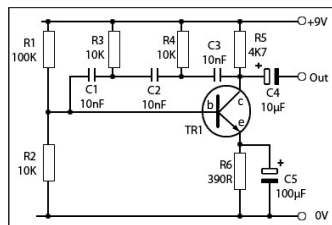# *We go virtual for real*

Peter Werkhoven, TNO/UU
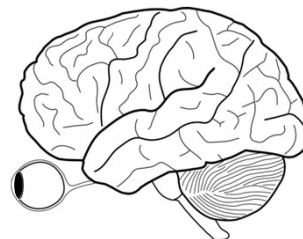
WND conference
December 17, 2016
NH Leeuwenhorst, Noordwijkerhout

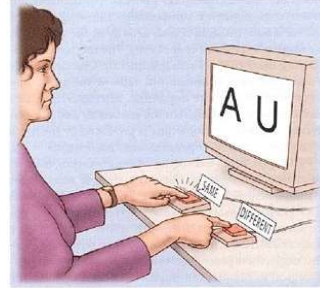---

Thema: Hoe meet je dat nou?

What is the oscillation frequency?

What does this person see?

Psychophysics

Psychophysics
(coined by physicist Fechner in 1860) is the
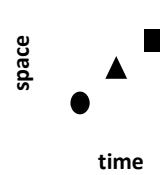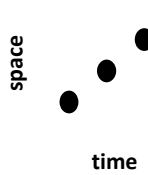quantitative study of perception.
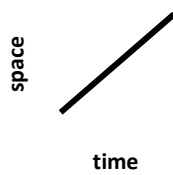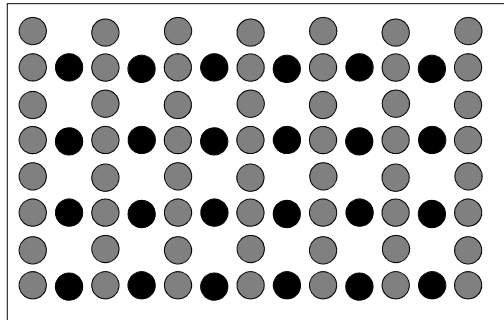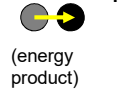
Human motion perception?

Continuous

Sampled

Features?

space

time

space

time

space

time

Feature matching?

What motion
is stronger?

or

?

(feature
match)

(energy
product)

Orientation in space time ...
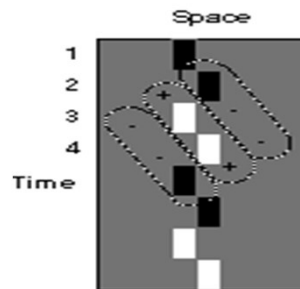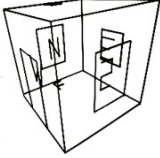
Perception in VR

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1 - VR so far
  – Technology
  – Psychology

2 - VR applications
  – Training
  – Telepresence

3 - Augmented Reality
  – MS Hololens
  – Occlusion?
  – Communication?

4 - What's next?
  – Beyond A/V: tactile
  – Beyond senses
  – Beyond bodies
  – Beyond keys: brain out
  – Beyond displays: brain in

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1 - VR so far

VR: The pioneers

In 1966, Ivan Sutherland (prof at Harvard) turned "Remote Reality" vision systems into Virtual Reality by replacing the camera with computer images, viewed with a Head-Mounted Display.

Wire frame room

Ivan Sutherland

VR: Almost a commodity

1996
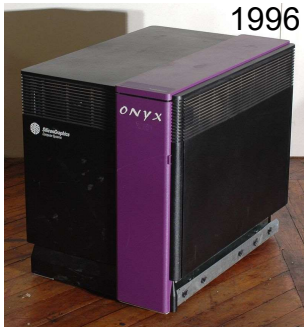
2016

SAMSUNG Gear VR

VR: Natural, adaptive, safe, fun

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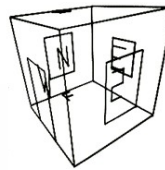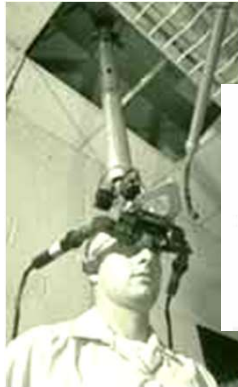

TNO, 1996

Tracking: head and hand positions

Simulation: model-computations (geometry, behaviour)

Feedback: vision, audition, proprioception

Control: navigation, manipulation

VR: Technology (haptics)

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Cyber Grasp
(Cyber Glove Systems Inc.)

2D: CyberWalk

3D: Desdemona (TNO)

VR: Psychology (stress)

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Stress respons

Stressors
- *Task load* (completion time, taskswitches, level of reasoning)
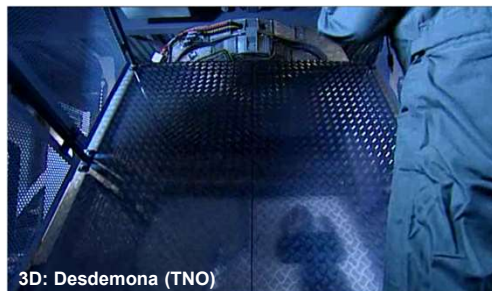- *Negative* feelings (loss)

Adjust stressor levels

Stress measurements
- **Physiological**: Heart rate, blood pressure, skin conductivity, brain signals
- **Questionnaires** (emotions)
- **Performance** (time, score, impulsivity)

Thesis Benny van der Vijgh

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2 - VR apps

VR application domains

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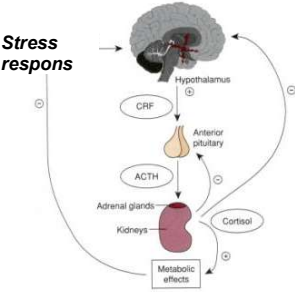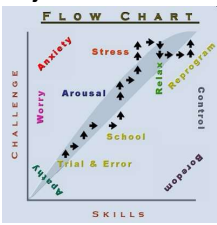**Education**
(math games, VR field trips)
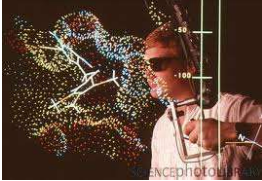
Prototyping
(architecture, product design, configure kitchen, fit clothes)

Arts & leisure
(games, virtual musea)

Science
(molecular docking)

Training
(battlefield, procedures, therapy, rehabilitation, social skills)

Telepresence
(tele-surgery, virtual tourism)

VR apps: Gastronomic experiences

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Restaurant WT Urban & Kitchen,

Oude watertoren in Utrecht,

VR enhanced gastro-sensory experience

VR apps: Mission training

Goal
Use brainpower of game communities to test military operations

Challenge
Generate world model and scenario within 24 hours

Consortium
TNO & Thales

VR apps: Tele-presence

Be the eye of the drone

For an immersive experience, the orientation of the fisheye (180 °) camera of the Bebop Drone can be controlled by your head movements through headtracking (available with Oculus Rift).
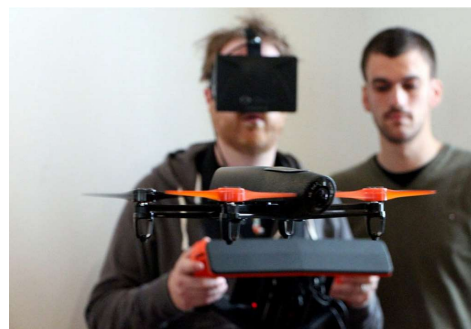
VR apps: Tele-navigation
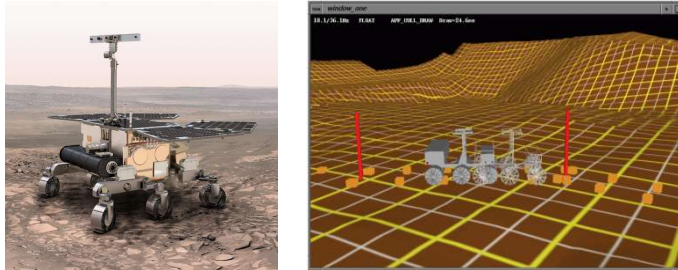
- **Smart Teleoperation Workstation for planetary rover** (1999, TNO for ESA)
- **Challenges**: unknown environment, time delay (4.3 light min), limited bandwidth.

- **Solution**: reconstruct 3D environment, drive in VR, update model.
- **Demonstrated** with EVE rover (camera, laser) on test site CNES.

- **ESA ExoMars-rover** mission 2018.

VR apps: Tele-operations

1971, NAT robot (MBA)

EOD robot (TNO)

Source: http://robotik.dfki-bremen.de/en/about-us/dfki-gmbh-robotics-innovation-center.html

3 - AR

Augmented Reality (AR)

Magic Leap

MS HoloLens

AR: Occlusion of virtual *and* real

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www.michaelbach.de/ot/mot_motionBinding/index.html

AR: Occlusion of virtual *and* real

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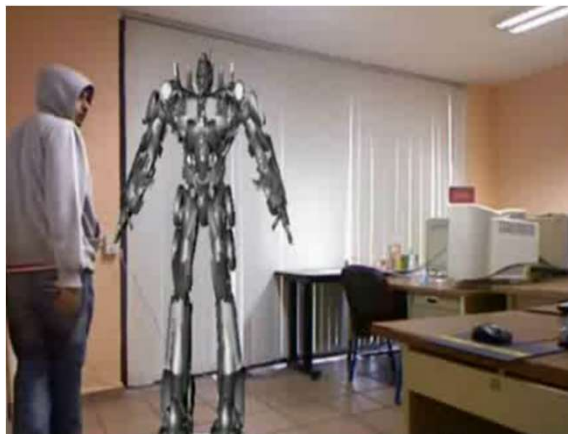
AR: Face-to-face communication
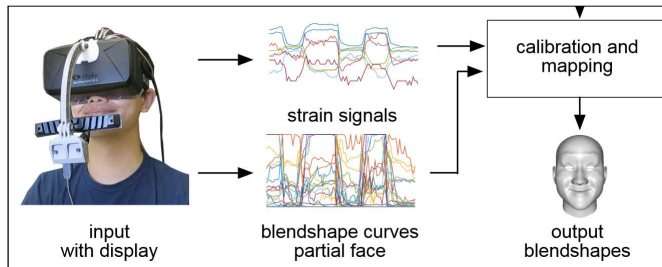
Source: Hao Li et al (2015). Facial Performance Sensing Head-Mounted Display. Proceedings of ACM SIGGRAPH 2015.
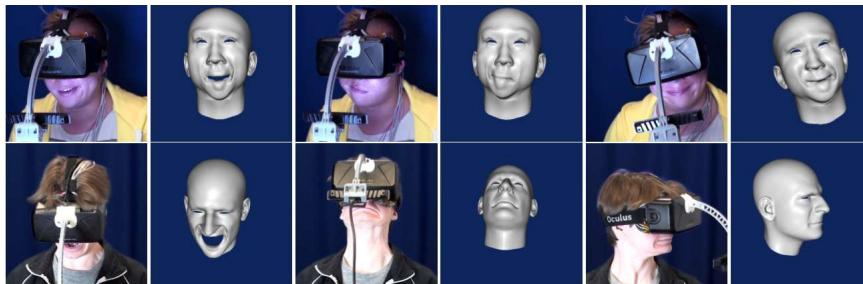
4 - What's next?

Beyond AV: tactile
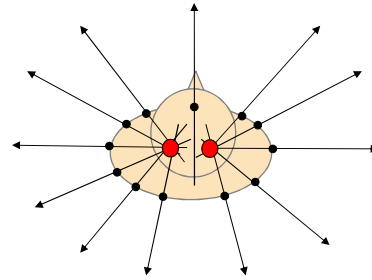
Erp J.B.F. (2007). **Tactile displays for navigation and orientation± perception and behavior**. Thesis University Utrecht.

Beyond AV: feel gravity

*International Space Station, Russian "Sojoez" flight,
April 19, 2004. Dutch astronaut Andre Kuiper.*

Beyond senses: synaestetic

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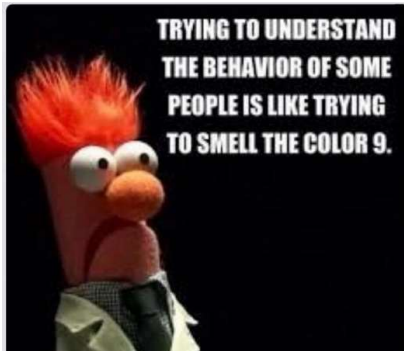
Two shapes: Kiki and Buba.

Credits: Wolfgang Köhler, German Gestalt psychologist (1887 – 1967)

Beyond senses: Hearing colors

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Source: TED Talk, 2012, Neil Harbisson

Beyond senses: Feeling images

Source: BrainPort Technologies, Wicab, Inc.

Beyond bodies: own another
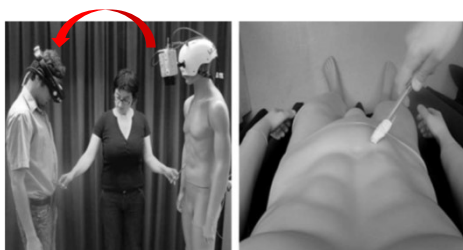
A) See another body when looking at your own body, with synchronised visual and tactile stimulation.
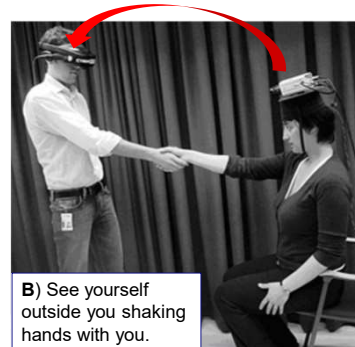
B) See yourself outside you shaking hands with you.

Ownership.
A) Physiological: Threatening the mannequin evokes anxiety (skin conductance response).
B) Questionnaire: Participants think that the experimenter's arm was their own arm and that they can sense their entire body just behind this arm.

Source: Petkova, V.I., & Ehrsson, H.H. (2008). **If I Were You: Perceptual Illusion of Body Swapping**. PLoS ONE 3(12): e3832.

Beyond keys: Detect mental state

- Identify EEG, HR and breathing patterns associated with extreme mental focus,
- provide neuro-feedback (vibrotactile, neck) to train brain patterns.
- Applications: military (DARPA) and leadership (attention, empathy).

(Chris Berka,
Advanced Brain Monitoring)

Beyond keys: Brain navigation

Move chess pieces with brain waves

Marieke Thurlings (PhD Utrecht University)

Collaboration with Technical University Berlin (dept of Software Engineering and Theoretical Computer Science).

Beyond keys: Know what you see

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Reading unconscious threats

- DARPA tested a Cognitive Technology Threat Warning System for troops in the field that scans warfighters' brainwaves (P300) while a **camera** surveys the area.

- Field tests show that # enemy targets identified doubles.

Source: www.darpa.mil/Our_Work/DSO/Programs/Cognitive_Technology_Threat_Warning_System_(CT2WS).aspx

Beyond keys: Detect your dreams

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Utrecht University

- Use fMRI scan of brain activity in visual cortex,
- and trained (Bayesian) computer model.

- reading dreams ….

Presented clip | Clip reconstructed from brain activity

Presented clip | Clip reconstructed from brain activity

Source: Jack Gallant, UC Berkeley

Beyond keys: Control by thought

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**Thought control of a robot arm**

Braingate, 2012,

John Donoghue,
Brown U.

natureVideo
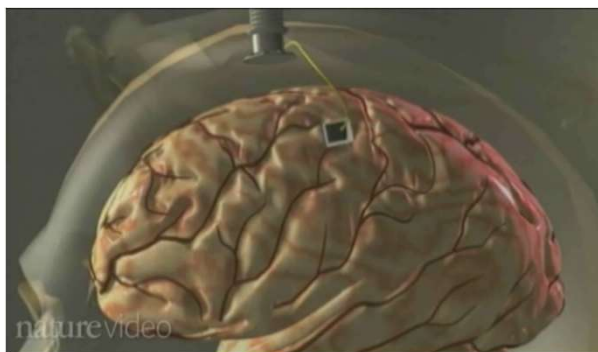
- Patient Cathy: stroke in 1997, damaged brain stem, tetraplegia, unable to speak.
- 96-channel intracortical microelectrodes in motor cortex (implanted 2005).
- 3D reach and grasp movements (with DEKA Arm System).

Source: Hochberg, L. R., et al. (2012). Nature 485.

Beyond keys: Cortical touch

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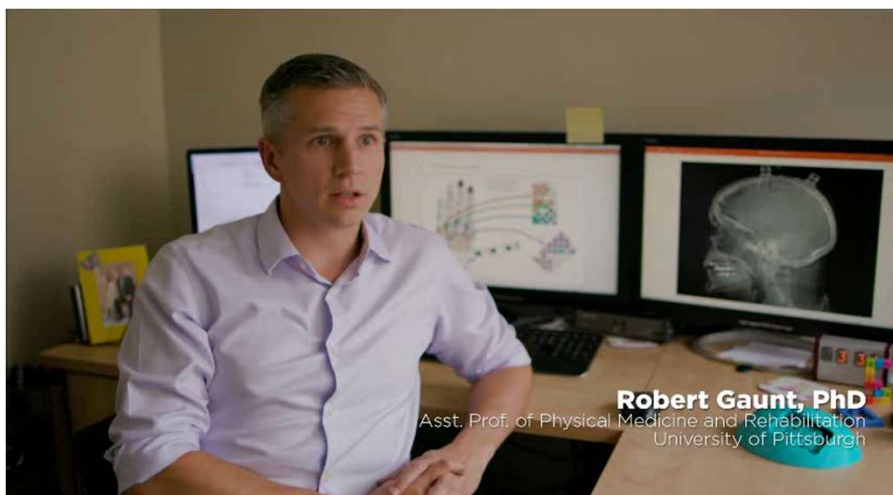
Robert Gaunt, PhD
Asst. Prof. of Physical Medicine and Rehabilitation
University of Pittsburgh

Source: Rob Gaunt et al (2016). University of Pittsburgh.

Rob Gaunt (U Pittsburgh) performs sensory test on blindfolded man (identifying different fingers through a mind-controlled robotic arm).
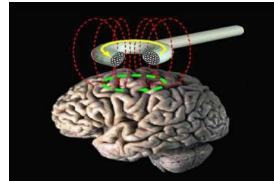
Beyond displays: Brain in

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Deep brain stimulation (DBS) : implanted microelectrodes stimulating deep tissue. Applied to treat movement disorders (Parkinson), affective disorders (depression), obsessive-compulsive disorder (Tourette, chronic pain).
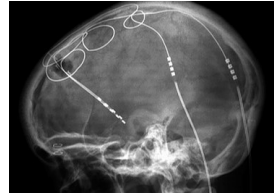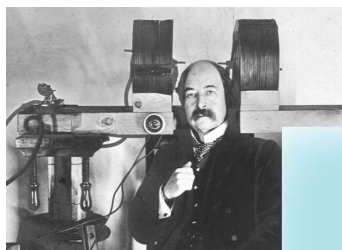

Transcranial magnetic stimulation (1 Hz) to stimulate deep sleep and intensify *memory consolidation* (Jan Born, Lübeck).
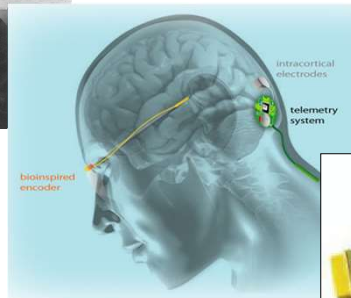

Optogenetics. Lasers to stimulate genetically manipulated light sensitive cells (Karl Deisseroth, bioengineer Stanford).

Beyond displays: Cortical imaging

TNO innovation for life
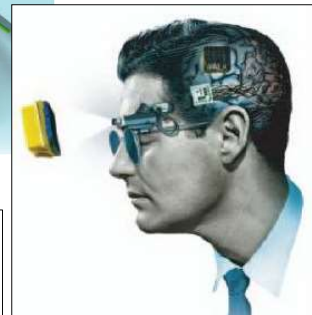Utrecht University

prof Thompson (UK, 1851–1916), flickering bluish illumination.

EU project Cortivis (2002)

intracortical electrodes

telemetry system

bioinspired encoder

Richard Normann, Utah U, 2012): Intra-cortical, monkey, point-flash percepts.

Beyond displays: Brain-brain

Human 'sender':
- Plays a game and imagines right hand movements (detected with EEG) to press a button to shoot a cannon.
- Using a 64-channel electrode cap to detect changes in 8-12Hz brain waves.

Human 'receiver':
- Somewhere elese, does not see the game.
- Transcranial Magnetic Stimulation of motor cortex region (muscle extending the wrist)
- Causes a press on a touchpad (firing a cannon in the game seen by sender).

Source: Washington University: Rao et al. (2014). A Direct Brain-to-Brain Interface in Humans. Plos|One.

Beyond displays: Neuro Reporters

Source: www.aaas.org/sites/default/files/roukes_mapping_brain.pdf (2013)
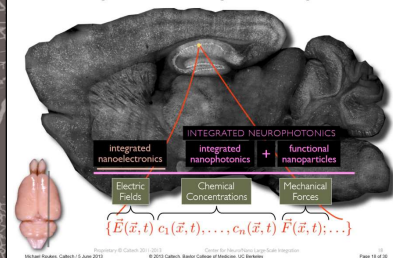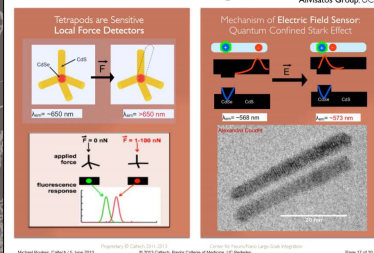
Beyond VR: Internet of brains

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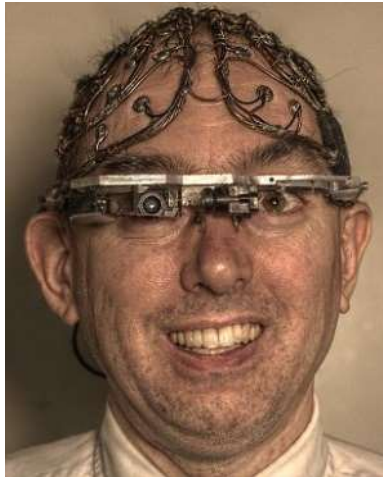
- Steve Mann: Exosomatic memory (capturing, retrieving and sharing experiences).

- *HoloLens*: Augmented reality with internet connectivity.

- Cortical interfaces

- Sharing through networks (brain-brain) (team members tap each other's sensors and experiences)

- A system evolution from *Homo Universalis* to symbiotic distributed human organisms.

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Thank you!

peter.werkhoven@tno.nl