intended result of the next stage of BIOS project would be a new setup that (hopefully) would be:

- 1) much more accurate 'reading' of eye, and hearing signals
- 2) more easy to set up and efficient experience for visitors
- 3) provide with platform for starting more experiments and applications (e.g. not only feedback within one person but between 2 or among more persons)

a possible version of new BIOS chair:

- more relaxing leaning with body and head to the electrodes instead of uncomfortable helmet
- other type of HMD considered incl. panoramic projection instead of active screen (depending of technical advancements within next 6-12 months)



As the BIOS project has already has received a certain attention from art scene (due to its exposition in 2002, and that it recently got included in the upcoming catalogue of ZKM "Future Cinema. The Cinematic Imaginary after Film" – publication, edited by Jeffrey Shaw and Peter Weibel – we feel very encouraged to explore this theme further. Another side is that this project (beyond largely aesthetic and slightly 'irrationally speculative' aspect) in our opinion might be interesting to circles normally not so close (or familiar) to media art scene. As the project develops or completes we would certainly try to introduce it to some of the popular media art festivals, but we feel it could find it's interesents e.g. in medical, educational, family 'edutainment', or children's public. We sincerely would not like to share it with any military or purely commercial application enthusiasts (© although if in some aspect - probably technical - they might be already more advanced anyway!)

Duration of the project:

The duration of project is intended approx 12 -18 months – (i.e. could be finished in 2004/2005) that would be not too short time to implement a qualitatively new stage of research, development, and realization for our 4 people (or possibly slightly larger) group. An in the same time we are eager to see results sooner and also to insure support from KHM.

References:

Additional online materials:

http://BIOS.x-i.net

http://BIOS.x-i.net/documentation

Contact e-mail for BIOS team: bios@x-i.net

We would like to mention following people that most supported us in our inquires:

For his time, sharing with us some of his knowledge: **R.F. Schmidt** (member of Editorial Board of journal "Experimental Brain Research" http://link.springer.de/link/service/journals/00221/about.htm)

Institute of Physiology University of Würzburg 97070 Würzburg, Germany e-mail: rfs@mail.uni-wuerzburg.de

Anthony Moore, principal of KHM, for organizational support http://www.khm.de/personen/staff/moore_e.htm

Especially we would like to thank Prof. Dr. **Siegfried Zielinski** <u>http://www.khm.de/personen/staff/zieli_e.htm</u> for his patience being the KHM mentor (consulting professor) for the BIOS project

Cost calculation:

Requested funding:

Equipment:

64-128 channel EEG (incl. bundled specialized computer)

ca. 10.000- 58.000 EUR

Note: used EEG devices theoretically suitable for intended purposes have prices starting at approx EUR 10 000 with accessories) but additional costs for transportation / import / customs may occur. However, newer models are much more mobile and easy to set up, have better interfaces to external computing, more detailed documentationand support.

Apple Macintosh computer G4 >=1GHz	ca	. 4.000	EUR
PC-type computer with >=2.5 GHz dual processor 2 GB RAM / power	ful graphic card ca	. 3.000	EUR
Stereoscopic head mounted display (rebuilt or	developed) ca	. 5.000	EUR
Honoraries for programming and engineering (signal conversion hardware and software)	са	. 3.000	EUR
	Total: 25.000 - 75.00	0 EUR/I	JSD

Received financial support for the 1st stage of BIOS in 2002:

from KHM – Academy of Media Arts, Cologne: for building parts (electrodes, electronic circuits, cables, helmet mechanics) and purchased equipment (such as stereoscopic HMD) ca. **2.900** EUR

from "KHM friends' circle" – philanthropic organization supporting KHM projects: Traveling / transportation / insurance costs (4 people and equipment) to exhibition "VISION – image and perception" in Budapest, 2002 ca. **2.200** EUR

For next stages BIOS project **can count on further support from KHM** - certain specific hardware, software and litera ture purchasing costs, medium traveling, presentation and documentation costs, that financially could be estimated in total of EUR **3.000-5.000** within 1-1,5 years, while 1-2 of 4 BIOS team members still have KHM student status.

Other considerations:

BIOS team been trying and will keep trying to get eventual smaller or larger sponsorship from medical equipment companies or research-support organizations. In some cases we have received discounts for some materials up to 60% by mentioning that is non-profit, experimental project, supported by KHM and being presented for larger public.

Consulted special literature for BIOS project:

- Rose David "Models of the visual cortex"
- Orban Guy A.
 "Neuronal Operations in the visual cortex"
- Gayer N.S., Horsburgh G.M., Dreher B. "Developmental changes in the pattern of retinal projections"
- Hoffmann K.P., Disther C.
 "A quantitive analysis of visual receptive fields of neurons in nucleus of the optic tract and drosal terminal"
- Daugman, J.G.
 "Six formal properties of 2-dimensional anisotropic visual filters"
- Hammon P. and MacKay D.M.
 "Differential responses of cat visual cortical cells to textured stimuli"
- Hubel D.H.

"Exploration of the primary visual cortex"

- Jung R. und Baumgartner G.
 "Hemmungsmechanismen und bremse nde Stabilisierung an einzelnen Nueronen des optischen Cortex"
- Marcelja S.

"Mathematical description of the responses of simple cortical cells"