

Olfaction as a Device Applicable to IoT

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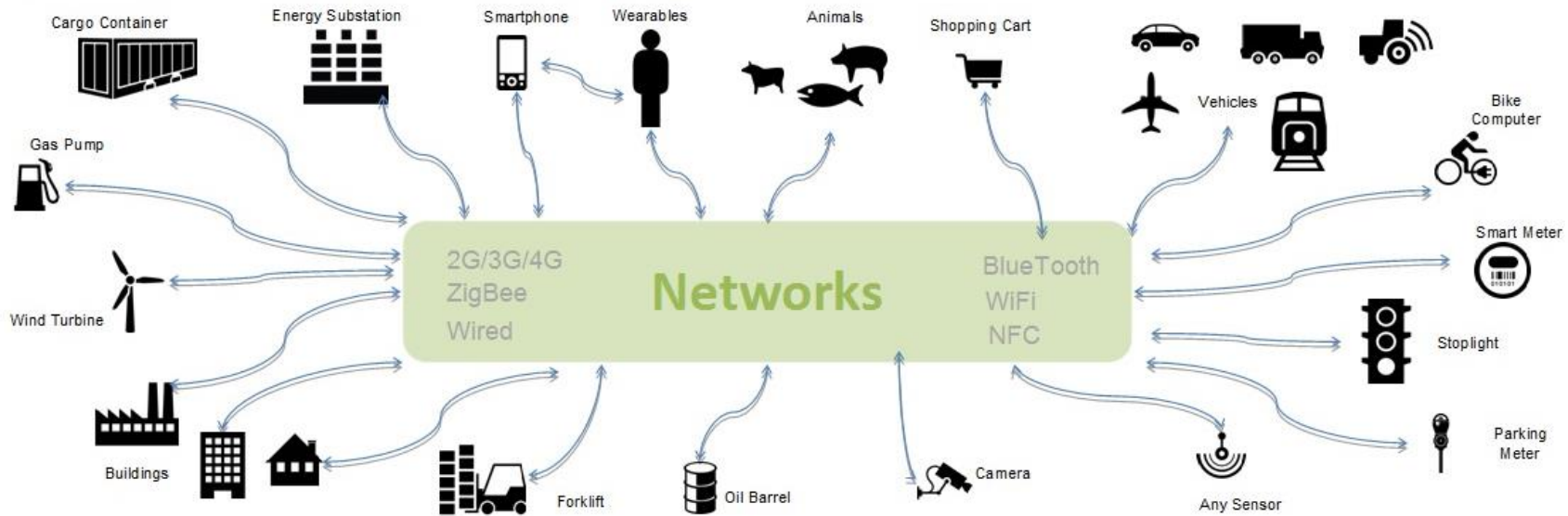
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02 A Device Applicable to Internet of Things

- Device for Exhale Breath Analysis
- Device for Odor Display for Multimedia Application

03 Summary & Further Works for Collaboration

Introduction - IoT

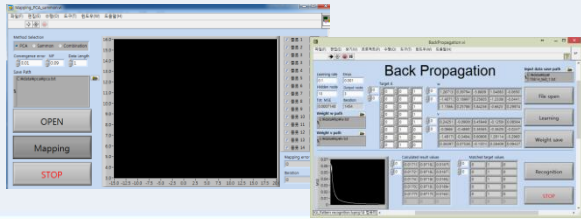


- IoT - Connecting people to physical things and also among the physical things, all in real time.
- IBM data source (IDC) has estimated that by 2020 there will be **30 billion** internet-connected and sensor-enabled objects.

Image from ibmcai.com, "The next phase of the Internet: The Internet of Things"

Introduction – Olfaction

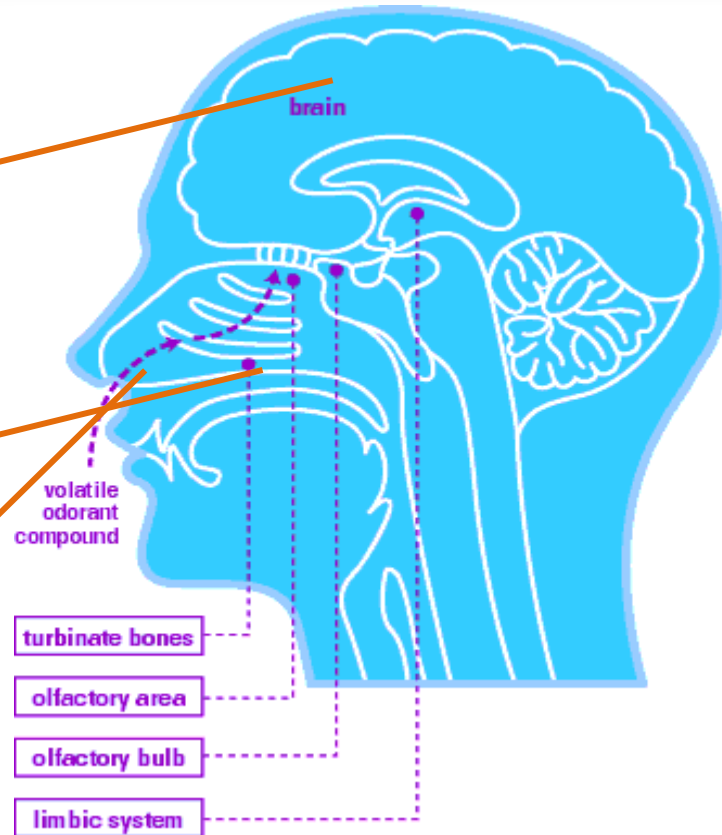
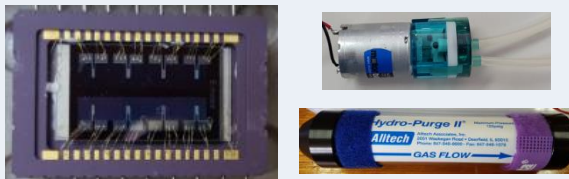
Analysis part



Electronic part

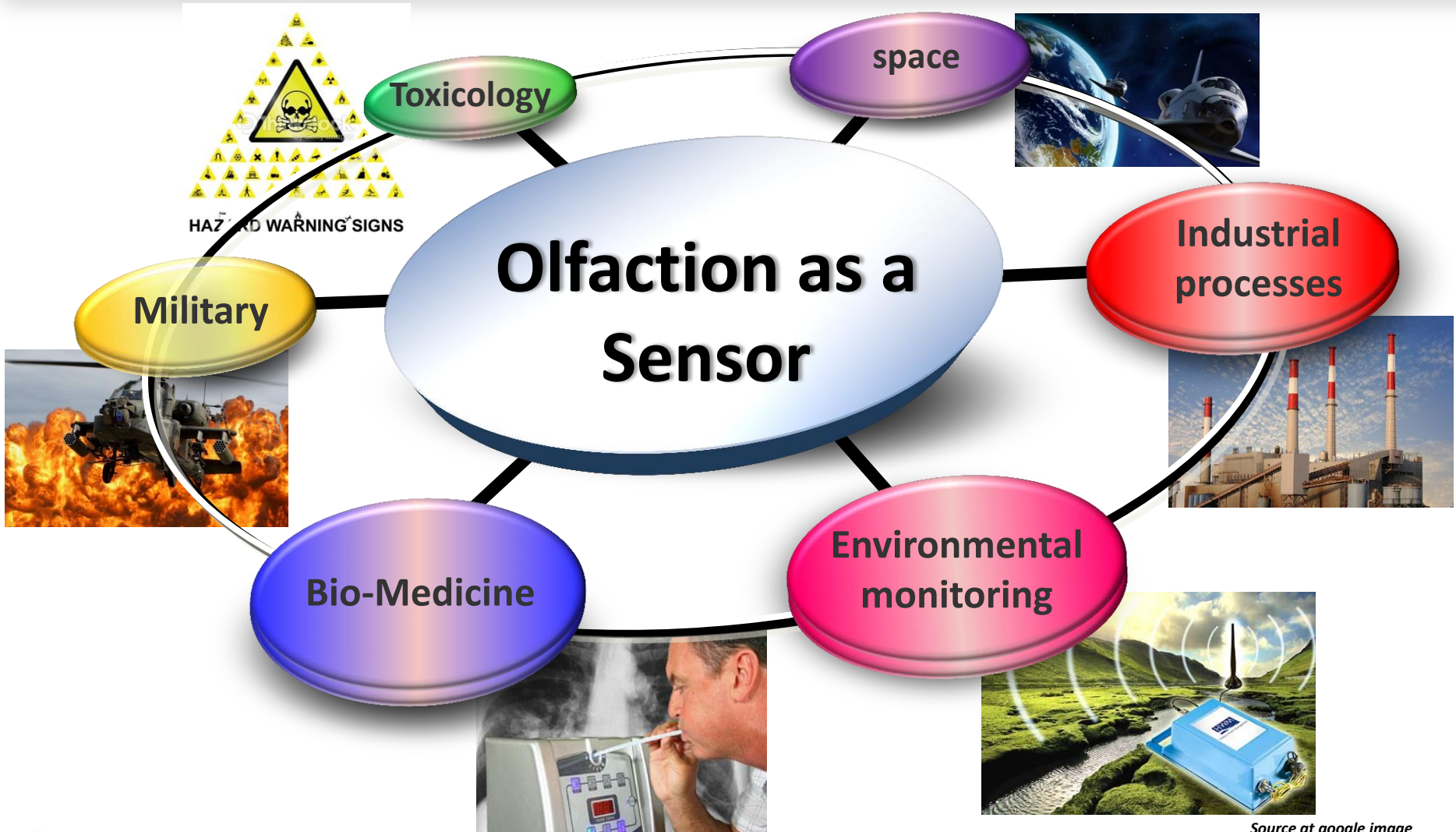


Physical part



<http://www.profumo.it/internet-documents/olfatto/biological.htm>

Introduction – Olfaction as a Sensing



Source at google image

Introduction – Olfaction as an Actuating



4-D Multiplex



Scent Alarm Service with Smart Phone



Game

Olfaction as an actuator

Scent Mailing Service



Nicola; Jamaica:
"I play the first-ever scent-enabled CD from Zan. It's SENXational!"



Anonymous; United Kingdom:
"Mmmm..."



VR with HMD



Medical

Exhale Breath Analysis (I)

What Your Breath Reveals

EXHALED BREATH CONTAINS thousands of chemical compounds that can signal health issues. Scientists are developing tests to diagnose a growing list of diseases based on breath. Some diseases—and the clues that come out of your mouth:

ASTHMA: *Nitric oxide* levels rise when airways are inflamed.

STOMACH ULCERS: The gut bacteria *H. Pylori*, when mixed with a chemical tracer, emits a **carbon isotope** in breath.

LUNG CANCER: Tumors create dozens of unique **volatile organic compounds**, while sensory arrays identify telltale patterns.

DIABETES: Elevated levels of **acetone in breath** indicate ketosis, which reflects insufficient glucose.

KIDNEY DISEASE: 'Electronic nose' test recognizes **ammonia-like odor** linked to renal failure.

LIVER DISEASE: Patients whose livers can't metabolize a tracer solution containing methacetin show changes in **carbon dioxide levels**.

IRRITABLE BOWEL SYNDROME: **Elevated hydrogen** in breath can indicate bacterial overgrowth in small intestine.

LACTOSE MALABSORPTION: Undigested lactose in the colon is fermented by bacteria, **raising hydrogen breath levels**.

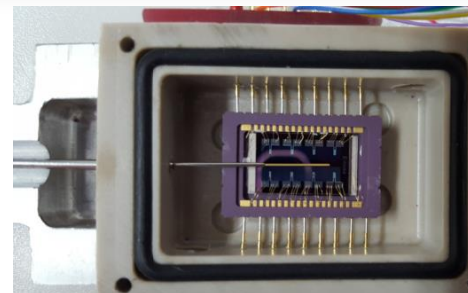
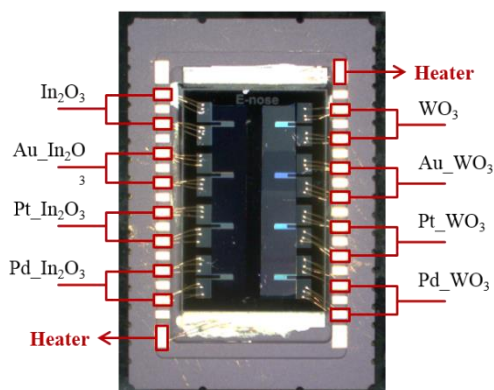
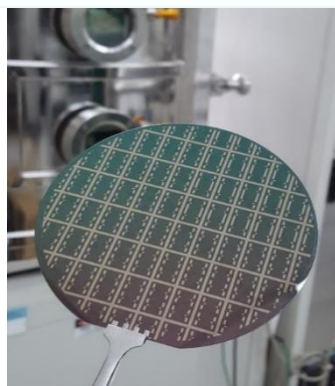
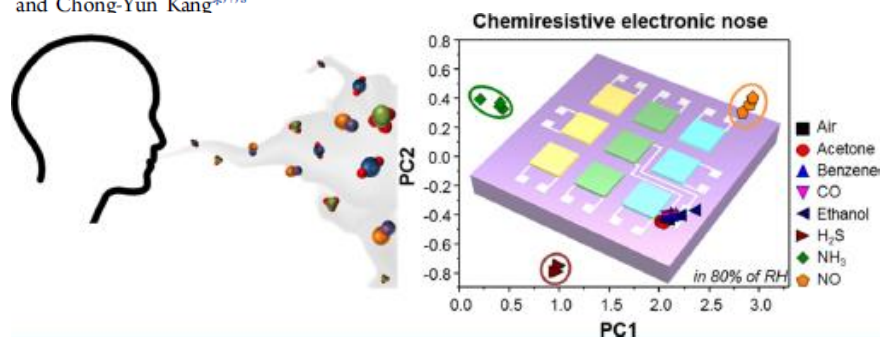
HEART TRANSPLANT REJECTION: Rejection creates 'oxidative stress' that produces **alkanes and methylalkanes** in breath.

Source: WSJ reporting

Exhale Breath Analysis (II)

Chemiresistive Electronic Nose toward Detection of Biomarkers in Exhaled Breath

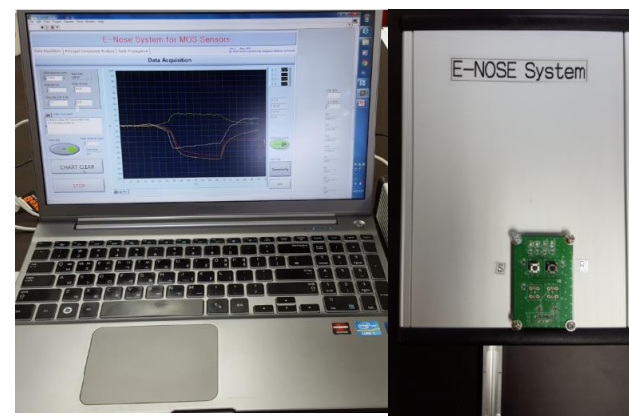
Hi Gyu Moon,^{†,‡} Youngmo Jung,^{‡,||} Soo Deok Han,^{†,§} Young-Seok Shim,[†] Beomju Shin,[⊥] Taikjin Lee,[⊥] Jin-Sang Kim,[†] Seok Lee,[⊥] Seong Chan Jun,^{||} Hyung-Ho Park,^{*,‡} Chulki Kim,^{*,⊥} and Chong-Yun Kang^{*,†,§}



Sensor Array Chamber



Sample Delivery using SPME

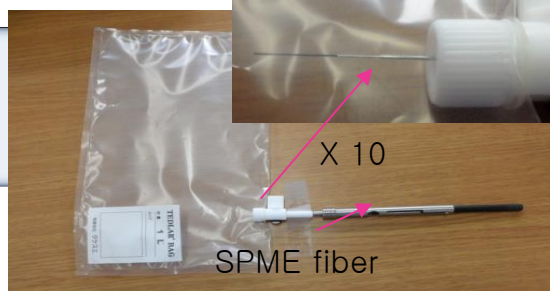


Exhale Breath Analysis (III)

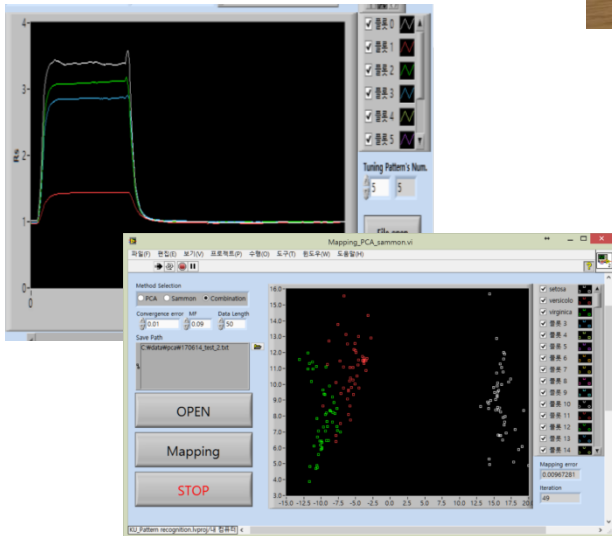
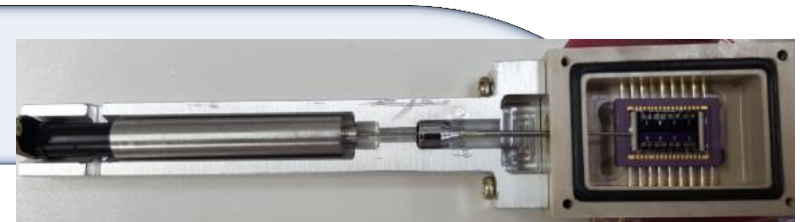
Breath Collection



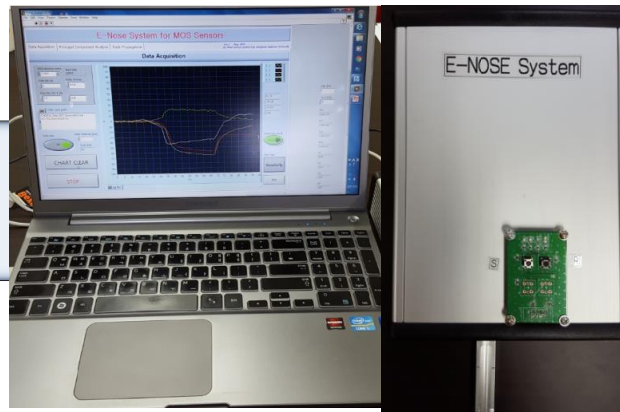
Breath Sampling



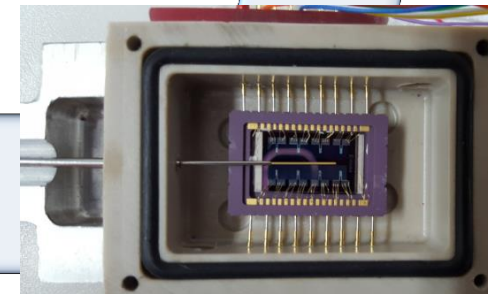
Breath Delivery



Identification



Breath test



Exhale Breath Analysis (IV)

Table 7. List of control group for breath measurement.

Sample no.	Sex	Age	Glucose(mg/dl)
1	M	37	92
2	F	32	97
3	M	29	87
4	M	31	85
5	F	26	94
6	F	34	99
7	M	30	93
8	F	30	90
9	F	24	82
10	F	22	83
11	F	54	100
12	F	47	100
13	M	50	106
14	F	58	97

Table 8. List of diabetics group for breath measurement.

Sample no.	Sex	Age	Glucose(mg/dl)
1	F	24	125
2	M	33	130
3	F	56	151
4	M	58	164
5	M	69	154
6	F	45	306
7	F	63	111
8	F	67	98
9	M	75	150
10	M	53	112
11	F	78	92
12	F	54	129
13	F	80	148
14	M	-	108

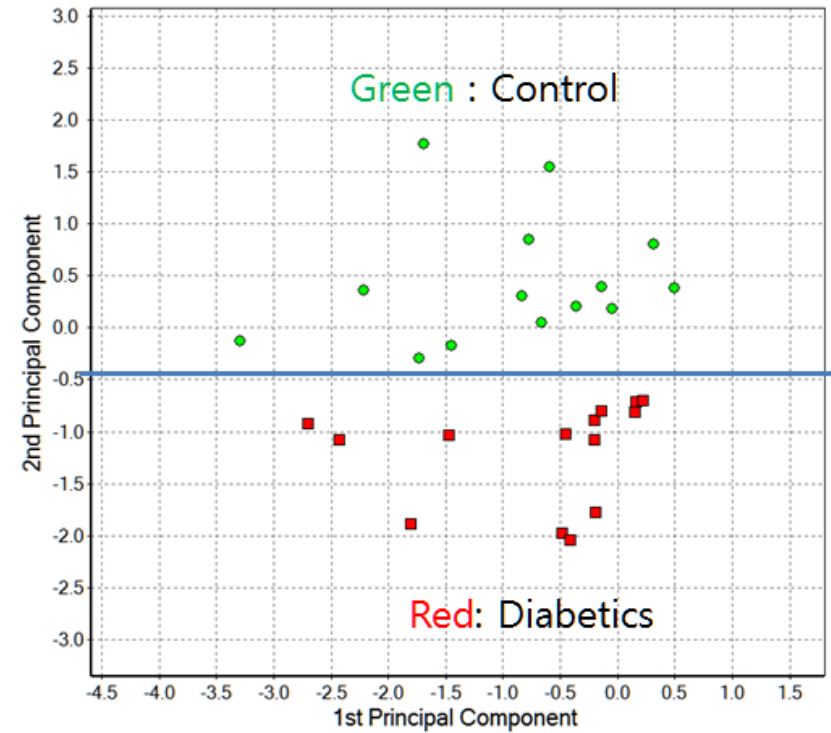
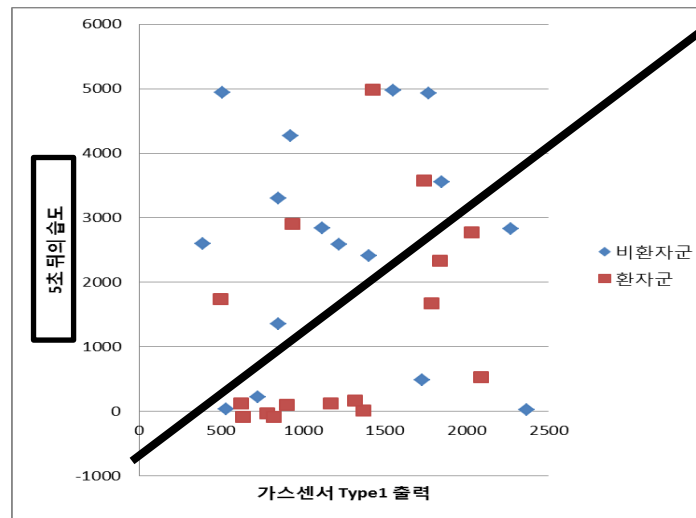
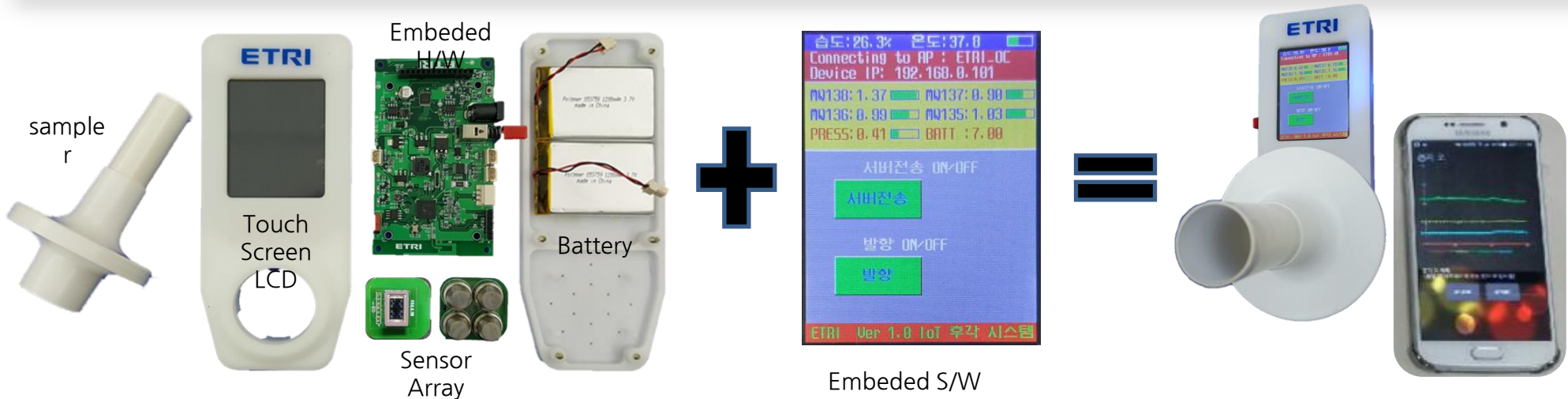


Fig. 14. PCA result of measured breath samples

Exhale Breath Analysis (V)



Portable E-Nose applicable to IoT

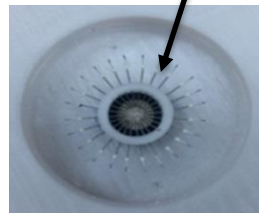
Exhale Breath Analysis (VI)

E-NOSE SYSTEM

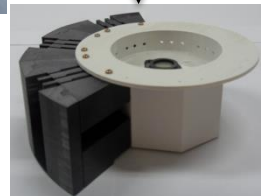
Odor Display for Multimedia (I)



Odor Displayer



Ultrasonic vibrator

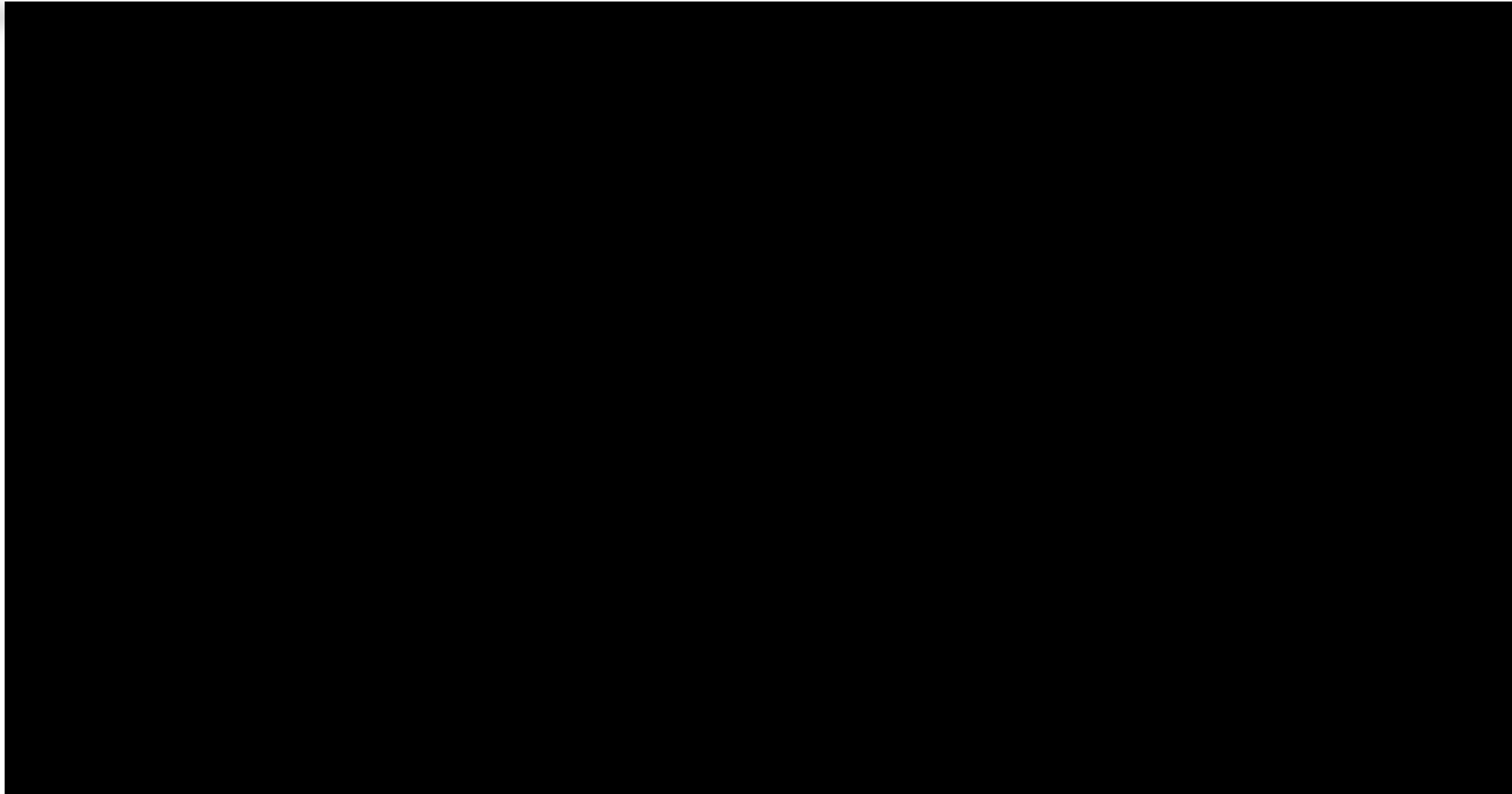


Odor Cartridge



Software for Odor Blending and Display

Odor Display for Multimedia (II)

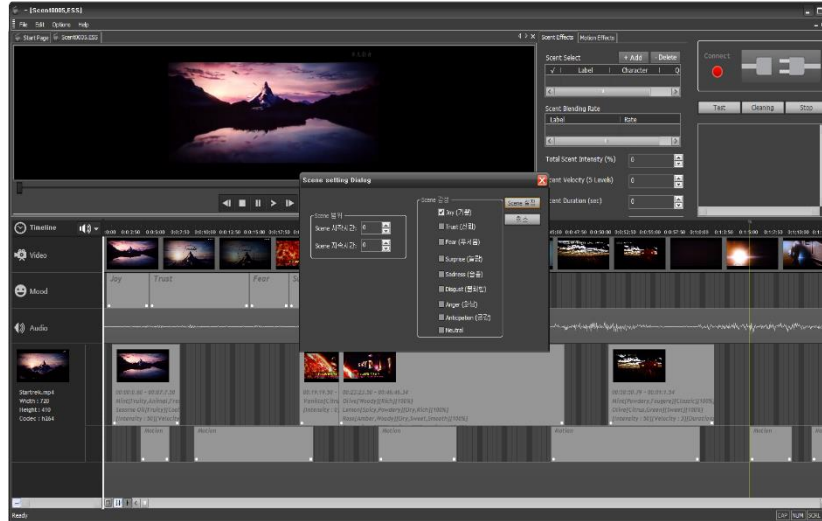


Odor Display for Multimedia (III)

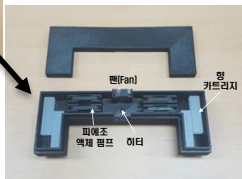
Olfaction for VR Application



Virtual Space



Olfaction Display Control Software



HMD with Olfaction



Odor Display for Multimedia (IV)

OLFACTION FOR VR
APPLICATION

Odor Display for Multimedia (V)

OLFACTORY AUTHORIZING TOOL &
SIMULATOR

Summary

- Introduction functionality of sensors and actuators based on nanotechnology for human sense of smell (Olfaction)
- Implementation for Olfaction as a device applicable to IoT
 - Olfaction Sensing Device for health care monitoring system based on chemical sensor array to exhale breath analysis.
 - Olfaction Actuating Device for multimedia applications based on odor display
- Olfaction sensing and actuating capabilities based on nanotechnology and ICT are a strong candidates for IoT

Further Works for Collaboration

- Hybrid Sensors and Interface development for various applications
- Standard Operation Protocol (SOP) development
 - Standardization protocol individual device operations
 - Connectivity protocol between devices
- Safety and Security developments for devices applicable IoT

Acknowledgement

This work was supported by Institute for Information & communications Technology Promotion(IITP) grant funded by the Korea government(MSIP) (No.2015-0-00318, Olfactory Bio Data based Emotion Enhancement Interactive Content Technology Development)

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