Full Body, Olfactory, Gustatory Technologies

Full Body Interfaces: Overview

- Body systems
- Classification
  - motion platform
  - self motion
- Full Body Technologies

Full Body Interfaces: Mechanisms

- Vestibular system
  - orientation to vertical
  - centre of mass control
  - head stabilization
    - direct to spinal cord (vestibular-spinal reflex)
    - vestibular-ocular reflex
- Visual system
  - position and movement of head
  - slip of retinal image (optokinetic reflex)

Full Body Interfaces: Classification

- Passive Motion Platforms
  - cabins
  - chairs
  - centrifuges
  - examples (first practical VR applications):
    - flight simulators
    - games
- self-motion interfaces
  - user moves self through VE
  - active movement
  - alternative to “flying” interfaces

Full Body Interfaces: Classification

- Want surface characteristics
  - slope, resilience and texture
- want sense of effort for locomotion

Passive Motion I/F (Commercial)

- CAE Flight Simulator
- Chairs in motion
  - Cyber Air Base, Cyberchair, CyberMotion Seat, IntelliSeat, Sim245
  - pneumatics or motors

Passive Motion I/F (Commercial)

Photo courtesy of ViRtogo, Inc.

Photo courtesy of CineMotion International plc

Photo courtesy of Flogiston Corporation

JoyChair (Kawada)

Photo courtesy of Torus Systems, Inc.

Self Motion Interfaces: Commercial Products

- $8K - $55K
- Gyroscopes
  - Aerotrim, CyberTron, Orbotron, X-otron VR, Supertron
- Hang glider
  - DreamGlider
- Interactive Motion Platforms
  - PemRAM 3 & six axis motion base
- SimuPod and SimuSled

Self Motion Interfaces: Commercial Products

Specification

Floor Space	9.5 ft diameter circle
Device Height	9.5 ft
User Range of Motion	360° pitch, roll, yaw
Device Weight	750 lb
Max. Payload	275 lb
User Size	3.5 to 6.5 ft

Photo courtesy of Aerotrim USA, Inc.

Photo courtesy of Denne Developments, Ltd.

- Hollerbach (Utah)

Specification

Floor Space	7 x 8ft
Device Height	7 ft
User Range of Motion	Side-to-side, forward-back, and sway movements typical in hand gliding
Device Weight	500 lb
Max. Payload	325 lb
User Size	N/A

Photo courtesy of Dreamality Technologies, Inc. and Trailcraft Manufacturing, Ltd.

Self Motion Interfaces: Commercial Products

Photo Courtesy of Sarcos Research Corporation

Photo Courtesy of Sarcos Research Corporation

Photo Courtesy of Sarcos Research Corporation

Self Motion Interfaces: Research

- Some of the same companies that are making products also do the research
- Locomotion Interface
  - Hollerbach
- Hiroo Iwata (Tsukuba)
  - Haptic Walkthrough Simulator
    - modified roller skates
  - Probably group that makes terrain feedback
    - triangular segments controlled by hydraulic motors

Self Motion Interfaces: Swimming Across the Pacific

- swimming interface using VR technology
  - hct.ece.ubc.ca/research/sap

Self Motion Interfaces: Birdly

- Birdly: Zurich University of the Arts
  - now its marketed by: http://www.somniacs.co

Full Body Motion Interfaces: Summary

- Large systems dedicated to one task is effective
  - flight simulators
- Other uses
  - arcade games
  - military training
- Infancy of research

Olfactory Interfaces

- One of least developed
  - applications
  - poorly understood
  - social mores
- Useful for
  - fire fighting
  - surgical training
  - immersion
  - manipulate mood
  - increase vigilance
  - decrease stress
  - retention and recall of material

Olfactory Mechanisms

- Usually air with smell goes into nose then into nasal cavities (as large as brain)
- volatile chemicals interact with various sensors in nose
  - olfactory ephithelium (top of cavities)
    - connected to olfactory bulb to nerves
    - cells regenerate every 30 days
  - trigeminal stimulation (i.e. cooling effect)
  - vomeronasal organ, also known as Jacobson's Organ
    - close to entrance; pheremone sensitive
    - rich history

- check out: Kaye, J.: web.media.mit.edu/~jofish/thesis/

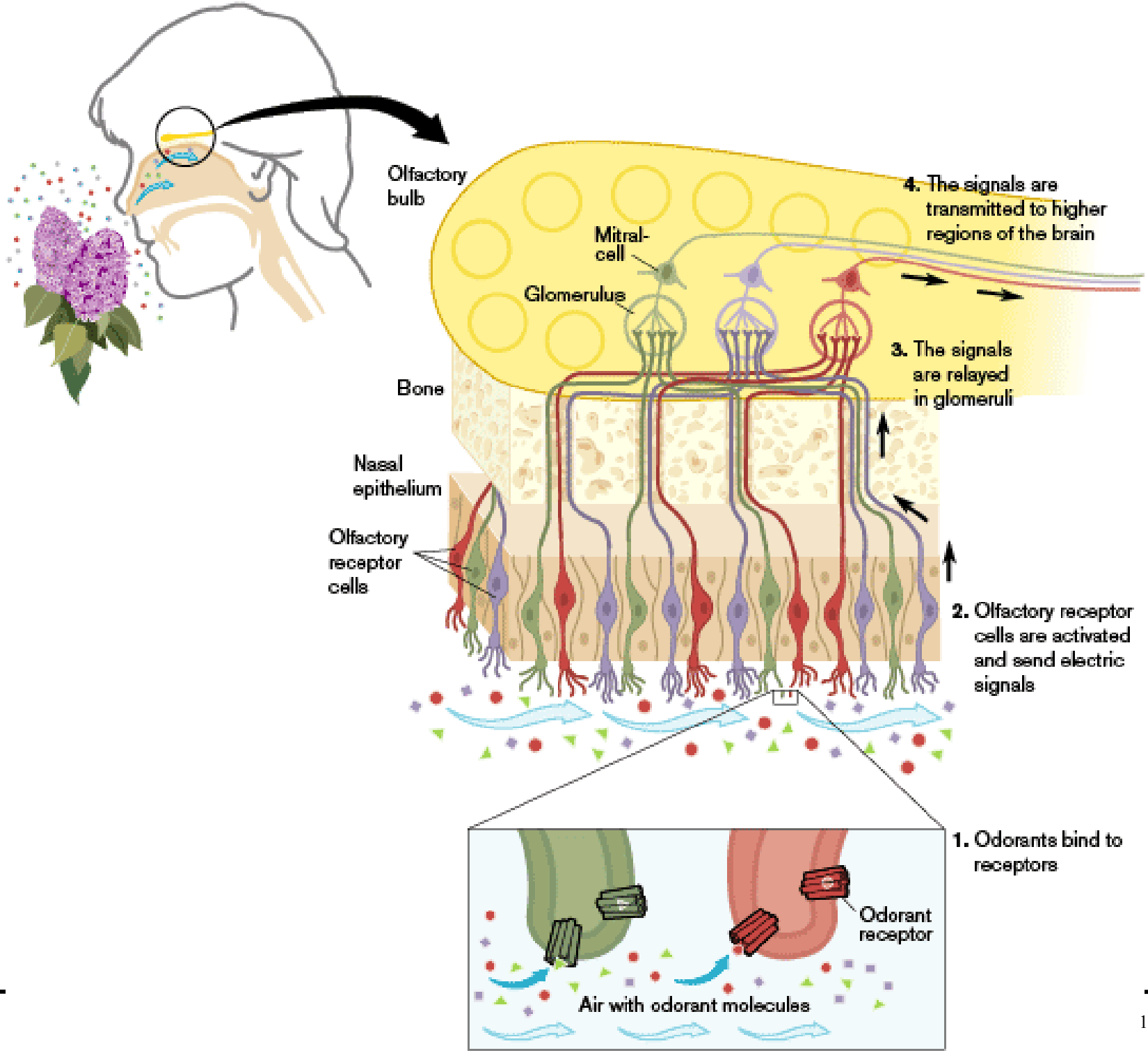
Olfaction: Artificial Mechanisms

- Electronic noses
  - conductive sensors: metal oxides/polymer sensors
  - mass changes: Absorbent polymers
    - mass measured with either SAW or quartz crystal microbalance
  - Metal-oxide-silicon field-effect-transistor
    - (Nagel, Schiffman and Guitierrez-Osuna 1998)
  - optical methods
    - Tufts, (Schmiedeskamp 2001)
    - (Rakow and Suslick 2000, Dagani 2000)

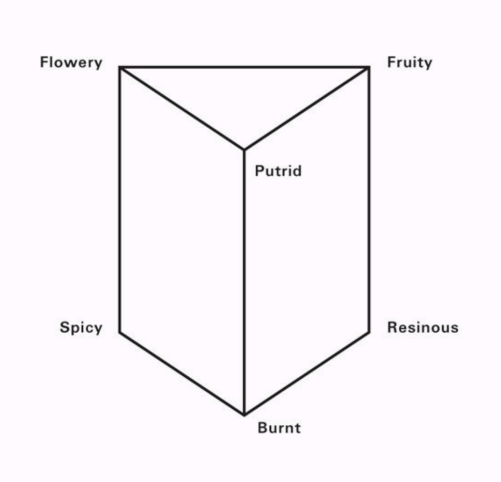
Figure 4. Digital smell camera. (Rakow and Suslick 2000).

How do we smell?

- Wright's Vibrational Theory
  - absorption peaks in their far infrared spectra
- Amoore's Stereochemical Theory
  - lock-and-key mechanism
- Turin's Spectroscopic Theory
  - vibrational sensing through inelastic electron tunneling
- Chiral Molecules
  - more complexities for smell than covered by any current theory
- Protein receptors (Axel and Buck, 1991)
  - Controlled by >1000 genes


Olfactory bulb
Mitral-cell
Glomerulus
4. The signals are transmitted to higher regions of the brain
3. The signals are relayed in glomeruli
Bone
Nasal epithelium
Olfactory receptor cells
2. Olfactory receptor cells are activated and send electric signals
1. Odorants bind to receptors
Odorant receptor
Air with odorant molecules

Olfactory Classification



- Lots out there:
  - Nothing accepted yet
- six category prism (Henning 1915)
- cultural classifications
  - i.e. pungent-smelling old men, old women, large mammals, macaw, some amphibians, medicinal plants
- Perfumery (Curtis and Williams 1994)
  - set of three letter codes
  - often trade-secret
- Domain specific
  - beer, wine and spirits

Wine wheel


WOODY
RESINOUS
PHENOLIC
BURNED
VANILLA
CEDAR
OAK
BACON
PHENOLIC
MEDICINAL
COFFEE
BURNT TOAST
SMOKEY
CARAMEL
HONEY
BUTTERSCOTCH
DIACETYL (BUTTER)
SOY SAUCE
CHOCOLATE
MOLASSES
NUTTY
WALNUT
HAZELNUT
ALMOND
EARTHY
EARTHY
MOLDY
DUSTY
MUSHROOM
MOLDY CORK
MOLDY
CHEMICAL
PETROLEUM
SULFUR
TAR
PLASTIC
KEROSENE
DIESEL
RUBBERY
HYDROGEN SULFIDE
NATURAL GAS, MERCAPTAN
GARLIC
SKUNK
CABBAGE
BURNT MATCH
SULFUR DIOXIDE
WET WOOL, WET DOG
PUNGENT
ETHYL ACETATE
ACETIC ACID
ETHANOL
SULFUR DIOXIDE
PUNGENT
HOT
COOL
ALCOHOL
MENTHOL
SHERRY
OXIDIZED
MICROBIOLOGICAL
YEASTY
LACTIC
OTHER
BAKERS YEAST
LEESY
SAUERKRAUT
SWEATY
YOGHURT
HORSEY
MOUSEY
FRUITY
FLORAL
SPICY
FLORAL
SPICY
CITRUS
BERRY
(TREE) FRUIT
(TROPICAL) FRUIT
(DRIED) FRUIT
OTHER
ORANGE BLOSSOM
ROSE
VIOLET
GERANIUM
CLOVES
BLACK PEPPER
LICORICE/ANISE
LEMON
GRAPEFRUIT
BLACK CURRANT (CASIS)
STRAWBERRY
RASPBERRY
BLACKBERRY
APPLE
PEACH
APRICOT
CHERRY
BANANA
MELON
PINEAPPLE
FIG
PRUNE
RAISIN
STRAWBERRY JAM
METHYL ANTHRANILATE
ARTIFICIAL FRUIT
HERBACEOUS OR VEGETATIVE
FRESH
CUT GREEN GRASS
BELL PEPPER
EUCLAYPTUS
MINT
CANNED/ COOKED
GREEN BEANS
ASPARAGUS
GREEN OLIVE
BLACK OLIVE
ARTICHOKE
DRIED
HAY/STRAW
TEA
TOBACCO

Olfactory Psychophysics

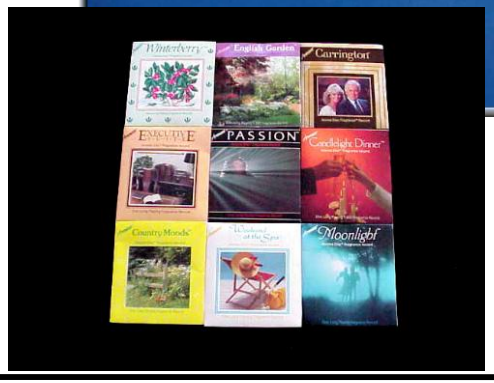
- How many can we distinguish?
  - Not clear
    - 1.5 bits to 10+ bits; 10,000 different smells
- How much?
  - Intensity measures
    - complicated by habituation
    - context sensitive
- very sensitive 1ppm to 1ppb
  - 15% to 30% change is detectable (closer to log than linear)

People and smell

- Emotional effect
  - not clear, cultural effects, non-repeatable
- Smell can evoke memories
- Impact sleep?
- Attraction and synchronization
  - pheromones

Olfactory Displays: Products

- Aromatron - what we want to create
- Scratch & Sniff
- DigiScents (bankrupt)
  - smell index (100-200 smells)
- TriSenx (bankrupt)
  - single smell controlled by serial port
- BOC Group Olfactory Delivery Systems
  - dissolve odorants in gas
- Smell Enhance Experience System
  - seven odors in liquid form
  - delivered with small tube
- Smell-o-Vision (K Opticom)
  - 6 gels, USB controlled
- Aroma 2100



Olfactory Displays: Research

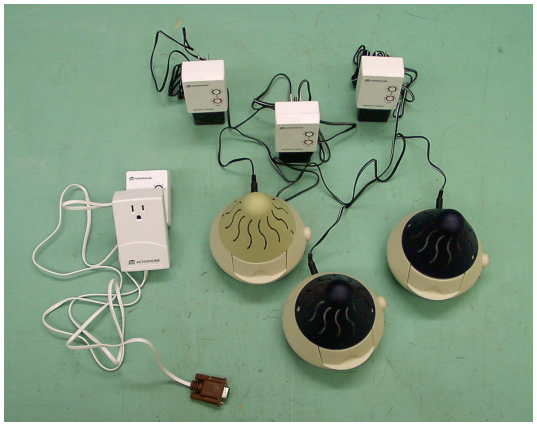
- DIVEpak (Southwest Research Institute, 1993)
  - 8 odors
  - contained in cartridge
  - heated and dissolved in air
  - blown at user
- E. Piaggio BioRobotic Lab (U. of Pisa)
  - smell camera
- Artificial Reality Corporation
  - developing odorants
- Marketing Aromatics, Ltd.
  - Aromatic oils vapourized

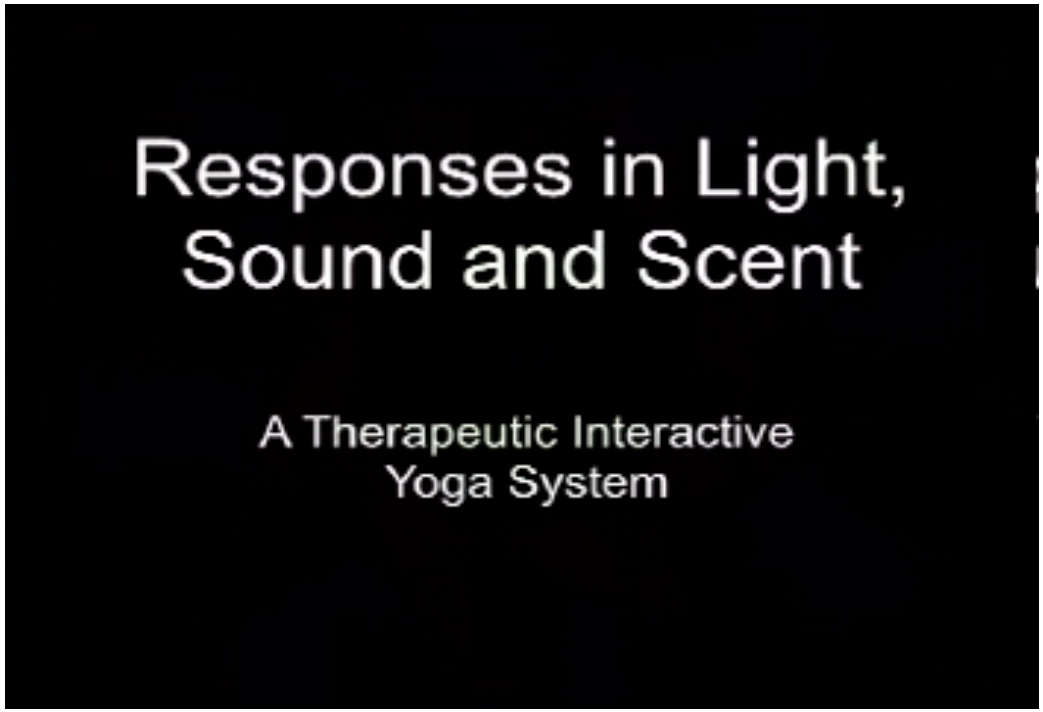
Some Olfactory Research

- Joe Kaye:
  - inStink
    - inTouch concept except with smell
    - CO2 through air brushes
  - Dollars & Scents
    - ambient media
    - perfume spray bottles
  - Scent Reminder
    - 5 channel D & S device
  - and more...

Olfaction Research

- Gauthier and Smith (HIT 02)
  - interactive yoga system
  - 3 aromatherapy diffusers
    - controlled through X10 protocol
  - turn on according to yoga postures
  - mixed with ambient sound and image according to Kundalini yoga theory





Olfactory Displays

- Storage media
  - liquid, gel or waxy solids
  - microencapsulate odorants
    - scratch and sniff
    - drops of liquids encapsulated in gelatin
    - placed using silk screening
- Display
  - air dilution
  - breathable membranes
  - liquid injection with air flow control

Olfactory Displays

Table 20. Olfactory Delivery Technologies[a]

Storage Technologies	Presentation Technologies	Advantages	Disadvantages
Liquid	- Unpowered evaporation: Saturated cotton balls Breathable membranes Permeation tubes Bubble chambers	- No power - Inexpensive	- Bulky - Odorants clumsy to handle
	- Heat induced evaporation	- Inexpensive	- Power hungry
Gels	- Electrostatic evaporation	- Good for large spaces - Materials easier to handle	- Never miniaturized - Requires higher voltages
Microencapsulation	- Mechanical release	- Could be valveless - Materials easy to handle	- Mass production technology - Impractical for small lots
	- Heat release	- Could be valveless - Materials easy to handle	- Mass production technology - Impractical for small lots
	- Valve design options: No valves	- Smaller, cheaper	- Intercontamination of odors
	Off-the-shelf valves	- Mass produced	- Bulky, power hungry - Fast or precise, not both
	Ink jet printer nozzles	- Precise control	- Single units large because of packaging
	Microvalves	- Potentially fast & small	- Must make custom minifolds to get greatest miniaturization

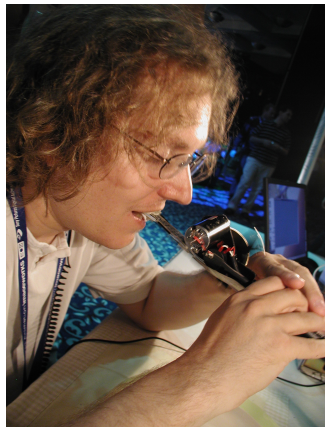
a. Based on Krueger (1995, 1996).

Olfactory Displays

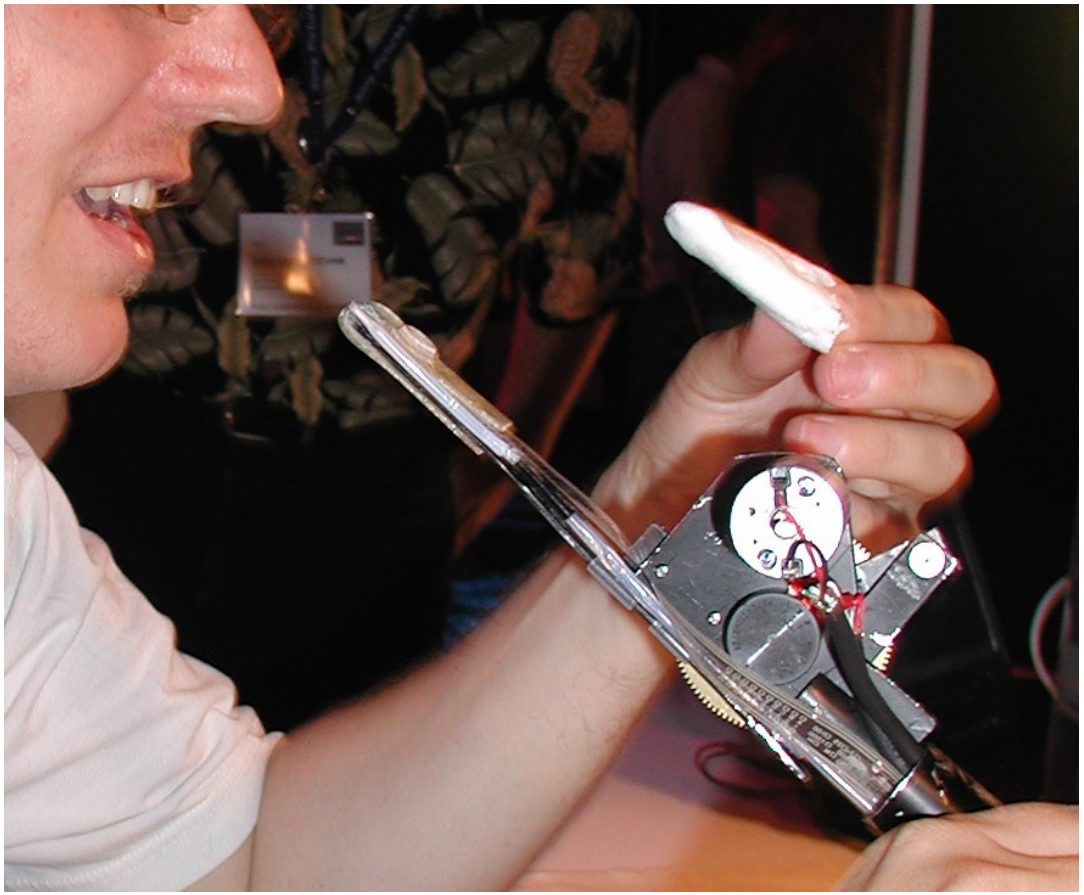
- Challenges
  - clean air input
  - evacuate air
  - clean output air
- control breathing space
  - sealed room with air filtration
  - air control in front of and behind user
  - sealed pod
  - tethered mask
  - tubes into an HMD from pack
  - built into HMD

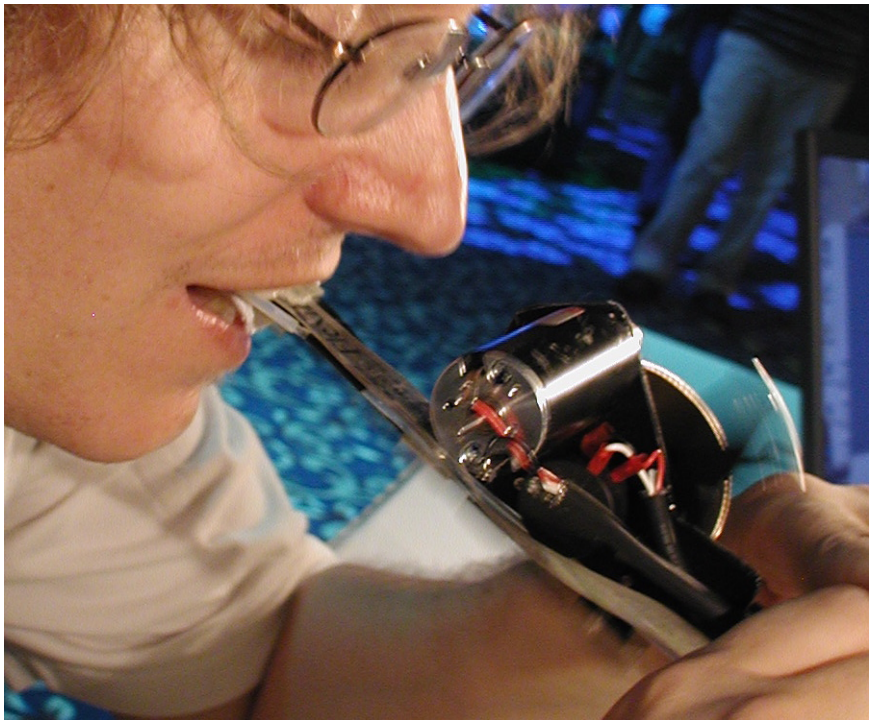
Gustatory Display

- Not much out there...
  - One performance at Opera Totale 4 by Beneton group
    - four biscuits of different colour that you ate
  - Iwata, Siggraph03
    - bite feedback and simulated taste/sound (apple and cracker)
  - Chemicals for synthetic flavour
- research topic
  - recording device?
    - Artificial tongue
  - display device?
    - Delivery mechanism
    - remove taste mechanism
    - human factor issues

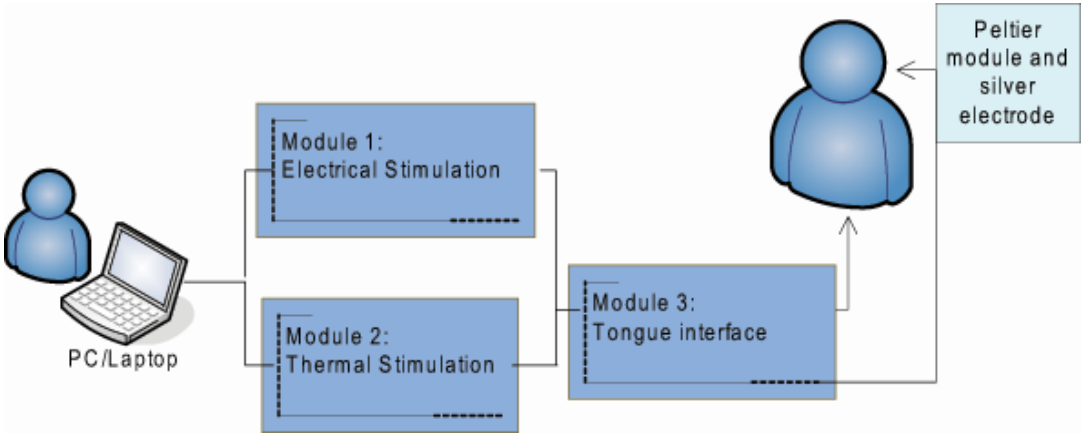


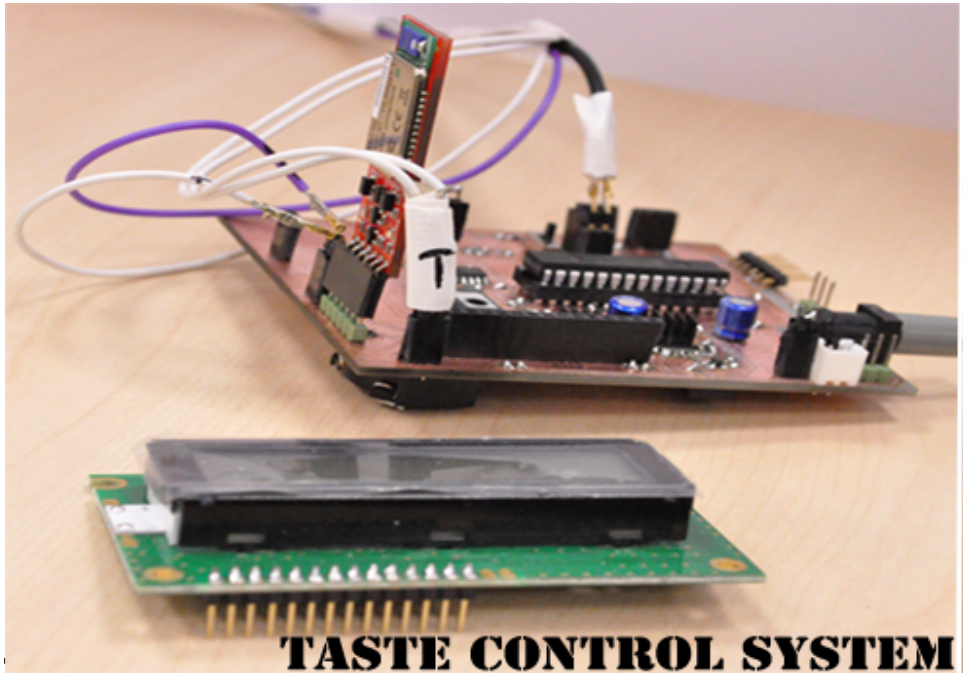
Iwata's Bite Simulator

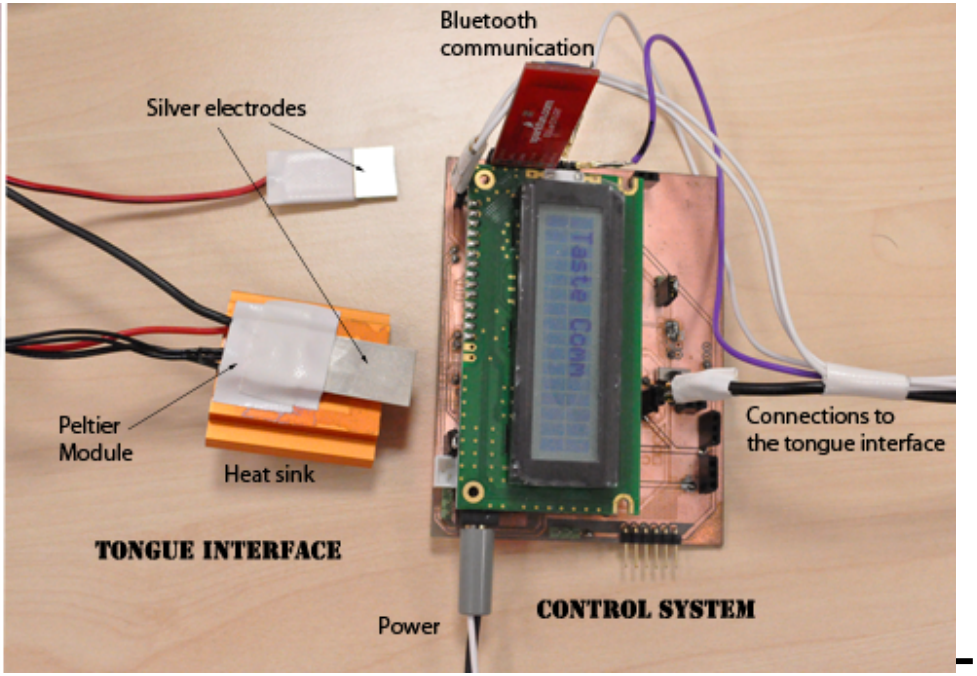




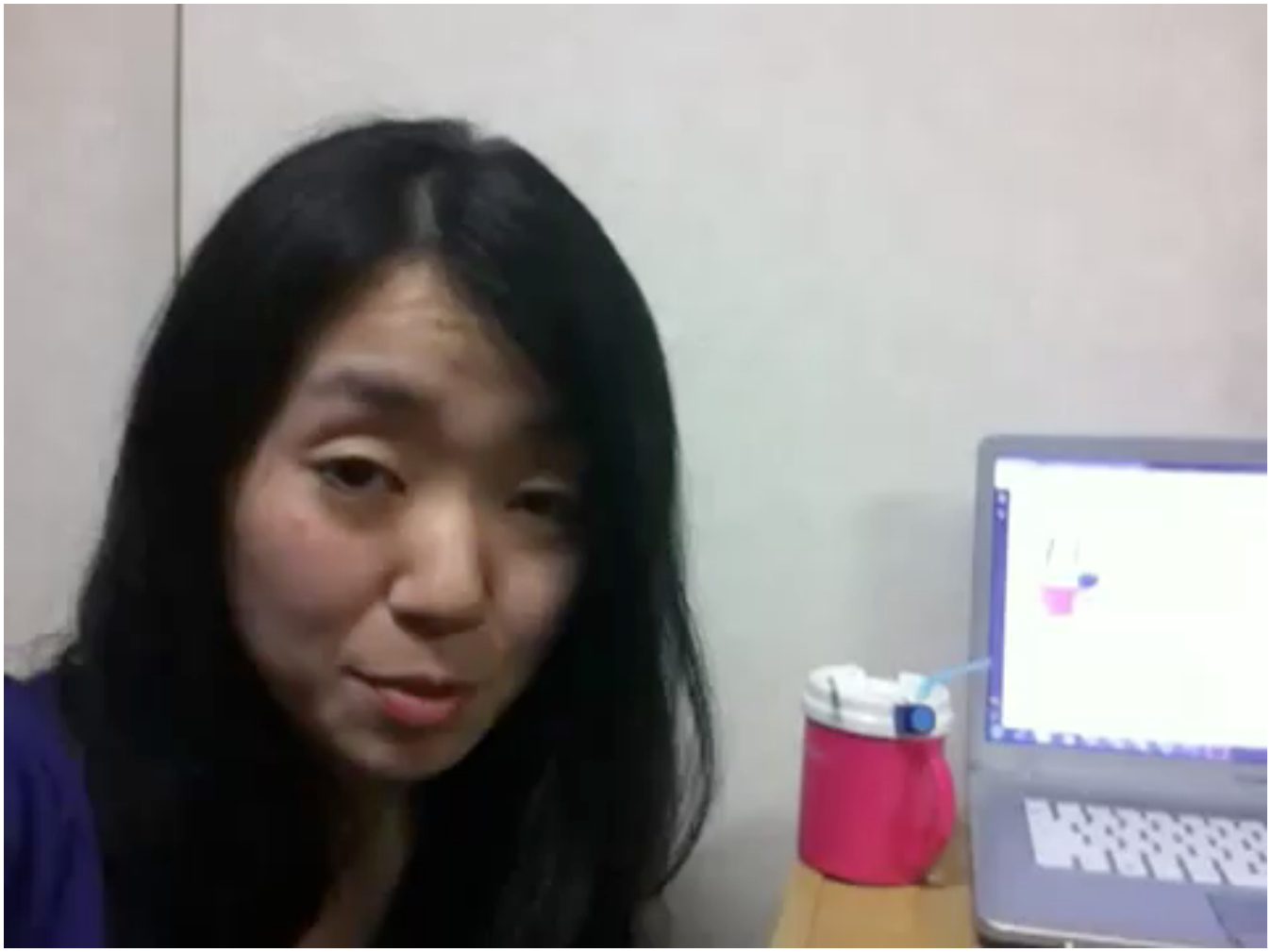
Digital Taste Interface (Ranasinghe & Cheok, 2012)







Another gustatory display



Nakamura & Miyashita, 2011

and one more… TransFork

Ying-Li Lin (National Taipei University of Technology), Tsai-Yi Chou, Yu-Cheng Lieo, Yu-Cheng Huang, Ping-Hsuan Han, VRST2018

https://www.youtube.com/watch?v=htHXi_b6MAg

Olfactory Displays: Summary

- Look forward to research
- still very new and understudied

Summary

- Human body is amazing
  - making displays for all parts is goal of much research
    - desire to make virtual reality
    - better “visualization” of information
    - better control of information
    - expression
    - fun
- Lots of room for research