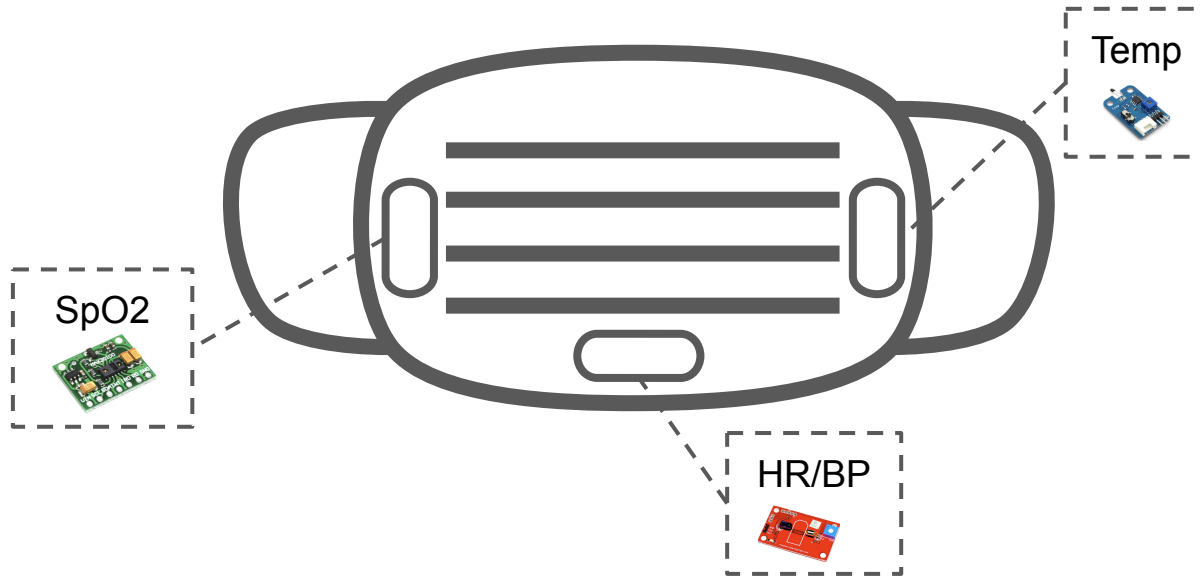# Smart Mask

Temp

SpO2

HR/BP

Yongshin Kim

Mask applications

Daily life

ER mask

Firefighter mask

Cardiopulmonary Exercise Testing (CPET)

Warrior Platform

Industrial mask

Call center

COVID-19

확진자　백신　14일　총계

코로나바이러스(코로나19)

Last updated: July 21, 2021, 11:37 GMT

Weekly Trends - Graphs - Countries - News

Coronavirus Cases:

192,393,605

view by country

Deaths:

4,136,695

Recovered:

175,056,304

Smart mask - Products

Smart mask - Papers

- Ghatak, B., Banerjee, S., Ali, S. B., Bandyopadhyay, R., Das, N., Mandal, D., & Tudu, B. (**2020**). Design of a Self-powered **Smart Mask** for COVID-19. *arXiv preprint arXiv:2005.08305*.
- Kalavakonda, R. R., Masna, N. V. R., Bhuniaroy, A., Mandal, S., & Bhunia, S. (**2020**). A **Smart Mask** for Active Defense Against Coronaviruses and Other Airborne Pathogens. *IEEE Consumer Electronics Magazine*.
- Ghatak, B., Banerjee, S., Ali, S. B., Bandyopadhyay, R., Das, N., Mandal, D., & Tudu, B. (**2021**). Design of a self-powered triboelectric **face mask**. *Nano energy*, *79*, 105387.
- Masna, N. V. R., Kalavakonda, R. R., Bhuniaroy, A., Mandal, S., & Bhunia, S. (**2020**). The **Smart Mask**: Active Closed-Loop Protection against Airborne Pathogens. *arXiv preprint arXiv:2008.10420*.
- Noronha, M., Jindal, A., & Mysore, V. (**2020**). Modified **mask** for aesthetic procedures on face during **COVID-19** era: chiseling our armamentarium. *Dermatologic Therapy*.
- Sethumadhavan, A., Mugunthan, D., Sakthivel, J., Venkatesan, S., Patturaja, D. P., Ganesh, D., ... & Sathiyanarayanan, M. (**2020**, October). Design of **Smart** Air Purifier Facial Mask. In *2020 International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE)* (pp. 581-584). IEEE.

Why smart mask?
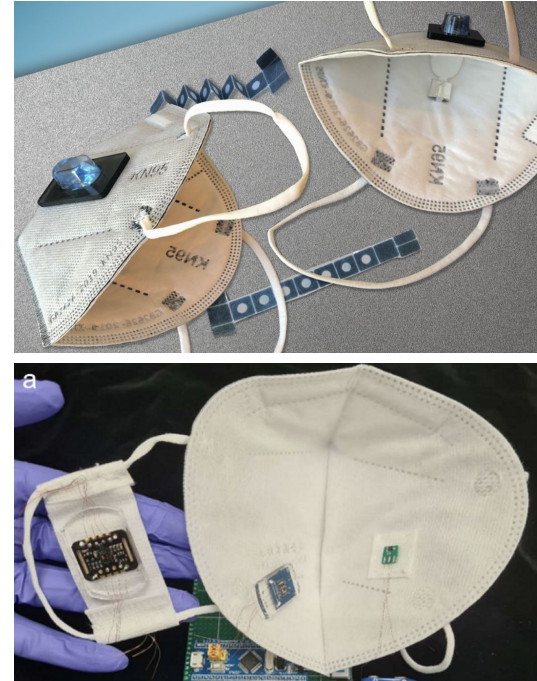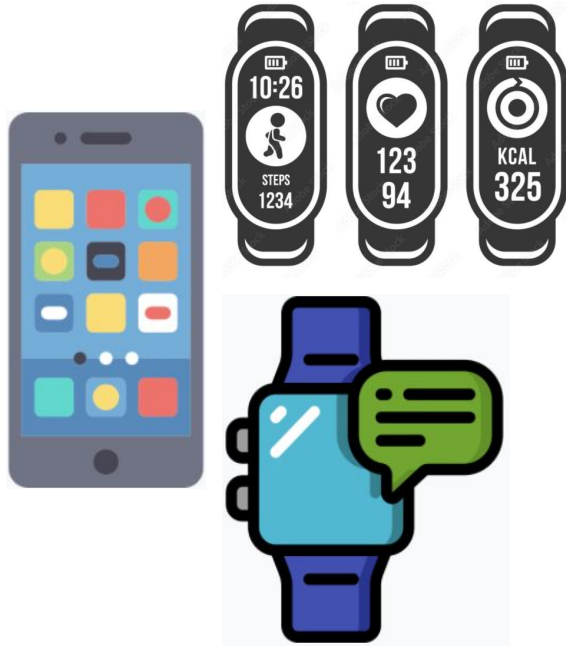
What is a smart mask?

- Research prototype or commercial product
- Considered three features
  - Sensing
    - whether it can sense anything through mask or things related to mask.
      - ex) body temperature, breathing rate, heart rate, blood pressure, ...
  - Actuation
    - Can the user operate/control the functions of the mask?
      - ex) fan speed, Powering the filter on/off, LED light on/off …
  - Wireless connectivity
    - ex) connect a mask to cell phone

Sensing

- Personal sensing
    - Physiological sensing: HR/SpO2 (PPG), Respiration (Sound, Vibration, Temp), Eye (EOG), EMG
    - Bodily sensing: head/body posture, head/body movements, physical activities (motion sensors)
    - Speech sensing: paralinguistic signals (e.g., speech duration)
- Environmental sensing
    - In-mask condition (temperature/moisture)
    - Ambient temperature / moisture
    - Ambient light
    - Air quality + toxic gas
- Device sensing
    - Fan current sensing (rotation)
    - Wearing time/durations
- Disease sensing
    - COVID-19 (e.g., DETECT Health Study)
    - Lung cancer (breath sensor)
    - Alcohol level
    - Depression/stress (mood disorder)

What kinds of sensing can be detected by using a smart mask?

- Heart rate
  - ECG(Electrocardiography), PPG(Photoplethysmography)[1]
  - BCG(Ballistocardiography) / SCG(Seismocardiography)
    - Slight movement of the body that occurs with each heartbeat
    - Analysis of these slight movements is known as BCG
- Skin temperature
  - Temperature sensor[1]
- Blood pressure
  - PPG(Photoplethysmography)[1]
- Blood oxygen
  - PPG(Photoplethysmography)[1]

What kinds of sensing can be detected by using a smart mask?

- Respiration
  - The standard deviation of a **pressure signal** when the mask is on is much higher than when the mask is off due to respiration.
    - Barometric pressure sensor
  - The warm air coming out from the mouth, every time a person breathes, shows a subtle but distinct periodicity from the inhale/exhale
  - Breathing volume, breath counts
- Mask fit & Wear time
  - IMU(Inertial Measurement Unit) & Barometric pressure sensor
  - Total mask wearing time

BCG (Ballistocardiogram)
-심탄도

PPG (Photoplethysmogram)
-산소 포화도 등을 측정하는 센서로 빛을 통해
조직의 혈액량 측정 가능

ECG (Electrocardiography), EKG
-심전도

EMG (Electromyography)
-근전도 검사
-골격근에서 발생하는 전기적인 신호를 측정하고
기록

EGG (Electroglottograph)
-음성 제작 중 진동 보컬 접힘의 접촉 정도를 비
침습적으로 측정하는 데 사용되는 장치

EMG (Electromyography)
-근전도
-골격근에서 발생하는 전기적인 신호를 측정하고
기록

EOG (Electrooculography)
-전기 안구도 기록
-안구 운동 추적 시스템

GSR (Galvanic Skin Resonse)
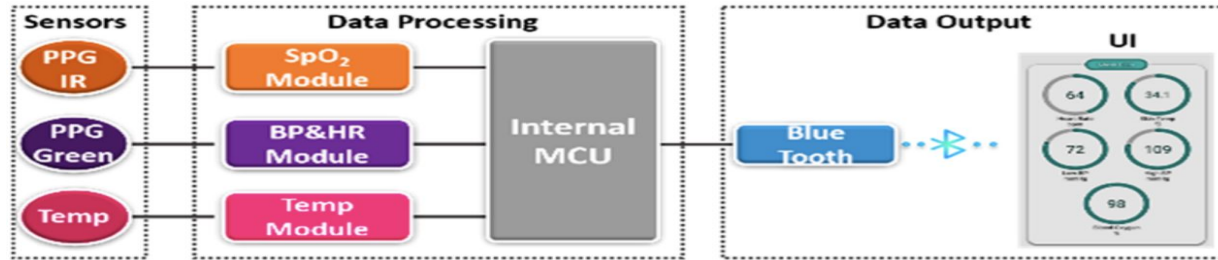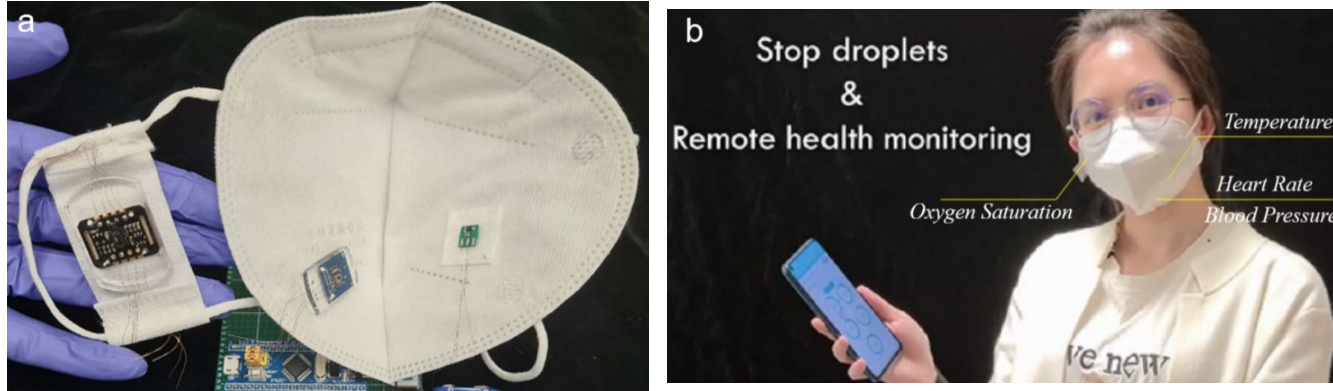-피부전도도
-땀 배출량과 체온 변화를 측정하고 그에 따른 피부
긴장도 파악

PPE (Personal protective equipment)
-개인보호구
-마스크, 보호의, 보호장갑, 보안경, 귀마개, 등
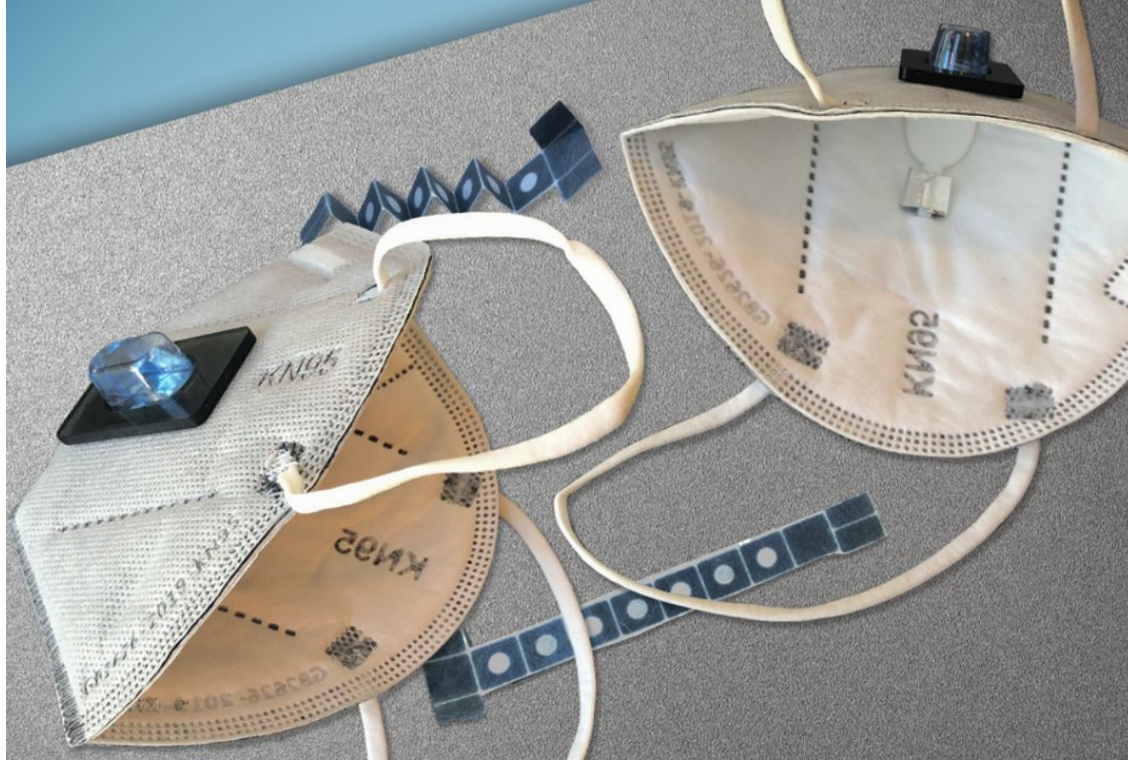
SCG(Seismocardiogram
-the recording of body vibrations induced by the heart
beat.

What kinds of sensing can be detected by using a smart mask?

What kinds of sensing can be detected by using a smart mask?

Detect Covid-19 infection

Design Considerations & Challenges

- Weight & size
  - average weight: 185g
- Materials (inner/outer space)
  - Plastic/cloth
  - Need to consider comfort levels
- Inner Moisture & Sweat
  - Temperature
  - Moisture (due to breathing) + Sweat
    - Electronics
  - Moisture (drying) due to fan
- Battery
  - Sensing frequency
  - Energy harvesting possibilities
- Sound/Speech
  - Sound muffling if smart masks are too bulky

- Mask filter
  - Using existing disposable face masks
    - Attachable (where to attach? inside or neck)
    - Mask guides
  - Using reusable face masks / replacing filters
- Hygiene and sanitization
  - Against possible germs or virus
  - Ultraviolet Germicidal Irradiation, hydrogen peroxide, and moist-heat
- Price
  - average cost: 145$

Smart mask - Products

Name	Brand Company	Weight	Material	Filter	Charging	Battery	Function	Domain	Price($)	String type	Note	Sensing	Actuation	Connectivity	Score
CX9	CELLRETURN	130g	silicon	1~7 days	USB-C Type	Lithium polymer battery 3.7V 450mAh	sterilize LED skin care safe activation	daily life	299	Adjustable ear strings and headband strap	washable	X	O	X	1
ATMOBLUE Electric Mask	ATMOBLUE	190g	silicone interface	HEPA H13 filter (last up to 6 weeks)	USB-C Type	last up to 8 hours on a single charge	3 speed dual fans, no more foggy glasses	daily life	199	omni-directional head strap		O (air-quality sensor on the mask)	O	O	3
CLIU	INDEMAND	200g	silicone, magnetic frame	Interchangeable carbon filter	charge the mask in less than an hour and kill all the bacteria in an instant.		Microphone, Bluetooth, Accelerometer	daily life	116.82/298.00(pro)	adjustable silicone band on head	transparent mask	O	O	O	3
Fresh Air Mask	Philips	300g	breathable meshes(body), aluminium(Air module)	Carbon filter (up to 122h)	Micro USB charge. fully charge in 3 hours	2-3.5 hours operation	water-resistant, 3 wind modes	daily life	199.00	normal string to ears	washable	X	O	X	1
ADAPT							pathogens sensing				research prototype	O			1
C-FACE	Donut Robotics		soft plastic and silicon cover	X	O	hours(single charge)	translation, transcript	medical, daily life	40	X	fit to other strap mask	X	X	O	1

Smart mask - Products

| Name	Brand Company	Weight	Material	Filter	Charging	Battery	Function	Domain	Price($)	String type	Note	Sensing	Actuation	Connectivity	Score
Lab-on-Mask	NTU					Li-battery with 880 mAh	monitor HR, BP, SpO2, skin temp	medical, daily life		X	attachable, research prototype	O	X	O	2
Purely	Xiaomi	50.5g	non-woven fabric, nanometer electret fiber	nano-fiber electret filter	O charging time: 30min	Polymer lithium-ion battery, (4-8hours operation)	fan speed(three-level)	daily life	32.99	normal string to ears	detachable design	X	O	X	1
AIRVISOR	CS ENL	125g		copper filter(7 days)	fully charge in 2 hours. USB C type	3.7V 600mA, 8 hours(1st speed)	3 speed modes	daily life	70	head strap		X	O	X	1
AO AIR	Atmos	290g	hypoallergenic materials including silicones	composite construction (1 month)	USB C type	5 hours of continuous use per charge	No seal around the mouth and nose.	daily life	350.00	head-mounted device		X	O	O	2
HAZEL	RAZER		recyclable plastic	N95 filter	Wireless charging case	all-day use	auto-sterilization, voiceamp technology, waterproof	daily life	not yet	adjustable ear loops		X	O	X	1
Belovedone		80g		4-layer filter	USB charging	4-8 hours operation after being fully charged	2 speed modes	daily life	29.99	thicker loops on head		X	O	X	1
TrendyNow365 LED Mask	TrendyNow 365	65g	cotton	carbon activated filter	fully charge in 2 hours. USB cable	8 hours operation	text display	daily life	19.99	adjustable ear loops		X	O	O	2

Smart mask - Products

| Name	Brand Company	Weight	Material	Filter	Charging	Battery	Function	Domain	Price($)	String type	Note	Sensing	Actuation	Connectivity	Score
PuriCare	LG	126g	medical-grade silicone	H13 grade HEPA filter (1 month)	fully charge in 2 hours. USB charger	820mAh Lithium-ion (Rechargeable), 8 hours operation	fan speed(high/medium/low)	daily life	249	adjustable ear loops	Air Purifier Case(not bundle)	X	O	X	1
MIT&Harvard face mask							detects COVID-19 infection	medical, daily life			research prototype	O	X		1
Forcit Benelux &TencoDDM smart face mask							built-in microphone to amplify the wearer's voice, temperature, oxygen saturation, breathing rhythm.	medical, daily life			research prototype	O	X	O	2

Possible sensor integration

		Source	Sensor	Feature	Applications
Mask Main Body	**Biosignal Information**	Breath (Respiration)	Pressure	Respiration rate /Volume	
			Chemical sensor	Ketone, Acetone	
				H2S	
				Toluene	
				Alcohol	
		Facial blood vessel	PPG	Heart rate Variability (HRV)	autonomic nervous system
				Oxygen Saturation	Physical Stress
				Blood Pressure	hypertension/hypotension
		Skin	EOG	Eye Blink	concentration
			GSR	GRS response	Emotion
			Temperture	Temperture change	Communicable diseases
			EMG	Facial Muscle	Emotion
					Speech
		Head	IMU	Motion	Posture
	Environment Information	Air	Chemical sensor	Environment Air Quality	Local Air Quality
		External Temperature	Thermocouple	Temperature	Local Temperature
		External Humidity		Humidity	Local Humidity
Mask Support Frame	**Biosignal Information**	Ear	EEG	Brain Activity	Real-life monitoring
		Neck	IMU	Motion	Posture
			ECG	Heart	Heart Disease

Mask illustration

Mask illustration

마스크 끈으로부터 벗어난 자유로움
귀 통증 완화 이어넥어스 마스크
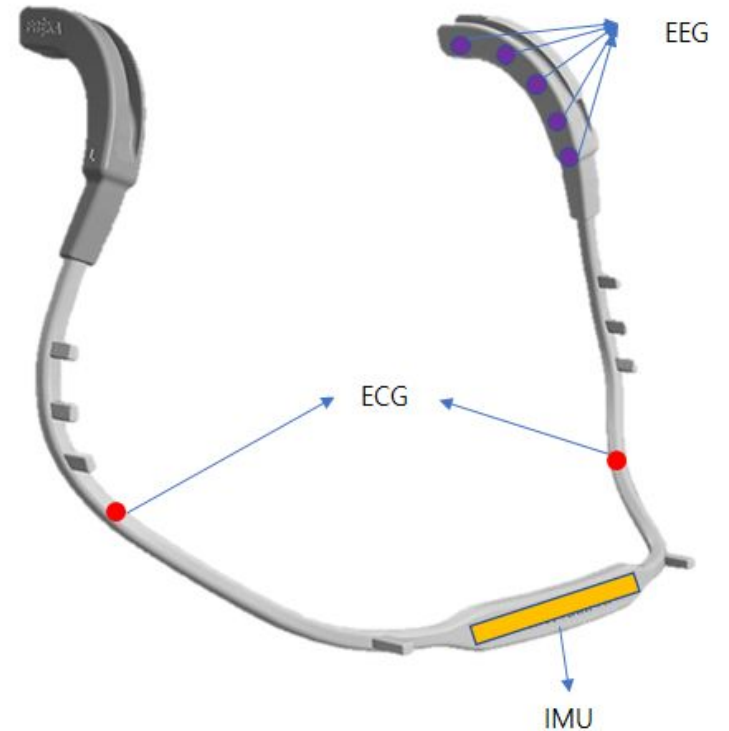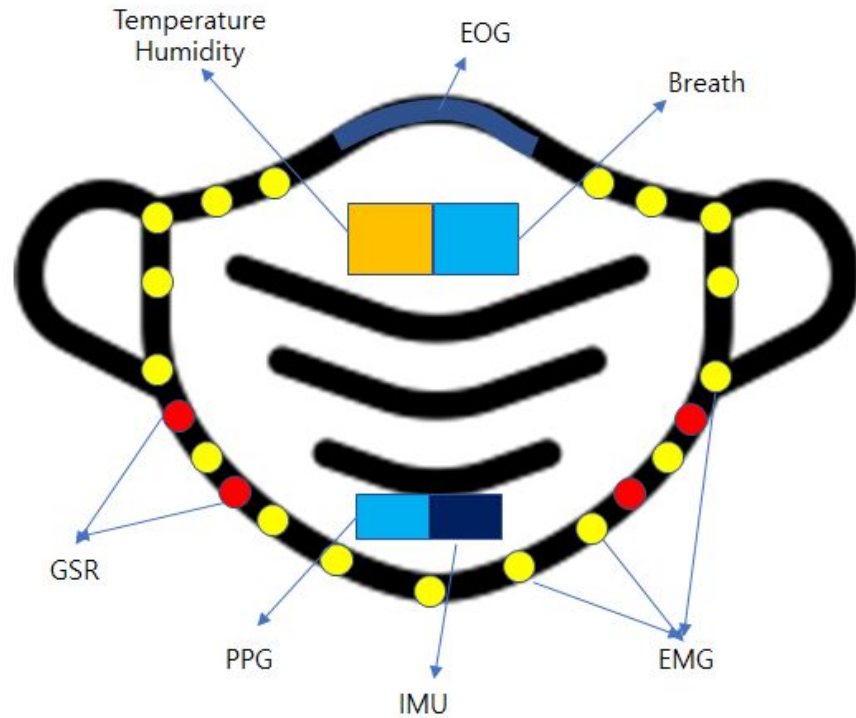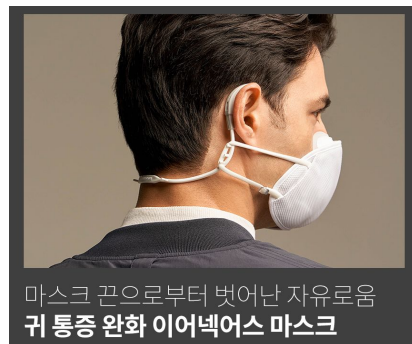
장시간 마스크 착용을 위한 용도

고강도 운동을 위한 용도

완벽한 차단을 위한 용도

References

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[2] Gupta, P., Moghimi, M. J., Jeong, Y., Gupta, D., Inan, O. T., & Ayazi, F. (2020). Precision wearable accelerometer contact microphones for longitudinal monitoring of mechano-acoustic cardiopulmonary signals. *NPJ digital medicine*, 3(1), 1-8.

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