دانشگاه علوم پزشکی و خدمات بهداشتی، درمانی ایران

Application of Artificial Intelligence in Otorhinolaryngology

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بسم الله الرحمن الرحیم

دانشگاه علوم پزشکی و خدمات بهداشتی، درمانی ایران

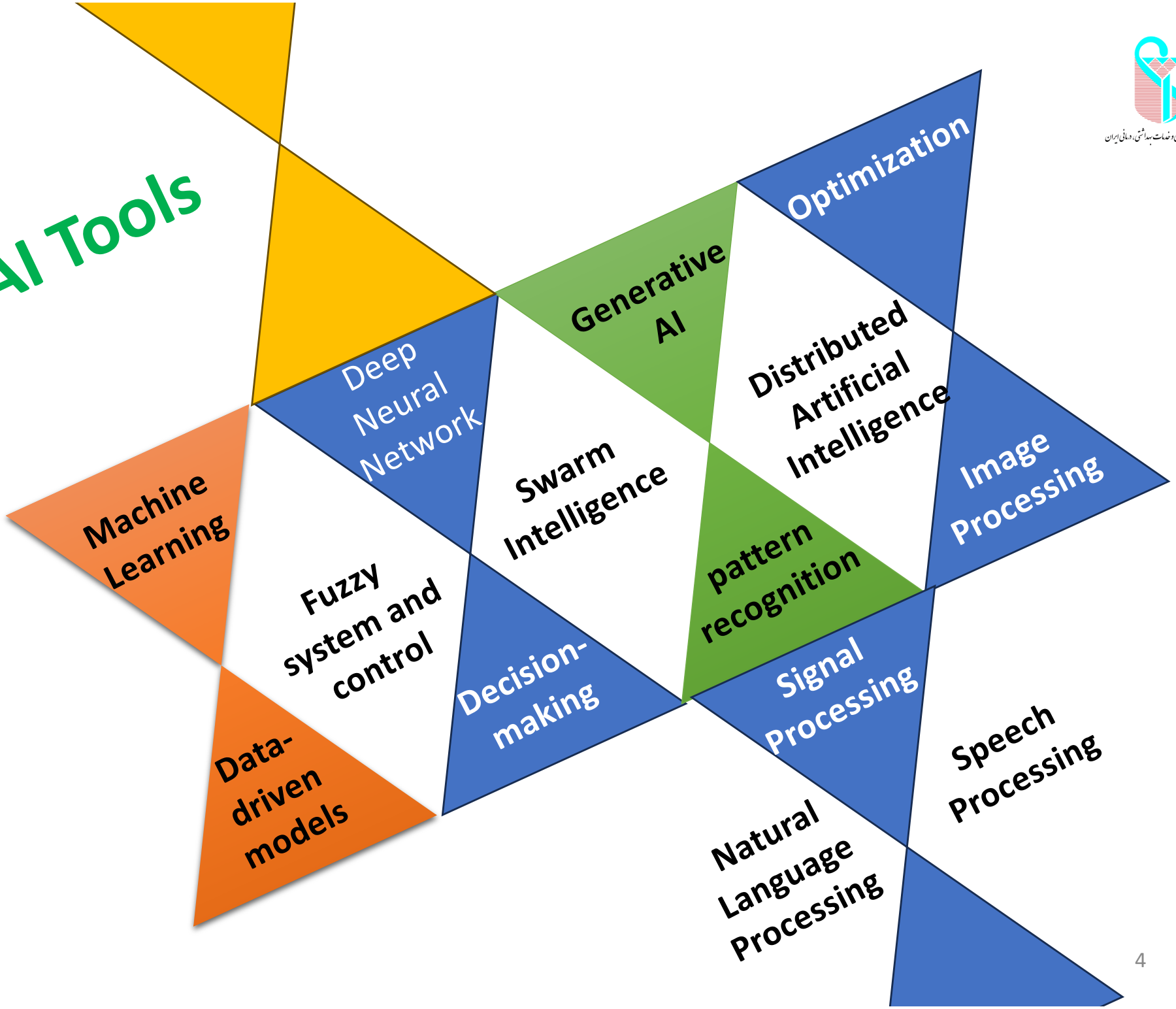
عنوان دوره آنلاین:

هوش مصنوعی در پزشکی با رویکرد بالینی

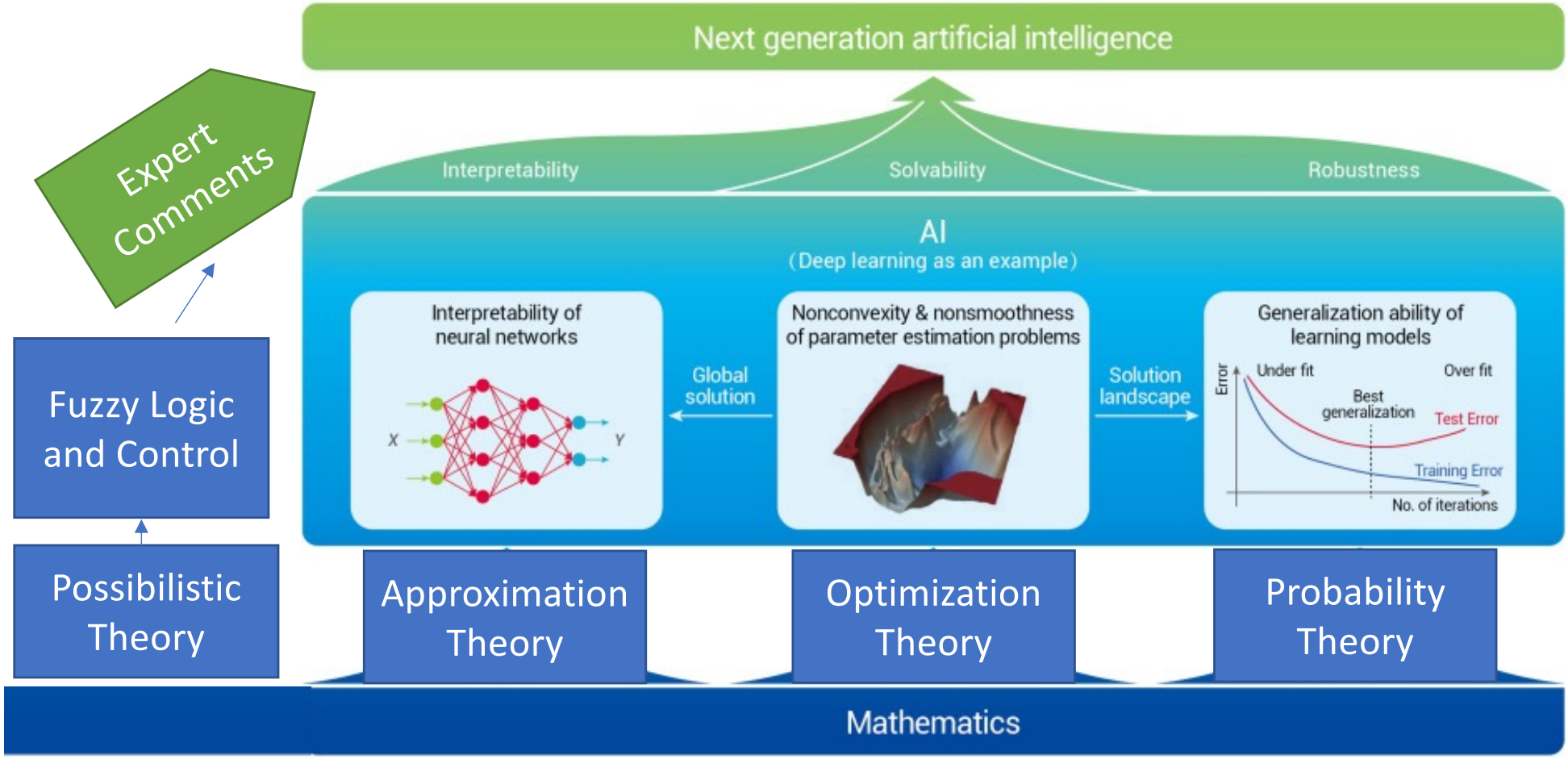
Online Course: Artificial Intelligence in Medicine with Clinical Approach

Course Topics	عناوین بیست و چهار جلسه	تاریخ جلسات
Artificial Intelligence (AI) in medicine	معرفی هوش مصنوعی در پزشکی	۲۸ بهمن ۱۴۰۲
AI and Fuzzy systems and its applications in medicine	هوش مصنوعی و سیستم های فازی در پزشکی	۵ اسفند ۱۴۰۲
Machine Learning and its applications in medicine	یادگیری ماشین و کاربردهای آن در پزشکی	۱۲اسفند۱۴۰۲
Evolutionary systems and its applications in medicine	الگوریتم های بهینه سازی تکاملی و کاربردهای آن در پزشکی	۱۹اسفند ۱۴۰۲
Neural networks and deep neural networks in medicine	شبکه های عصبی و شبکه های عصبی عمیق در پزشکی	۲۵فروردین ۱۴۰۳
Application of AI in Early Detection of Disease	کاربرد هوش مصنوعی در تشخیص زودهنگام بیماری ها	۱ اردیبهشت ۱۴۰۳
Swarm Intelligence and multi-agent/swarm in medicine	هوش ازدحامی، سیستم های چند عامله/ازدحامی در پزشکی	۸اردیبهشت ۱۴۰۳
Application of AI in Cancer	کاربردهای هوش مصنوعی در سرطان	۲۲اردیبهشت ۱۴۰۳
Application of AI in surgery	کاربردهای هوش مصنوعی در جراحی	۲۹ اردیبهشت ۱۴۰۳
Applications of AI in Neurology	کاربردهای هوش مصنوعی در مغز و اعصاب	۵ خرداد ۱۴۰۳
Application of AI in Internal Medicine	کاربردهای هوش مصنوعی در پزشکی داخلی	۱۲ خرداد ۱۴۰۳
Applications of AI in cardiovascular	کاربردهای هوش مصنوعی در قلب و عروق	۱۹ خرداد ۱۴۰۳
Applications of AI in Breast Disease	کاربردهای هوش مصنوعی در بیماری های پستان	۲۶ خرداد ۱۴۰۳
Application of AI in Ophthalmology	کاربردهای هوش مصنوعی در چشم پزشکی	۲ تیر ۱۴۰۳
Application of AI in Nephrology	کاربردهای هوش مصنوعی در نفرولوژی	۹ تیر ۱۴۰۳
Application of AI in Otorhinolaryngology	کاربردهای هوش مصنوعی در گوش و حلق و بینی	۱۶ تیر ۱۴۰۳
Application of AI in Gynecology and obstetrics	کاربردهای هوش مصنوعی در زنان و مامایی	۲۳ تیر ۱۴۰۳
Application of AI in pediatric medicine	کاربردهای هوش مصنوعی در پزشکی اطفال	۳۰ تیر ۱۴۰۳
Application of AI in anesthesia	کاربردهای هوش مصنوعی در بیهوشی	۶ مرداد ۱۴۰۳
Application of AI in emergency medicine	کاربردهای هوش مصنوعی در پزشکی اورژانس	۱۳ مرداد ۱۴۰۳
Applications of artificial intelligence in orthopedics	کاربردهای هوش مصنوعی در ارتوپدی	۲۰ مرداد ۱۴۰۳
Application of AI in pain management	کاربردهای هوش مصنوعی در مدیریت درد	۲۷ مرداد ۱۴۰۳
Application of AI in pharmacology	کاربردهای هوش مصنوعی در داروسازی	۳ شهریور ۱۴۰۳
Application of AI in dentistry	کاربردهای هوش مصنوعی در دندان پزشکی	۱۰ شهریور ۱۴۰۳

AI Tools


Machine Learning
Deep Neural Network
Generative AI
Optimization
Fuzzy system and control
Swarm Intelligence
Distributed Artificial Intelligence
Image Processing
Data-driven models
Decision-making
pattern recognition
Signal Processing
Speech Processing
Natural Language Processing

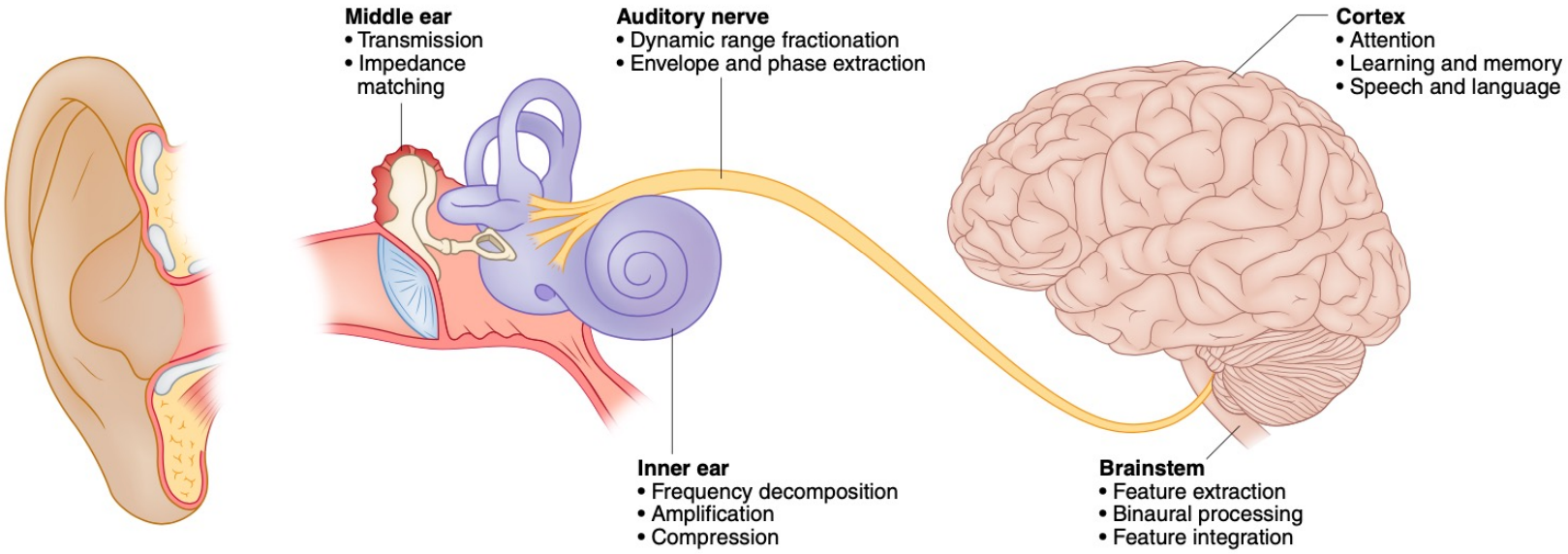
Artificial Intelligence



Artificial Intelligence in otorhinolaryngology

- The vast majority of those with hearing loss do not receive treatment and those who do often receive only limited benefits.
- Machines have already achieved human-like performance in important hearing-related tasks such as automatic speech recognition (ASR) and natural language processing.
- Eye screening technologies based on deep neural networks (DNNs) are already in worldwide use.

a



The auditory system and its disorders

- The auditory system is a marvel of signal processing.
- Its combination of microsecond temporal precision, sensitivity over more than five orders of sound magnitude and flexibility to support tasks ranging from sound localization to music appreciation is still without parallel in other natural or artificial systems.
- his remarkable performance is achieved through a complex interplay of biomechanical, chemical and neural components that implement operations such as signal conditioning, filtering, feature extraction and classification in interconnected stages across the ear and brain to create the experience of auditory perception

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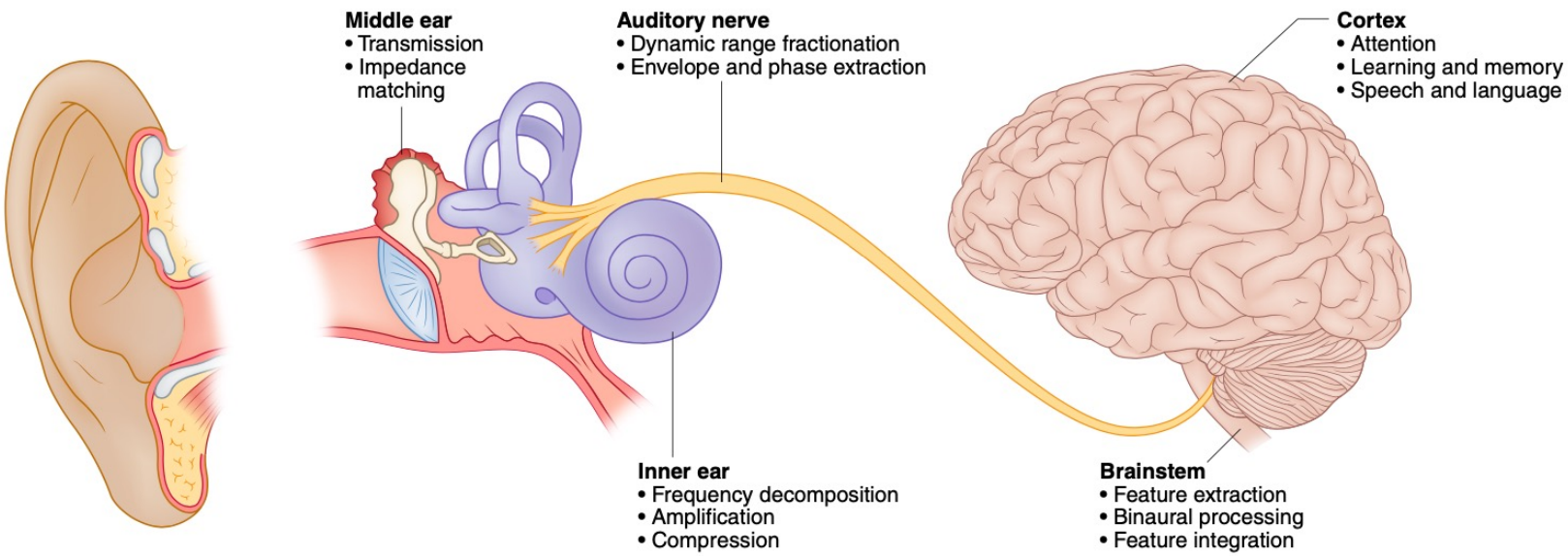


Middle ear infection

One example is middle ear infection (otitis media), which is the most frequent reason for children to visit the doctor, take antibiotics, and have surgery.

Despite its prevalence, the diagnosis of different middle ear conditions by clinicians remains problematic.

Accuracy has been estimated at 50% for non-specialists and 75% for specialists.

Thus, the application of AI to the diagnosis of middle ear conditions could bring dramatic improvements in both efficacy and accessibility.

Evaluating the generalizability of deep learning image classification algorithms to detect middle ear disease using otoscopy

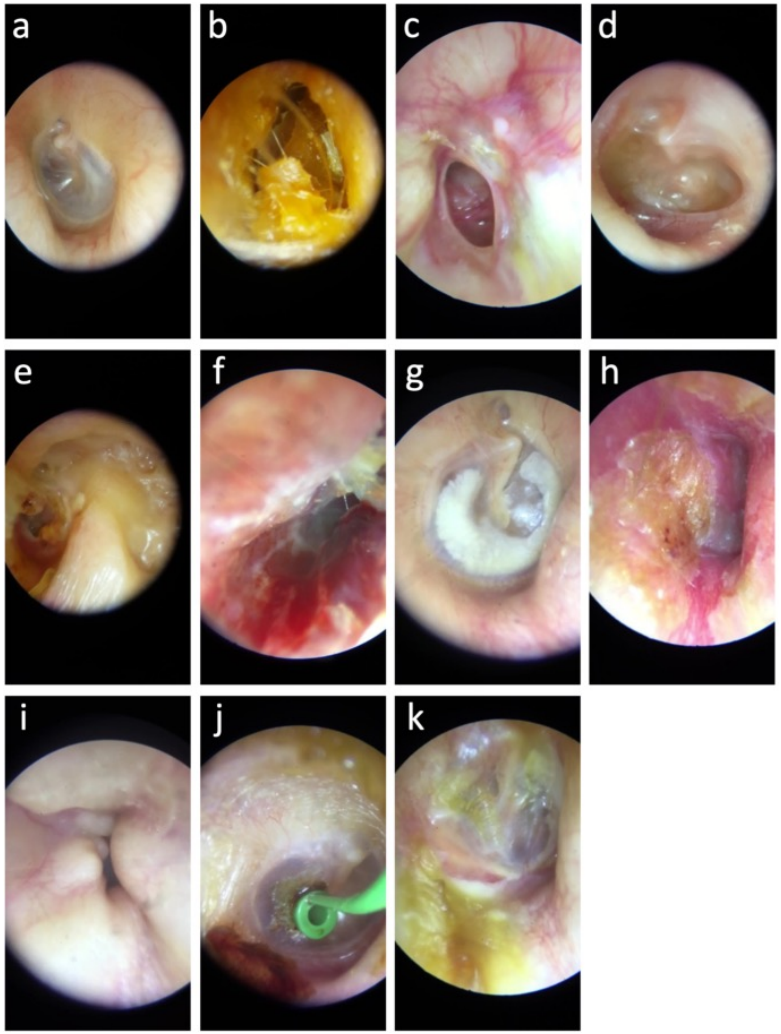
- Diagnostic categories consisted of (i) normal or (ii) abnormal.
- Deep learning methods were used to develop models to evaluate internal and external performance.

Scientific Reports **volume 13**, Article number: 5368 (2023)

Development and validation of a smartphone-based deep-learning-enabled system to detect middle-ear conditions in otoscopic images

- Deep learning (DL) may assist clinicians in interpreting otoscopic images.
- DL model was trained using 41,664 otoscopic images, and its diagnostic accuracy was evaluated by calculating class-specific estimates of sensitivity and specificity.
- 11 diagnostic classes:

a Normal, **b** wax plug, **c** eardrum perforation, **d** otitis media with effusion, **e** cavity after cholesteatoma removal, **f** otitis externa, **g** tympanosclerosis, **h** acute otitis media, **i** external auditory canal osteoma, **j** foreign body, **k** tympanic graft.

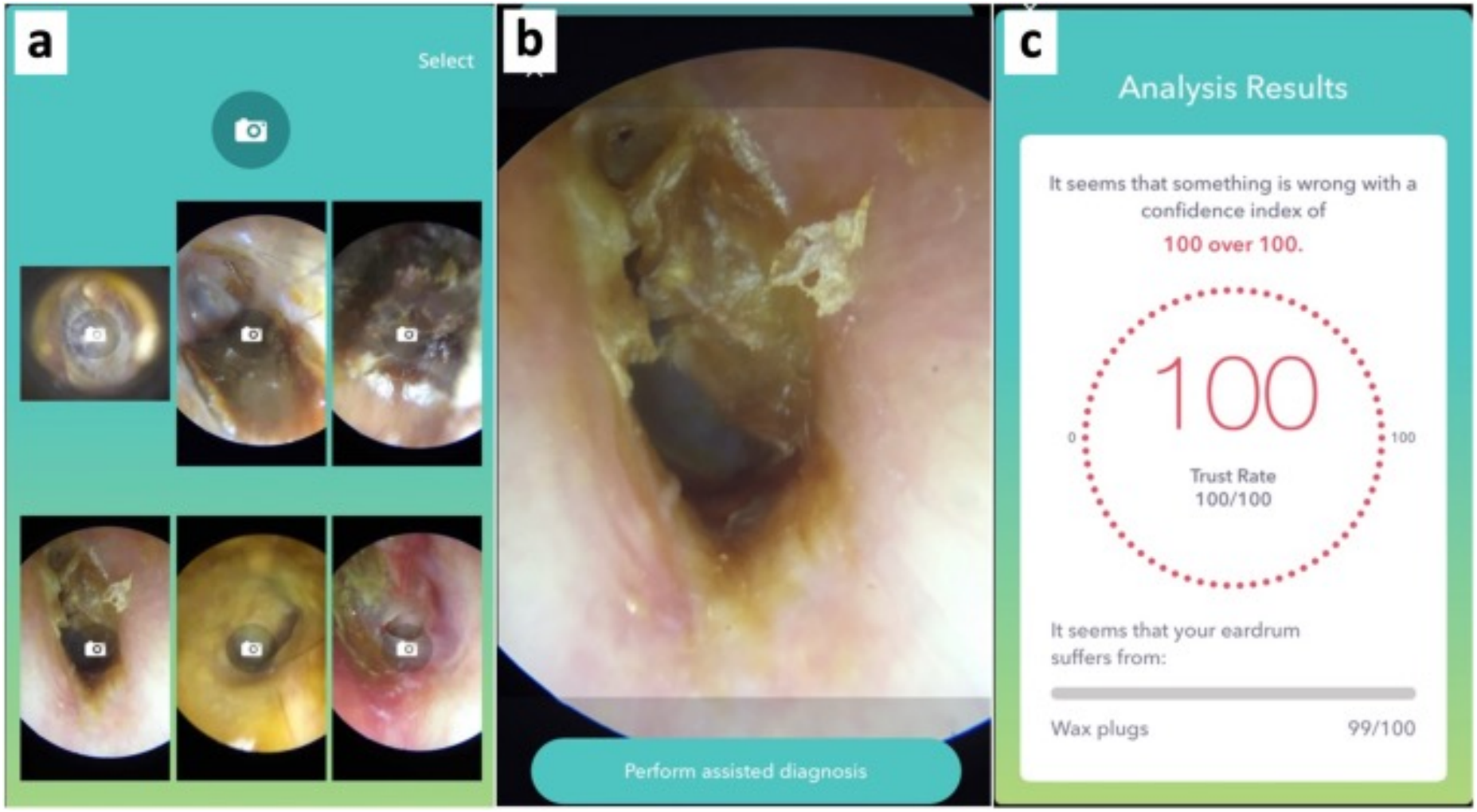


npj Digital Medicine **volume 7**, Article number: 162 (2024)

The Smart Scope system.

The model was then incorporated into a smartphone app called i-Nside.

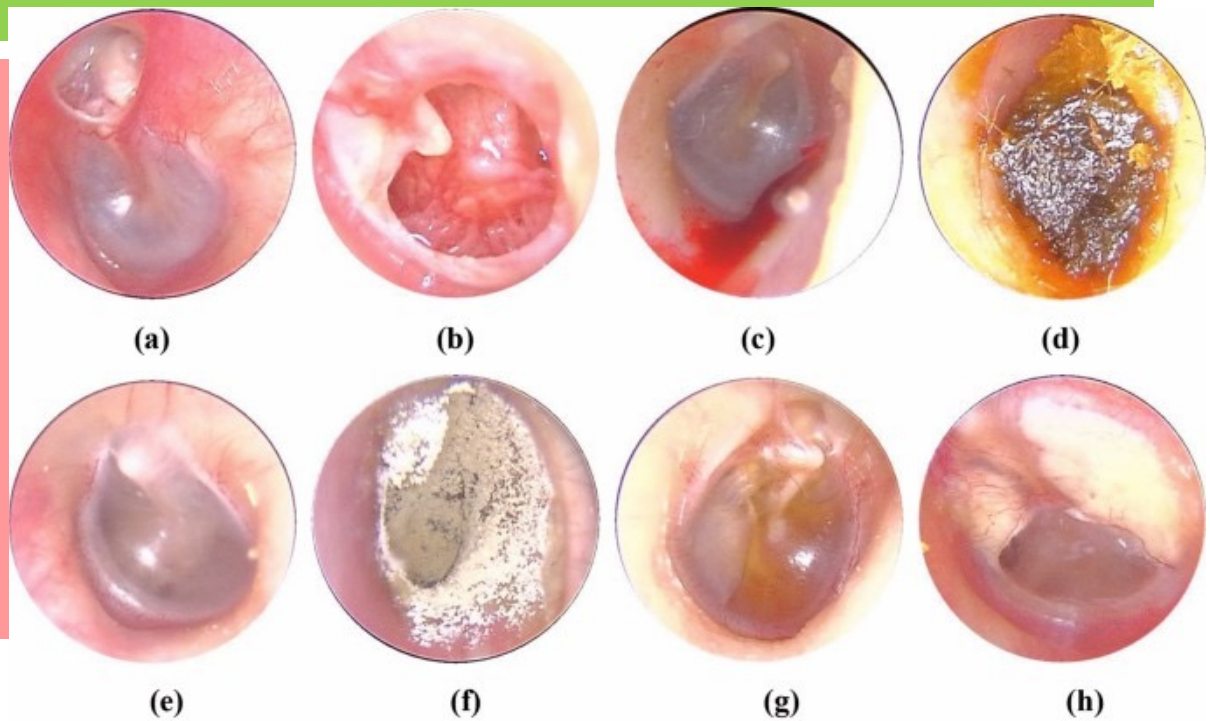
Result


a
Select
b
Perform assisted diagnosis
c
Analysis Results
It seems that something is wrong with a confidence index of
100 over 100.
100
0
100
Trust Rate
100/100
It seems that your eardrum suffers from:
Wax plugs
99/100

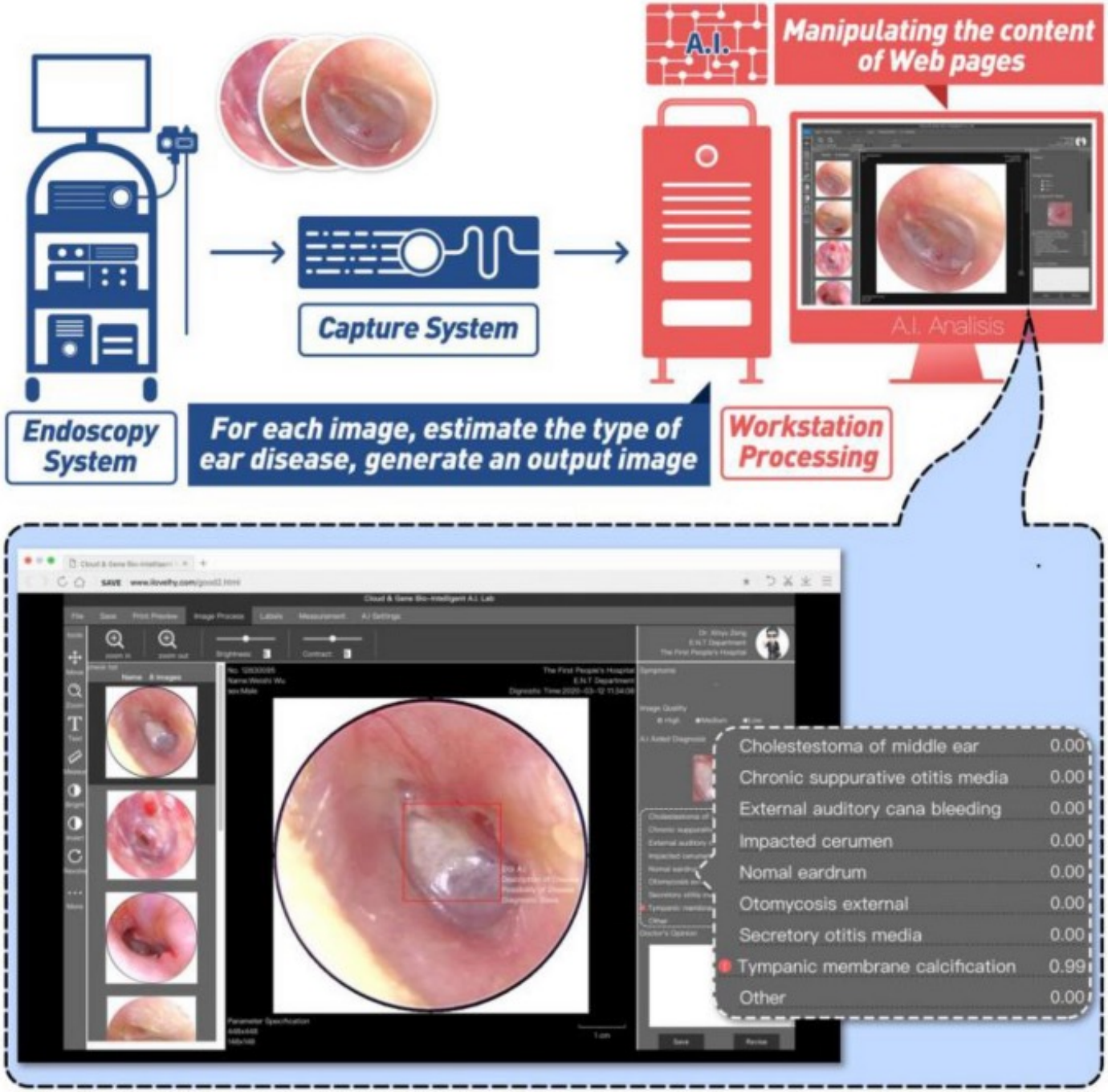
Efficient and accurate identification of ear diseases using an ensemble deep learning model

- Early detection and appropriate medical treatment are of great use for ear disease.
- However, a new diagnostic strategy is necessary for the absence of experts and relatively low diagnostic accuracy, in which deep learning plays an important role.

8 kinds of ear diseases were classified:
normal, Cholestestoma of the middle ear, Chronic suppurative otitis media, External auditory cana bleeding, Impacted cerumen, Otomycosis external, Secretory otitis media, Tympanic membrane calcification.



Scientific Reports **volume 11**, Article number: 10839 (2021)


A.I.
Manipulating the content of Web pages
Capture System
A.I. Analisis
Endoscopy System
For each image, estimate the type of ear disease, generate an output image
Workstation Processing
Cholestestoma of middle ear 0.00
Chronic suppurative otitis media 0.00
External auditory cana bleeding 0.00
Impacted cerumen 0.00
Nomal eardrum 0.00
Otomycosis external 0.00
Secretory otitis media 0.00
Tympanic membrane calcification 0.99
Other 0.00

Types of hearing loss

Sensorineural

- Aging
- Noise damage
- Drug side effects
- Auditory tumors
- Blast/explosion

Mixed

- Genetic disorders
- Infections
- Head trauma

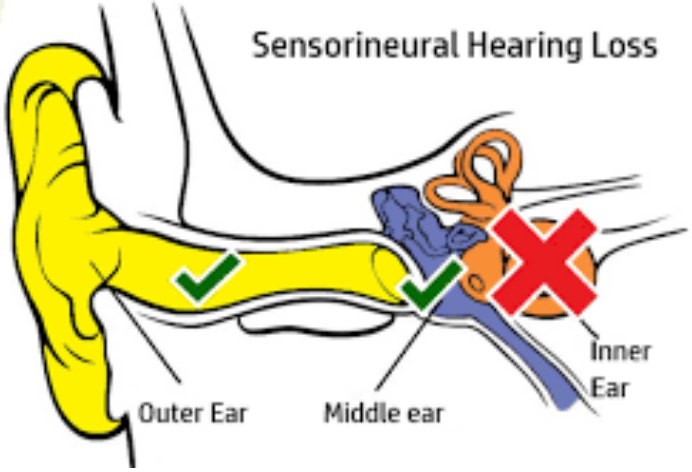
Conductive

- Fluid
- Foreign objects
- Allergies
- Ruptured eardrum
- Impacted earwax

Using Machine Learning to Predict Sensorineural Hearing Loss Based on Perilymph Micro RNA Expression Profile

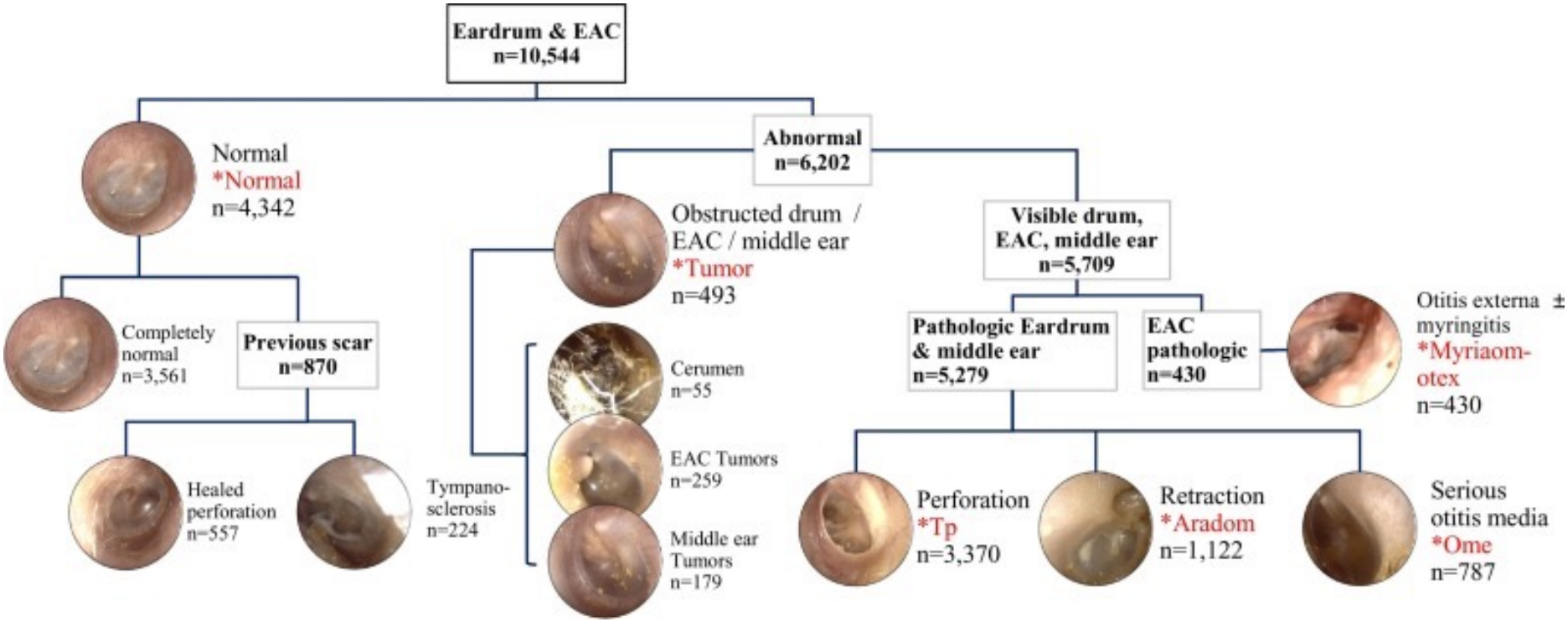
- Hearing loss (HL) is the most common neurodegenerative disease worldwide.
- Despite its prevalence, clinical testing does not yield a cell or molecular based identification of the underlying etiology of hearing loss making development of pharmacological or molecular treatments challenging.
- A key to improving the diagnosis of inner ear disorders is the development of reliable **biomarkers** for different inner ear diseases. **Analysis of microRNAs (miRNA)** in tissue and body fluid samples has gained significant momentum as a diagnostic tool for a wide variety of diseases.

A first step in developing miRNAs as biomarkers for inner ear disease is linking patterns of miRNA expression in perilymph to clinically available metrics.
Using machine learning (ML), we demonstrate we can build disease specific algorithms that predict the presence of sensorineural hearing loss using only miRNA expression profiles.



Scientific Reports **volume 9**, Article number: 3393 (2019)

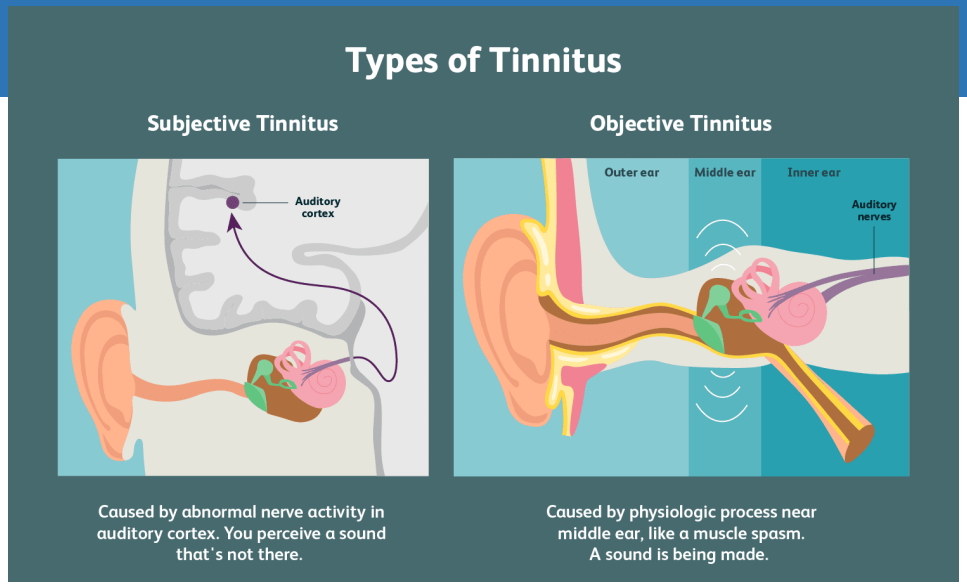
Efficient and accurate identification of ear diseases using an ensemble deep learning model



Scientific Reports **volume 11**, Article number: 10839 (2021)

Artificial intelligence approaches for tinnitus diagnosis: leveraging high-frequency audiometry data for enhanced clinical predictions

- machine learning to improve the diagnosis of tinnitus using high-frequency audiometry data.
- A Logistic Regression (LR) model was developed alongside an Artificial Neural Network (ANN) and various baseline classifiers to identify the most effective approach for classifying tinnitus presence.
- The methodology encompassed data preprocessing, feature extraction focused on point detection, and rigorous model evaluation through performance metrics including accuracy, Area Under the ROC Curve (AUC), precision, recall, and F1 scores.

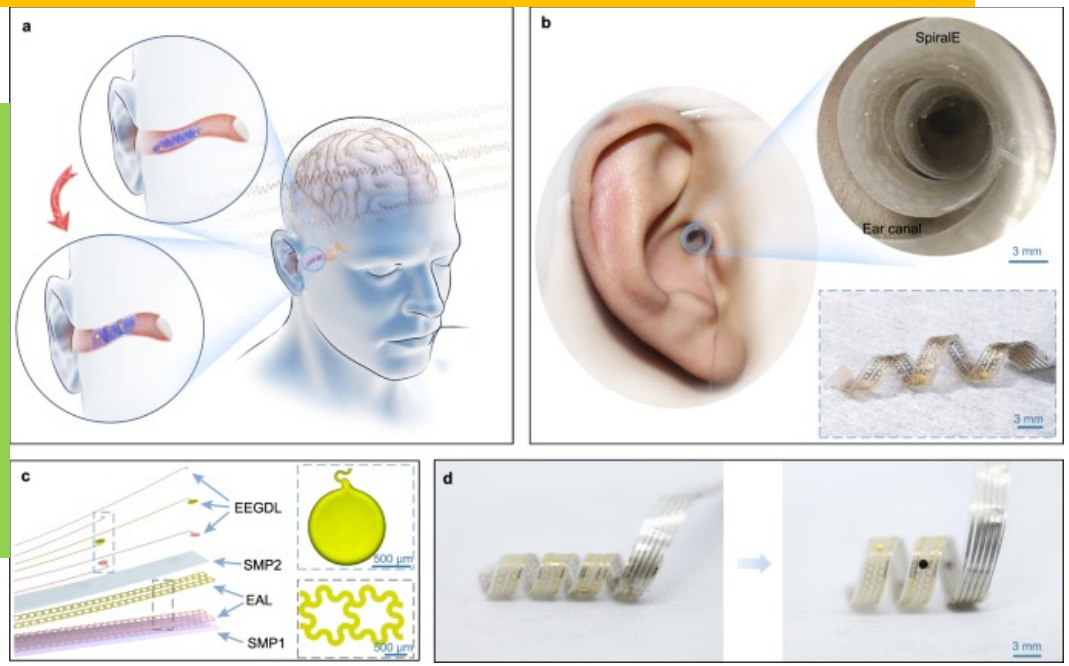


Front. Artif. Intell., 07 May 2024 Sec. Medicine and Public Health

Conformal in-ear bioelectronics for visual and auditory brain-computer interfaces

- Brain-computer interfaces (BCIs) have attracted considerable attention in motor and language rehabilitation.
- Most devices use cap-based non-invasive, headband-based commercial products or microneedle-based invasive approaches, which are constrained for inconvenience, limited applications, inflammation risks and even irreversible damage to soft tissues.

Here, in-ear visual and auditory BCIs based on in-ear bioelectronics, named as SpiralE, which can adaptively expand and spiral along the auditory meatus under electrothermal actuation to ensure conformal contact.

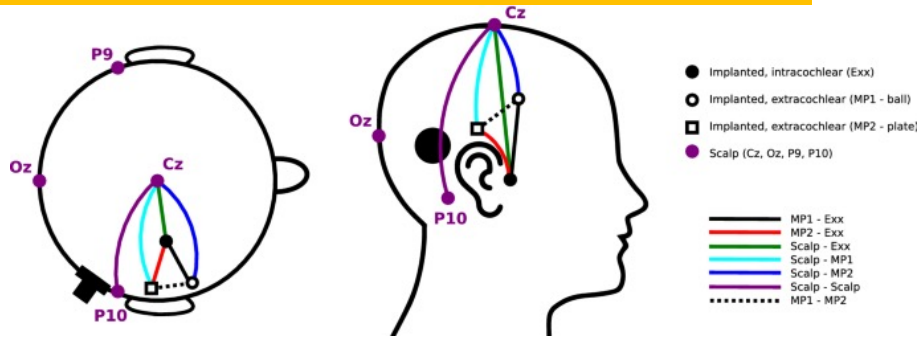


Nature Communications **volume 14**, Article number: 4213 (2023)

EEG-based diagnostics of the auditory system using cochlear implant electrodes as sensors

- The cochlear implant is one of the most successful medical prostheses, allowing deaf and severely hearing-impaired persons to hear again by electrically stimulating the auditory nerve.
- A trained audiologist adjusts the stimulation settings for good speech understanding, known as "fitting" the implant. This process is based on subjective feedback from the user, making it time-consuming and challenging, especially in pediatric or communication-impaired populations.
- Furthermore, fittings only happen during infrequent sessions at a clinic, and therefore cannot take into account variable factors that affect the user's hearing, such as physiological changes and different listening environments.
- from the implanted intracochlear electrode array in human subjects, using auditory evoked potentials originating from different brain regions.

An elegant solution is to record the neural signals using the implant itself.
Here, we record continuous electroencephalographic (EEG) signals



Scientific Reports **volume 11**, Article number: 5383 (2021)

Artificial Intelligence for Hearing Loss

- **1) Closed Captioning Personalization**
- Medical device company Cochlear has developed closed captioning personalization technology, which uses natural language processing to personalize closed captioning.
- The tech uses AI to transcribe live conversations in real-time, while also translating sign language to text quickly. The company has developed an AI assistant that helps in adjusting the sound processor of an auditory aid in order to fit the exact parameters of a person's ear shape and disability.
- This process is called "fitting" or "programming" and it's designed to create a balance of loudness and softness of sound, giving users the most fully-functional hearing system possible.

Auditory AI Assistants

Auditory AI assistants are essentially more advanced hearing aids that help determine the best fit based on an individual's cochlear implant.

The technology helps to improve patient outcomes, while also improving their hearing with daily tasks. San Francisco-based Ava has developed a **mobile app with natural language processing that transcribes conversations in real-time.**

- Every participant in a conversation needs to download the app to make it happen as it allows users to utilize the microphone on their devices. By speaking into the microphone, the app uses natural language processing software to gather the dialogue and transcribe it for everyone to hear in real time.

Sound Isolation

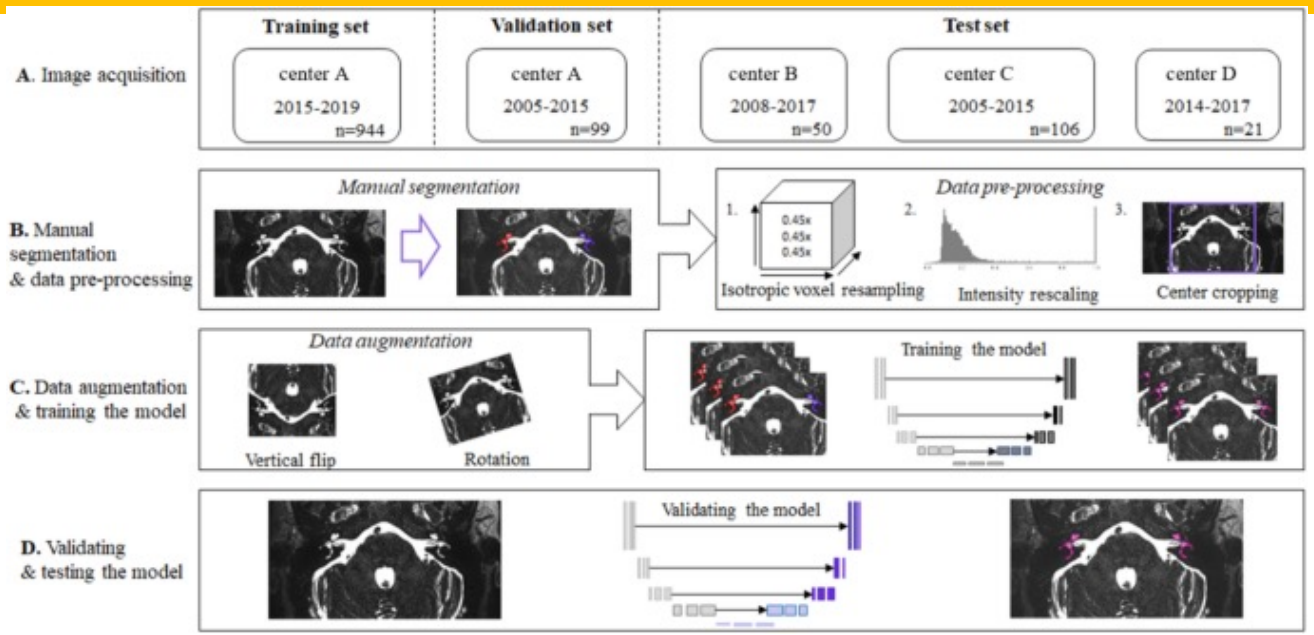
- Google researchers have created an AI application capable of isolating a single person's voice from a mixture of sounds, which includes other voices and any background noise.
- The technology uses the "party effect," in which a person with good hearing can focus their attention on a single speaker in a noisy environment, filtering out other sounds.
- They then trained an AI program to analyze the speakers' faces for signs when they spoke, including mouth movement and other cues, allowing them to create a program that can cleanly isolate sounds.

Prediction of Language on Cochlear Implants

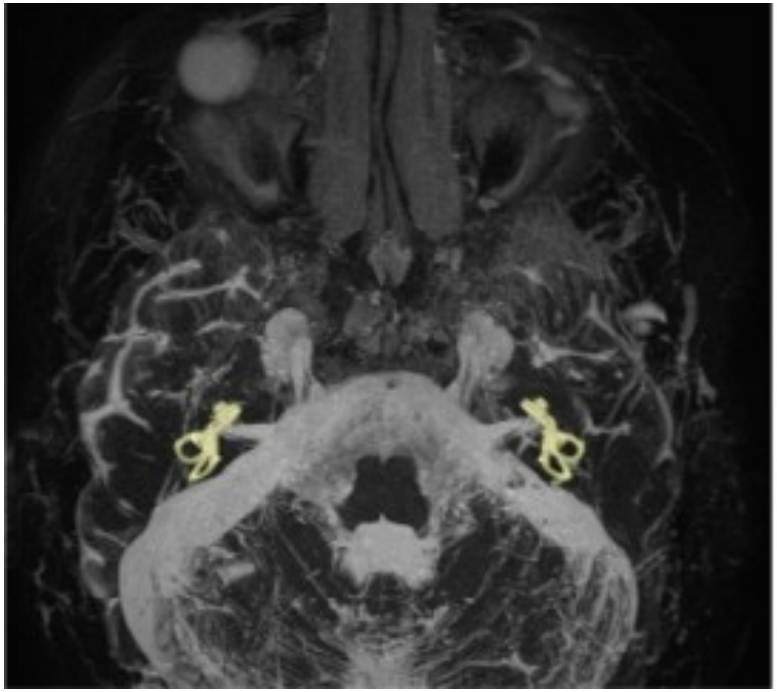
- Scientists are also using machine learning algorithms to analyze brain scans, which helps them predict hearing loss.
- Develop a machine learning algorithm that can predict language ability in deaf children with a cochlear implant.
- Researchers use advanced algorithms to predict individual children's future language development based on their brain images before surgery.
- This prediction ability can go far in developing personalized therapy and improving the quality of children's lives.
- The algorithm uses a high volume of images captured through magnetic resonance imaging (MRI). The machine learning algorithm identifies atypical patterns that indicate hearing loss early in life.

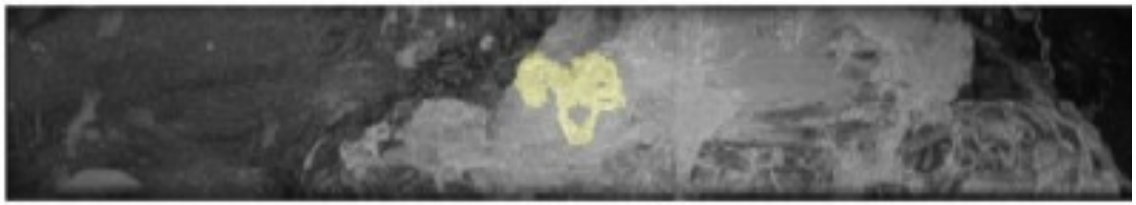
Deep learning for the fully automated segmentation of the inner ear on MRI

- segmentation of anatomical structures is valuable in a variety of tasks, including 3D visualization, surgical planning, and quantitative image analysis.
- Manual segmentation is time-consuming and deals with intra and inter-observer variability.
- To develop a deep-learning approach for the fully automated segmentation of the inner ear in MRI, a 3D U-net was trained on 944 MRI scans with manually segmented inner ears as reference standard.



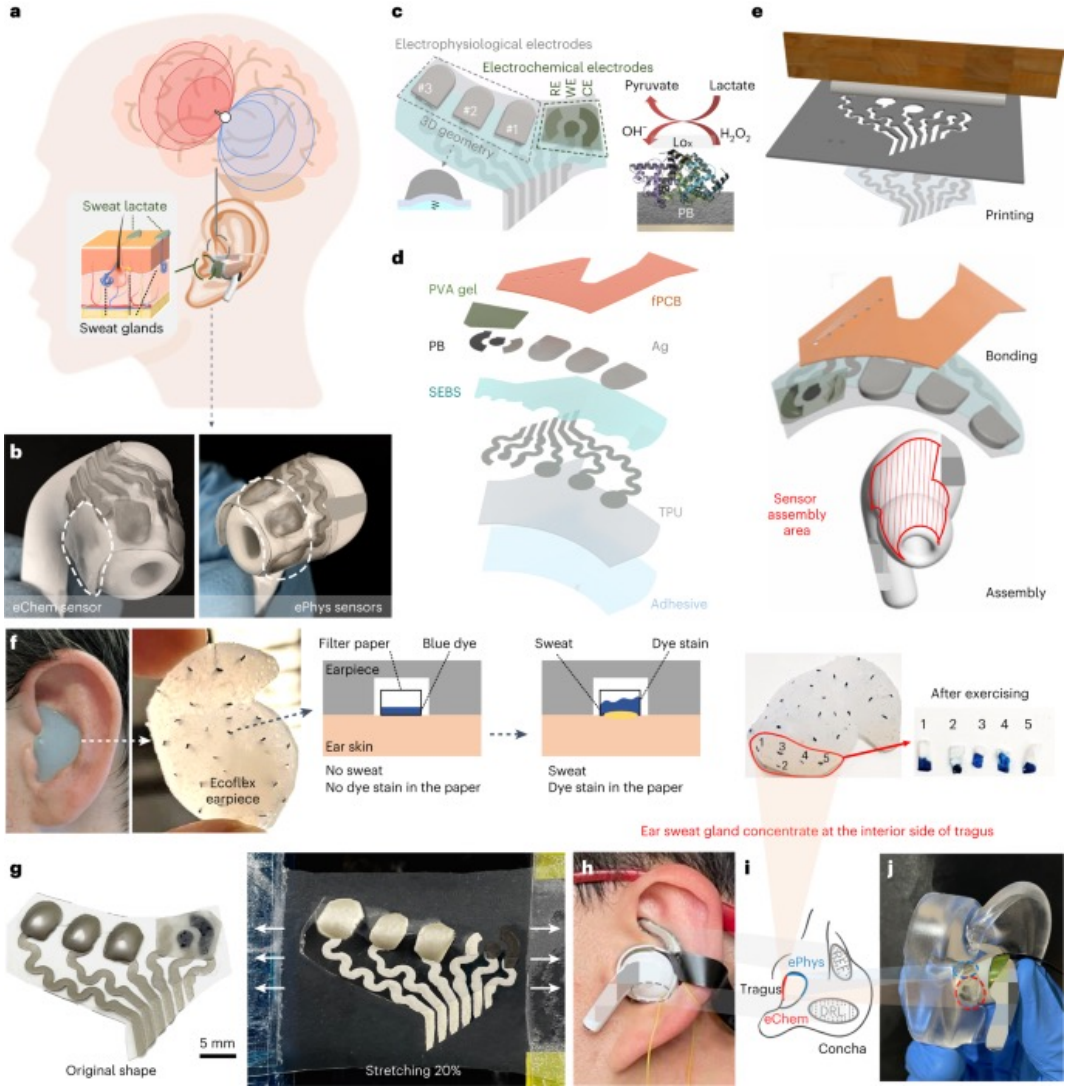
Scientific Reports **volume 11**, Article number: 2885 (2021)





In-ear integrated sensor array for the continuous monitoring of brain activity and of lactate in sweat

- Owing to the proximity of the ear canal to the central nervous system, in-ear electrophysiological systems can be used to unobtrusively monitor brain states.
- Taking advantage of the ear's exocrine sweat glands, describe an in-ear integrated array of electrochemical and electrophysiological sensors placed on a flexible substrate surrounding a user-generic earphone for the simultaneous monitoring of lactate concentration and brain states via electroencephalography, electrooculography and electrodermal activity.



Nature Biomedical Engineering **volume 7**, pages1307–1320 (2023)

Bioacoustic AI to make sense of animal sounds

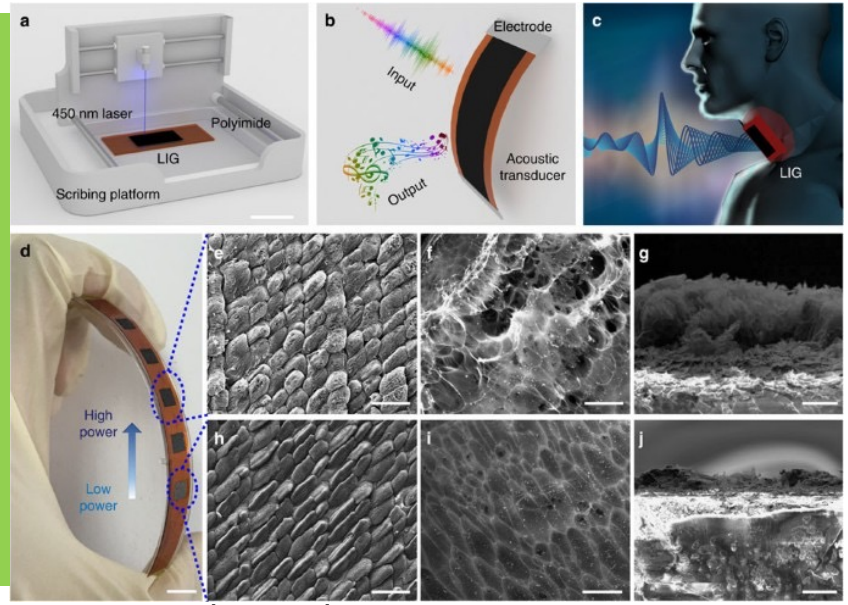
- Machine learning, often called 'AI', makes it possible to uncover the mysterious world of animal communication, analysing their sounds that convey so much information.
- A new project called 'Bioacoustic AI' is going to make this happen, and will use that information to monitor and protect wildlife.

An intelligent artificial throat with sound-sensing ability based on laser induced graphene

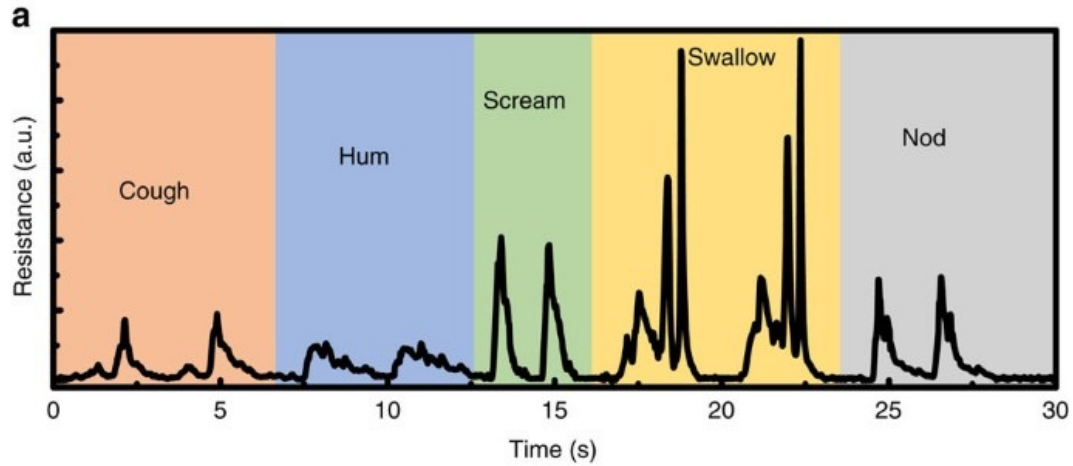
- Traditional sound sources and sound detectors are usually independent and discrete in the human hearing range.
- To minimize the device size and integrate it with wearable electronics, there is an urgent requirement of realizing the functional integration of generating and detecting sound in a single device.
- Here we show an intelligent laser-induced graphene artificial throat, which can not only generate sound but also detect sound in a single device.

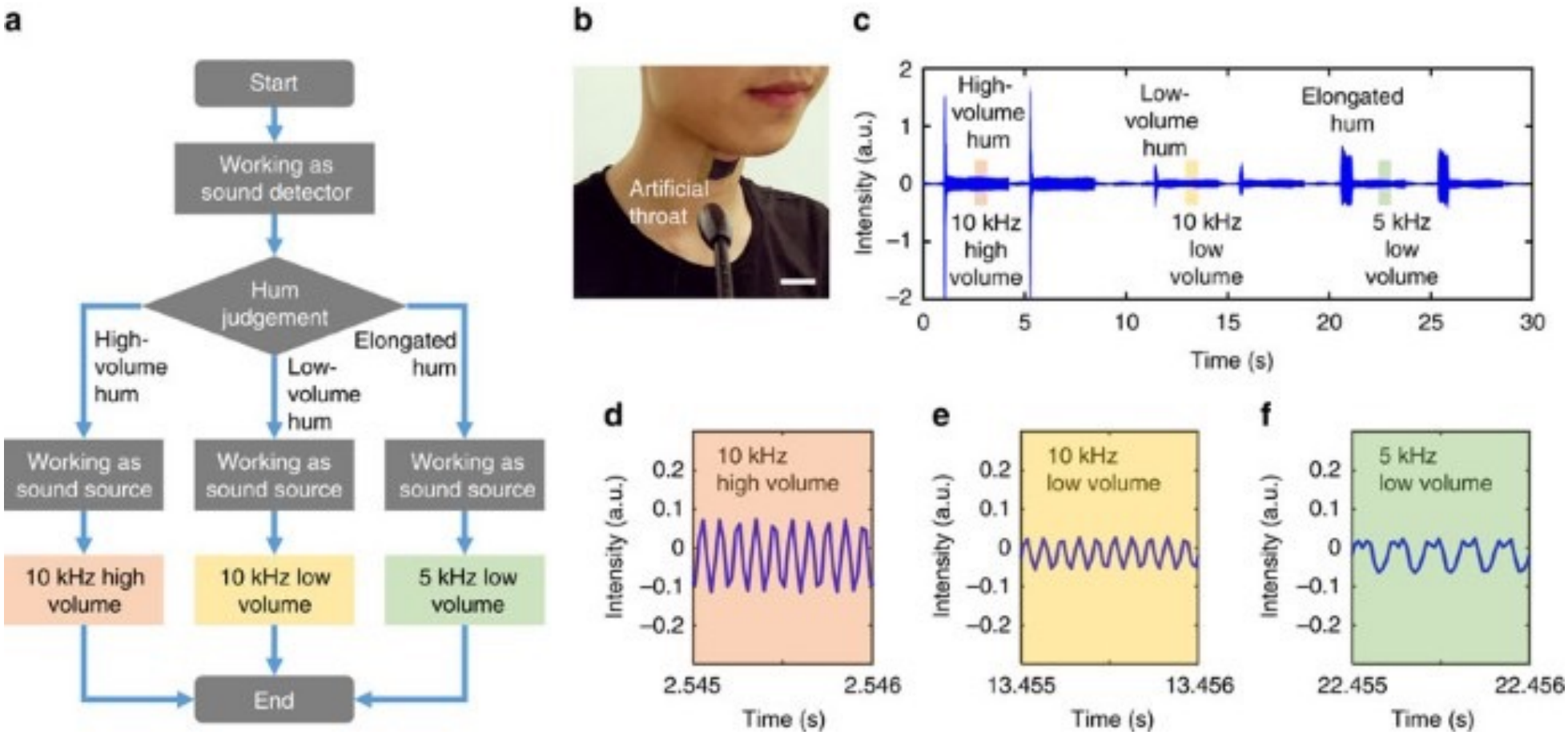
intelligent artificial throat will significantly assist for the disabled, because the simple throat vibrations such as hum, cough and scream with different intensity or frequency from a mute person can be detected and converted into controllable sounds.

Furthermore, the laser-induced graphene artificial throat has the advantage of one-step fabrication, high efficiency, excellent flexibility and low cost, and it will open practical applications in voice control, wearable electronics and many other areas.

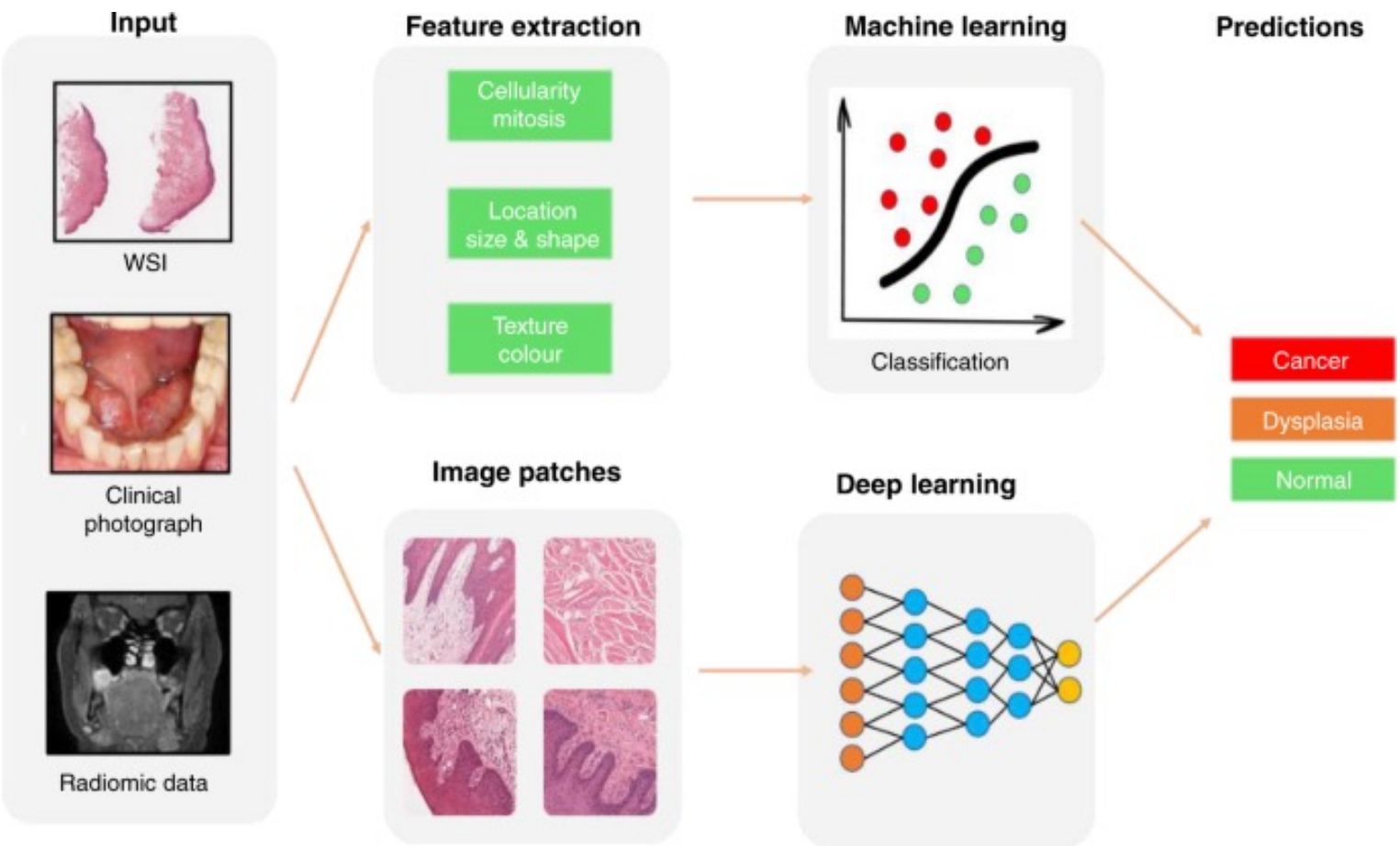


Nature Communications **volume 8**, Article number: 14579 (2017)


a
Cough
Hum
Scream
Swallow
Nod
Resistance (a.u.)
0
5
10
15
20
25
30
Time (s)

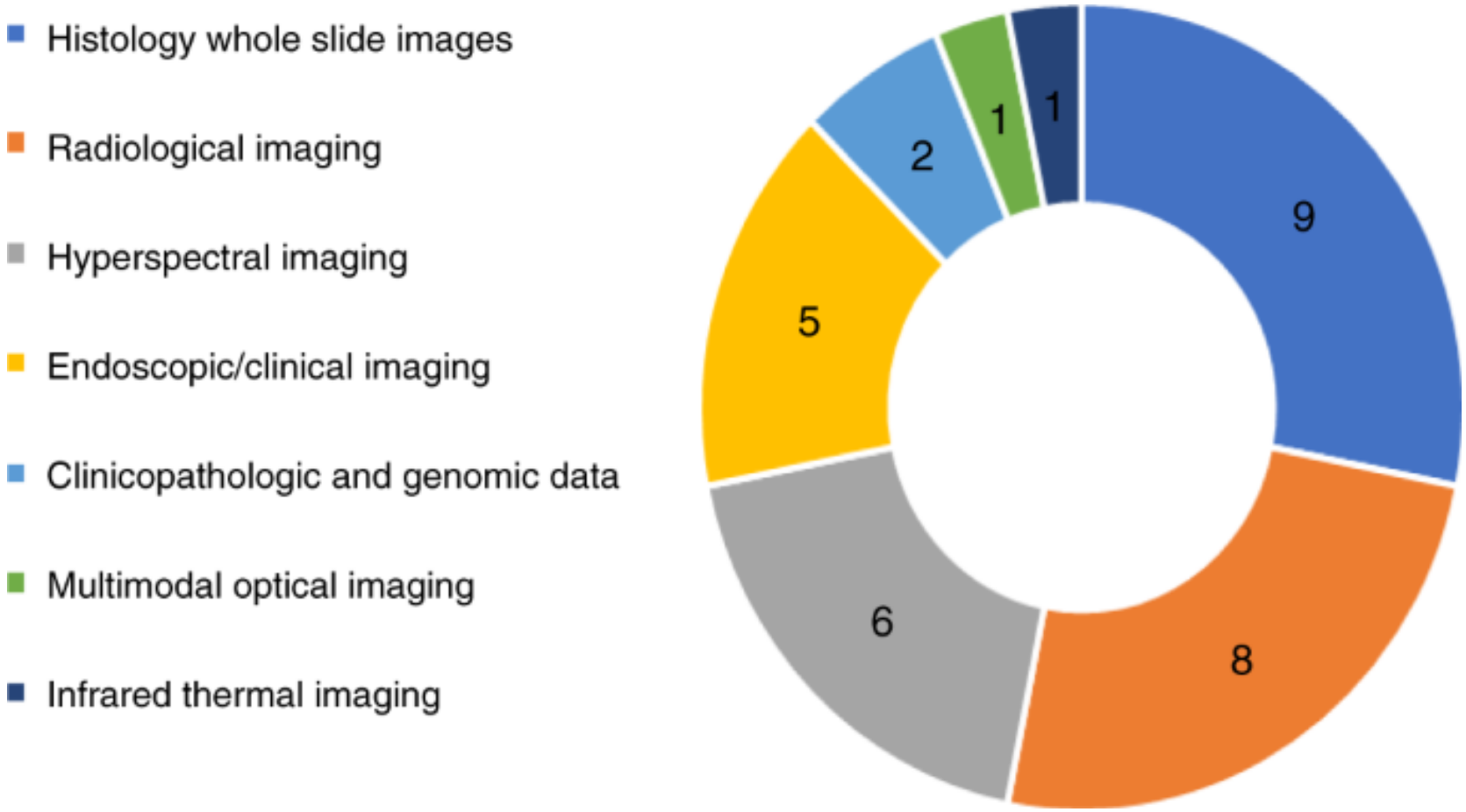

a
Start
Working as sound detector
Hum judgement
High-volume hum
Low-volume hum
Elongated hum
Working as sound source
Working as sound source
Working as sound source
10 kHz high volume
10 kHz low volume
5 kHz low volume
End
b
Artificial throat
c
High-volume hum
Low-volume hum
Elongated hum
10 kHz high volume
10 kHz low volume
5 kHz low volume
Intensity (a.u.)
Time (s)
d
10 kHz high volume
2.545
2.546
e
10 kHz low volume
13.455
13.456
f
5 kHz low volume
22.455
22.456
Intensity (a.u.)
Time (s)

Artificial Intelligence-based methods in head and neck cancer diagnosis



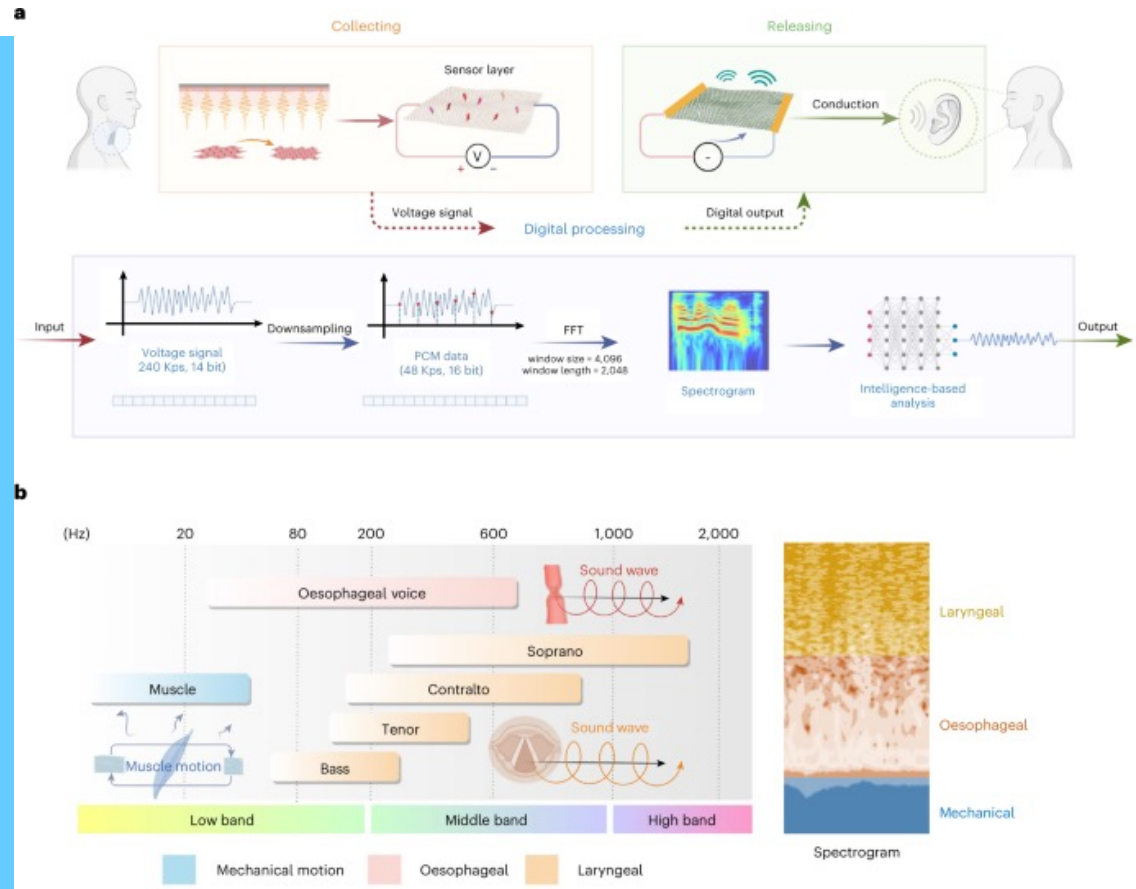
British Journal of Cancer **volume 124**, pages1934–1940 (2021)

Head and neck Cancer

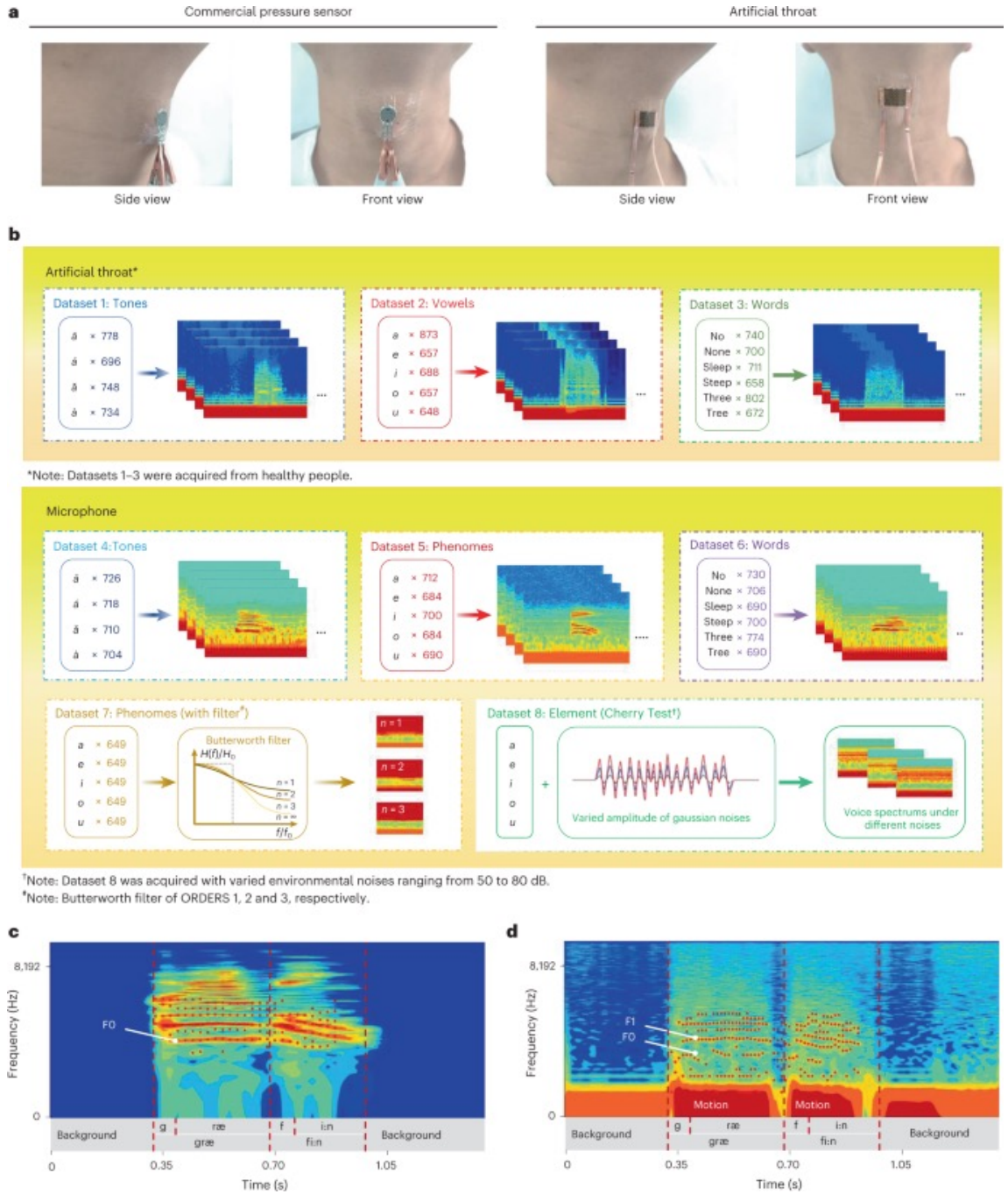


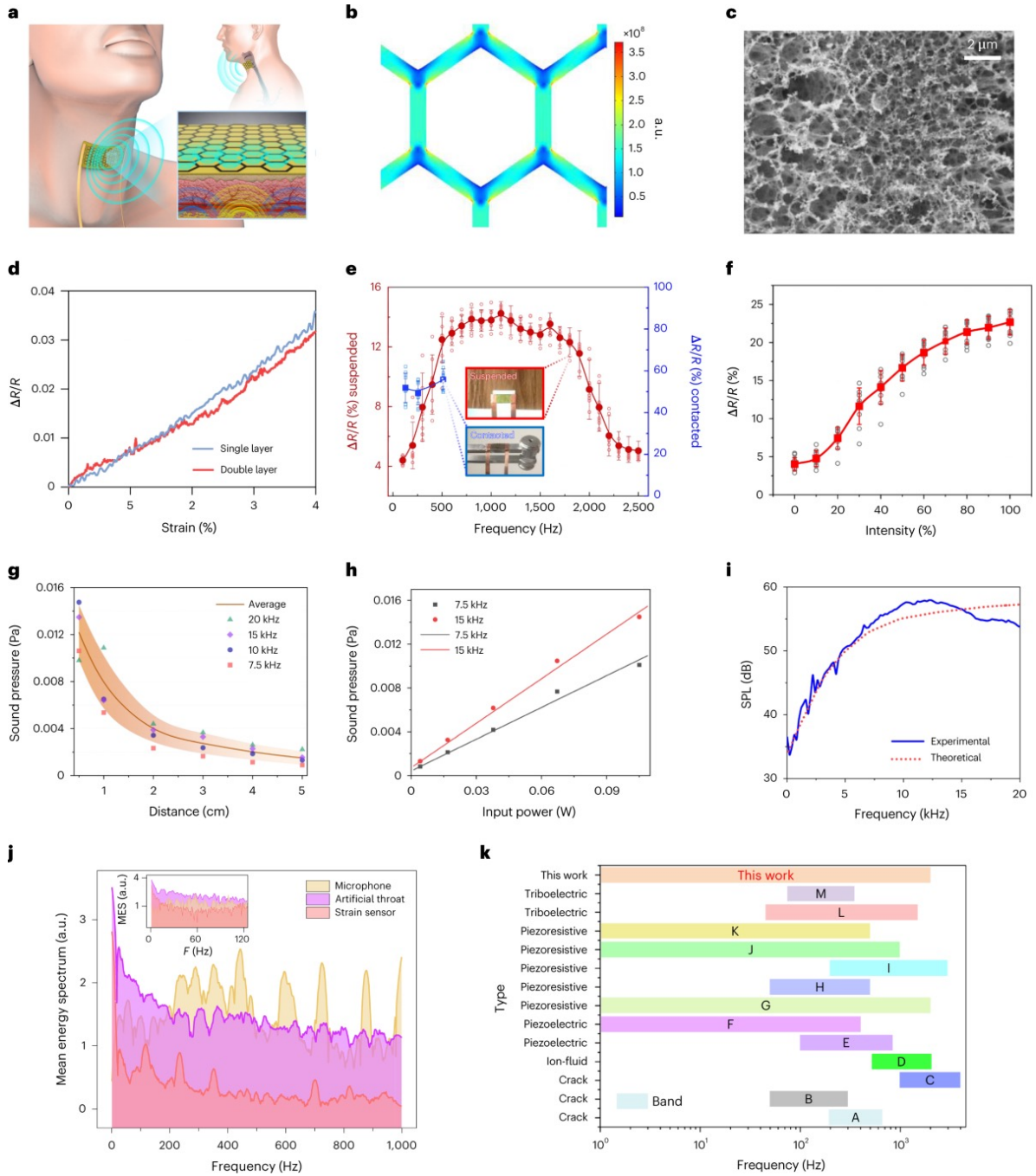
Mixed-modality speech recognition and interaction using a wearable artificial throat

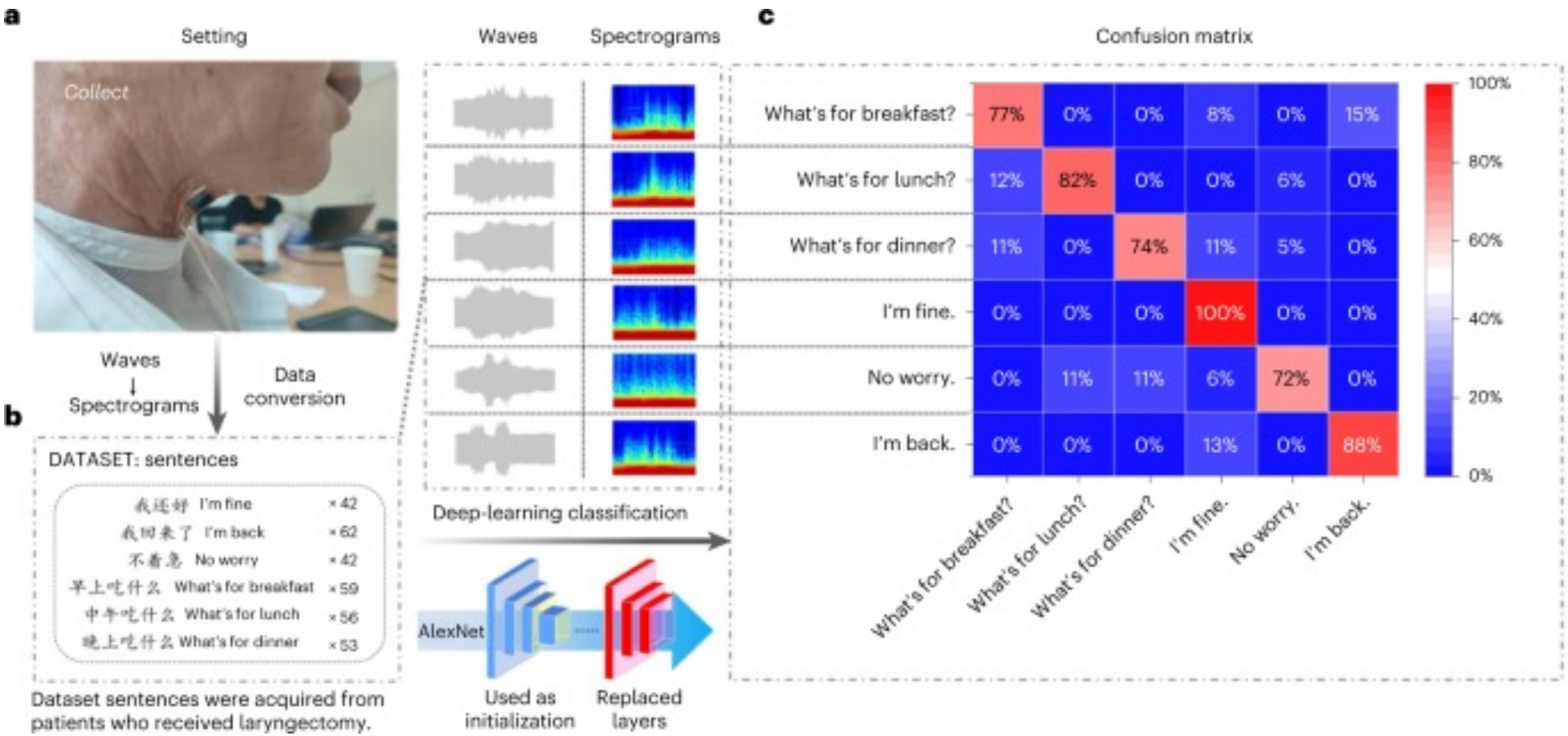
- Universal speech recognition and interaction that can work well with subtle sounds or noisy environments.
- Multichannel acoustic sensors can improve the accuracy of recognition of sound but lead to large devices that cannot be worn.
- To solve this problem, we propose a graphene-based intelligent, wearable artificial throat (AT) that is sensitive to human speech and vocalization-related motions.
- Its perception of the mixed modalities of **acoustic signals and mechanical motions** enables the AT to acquire signals with a low fundamental frequency while remaining noise resistant. through an ensemble AI model.

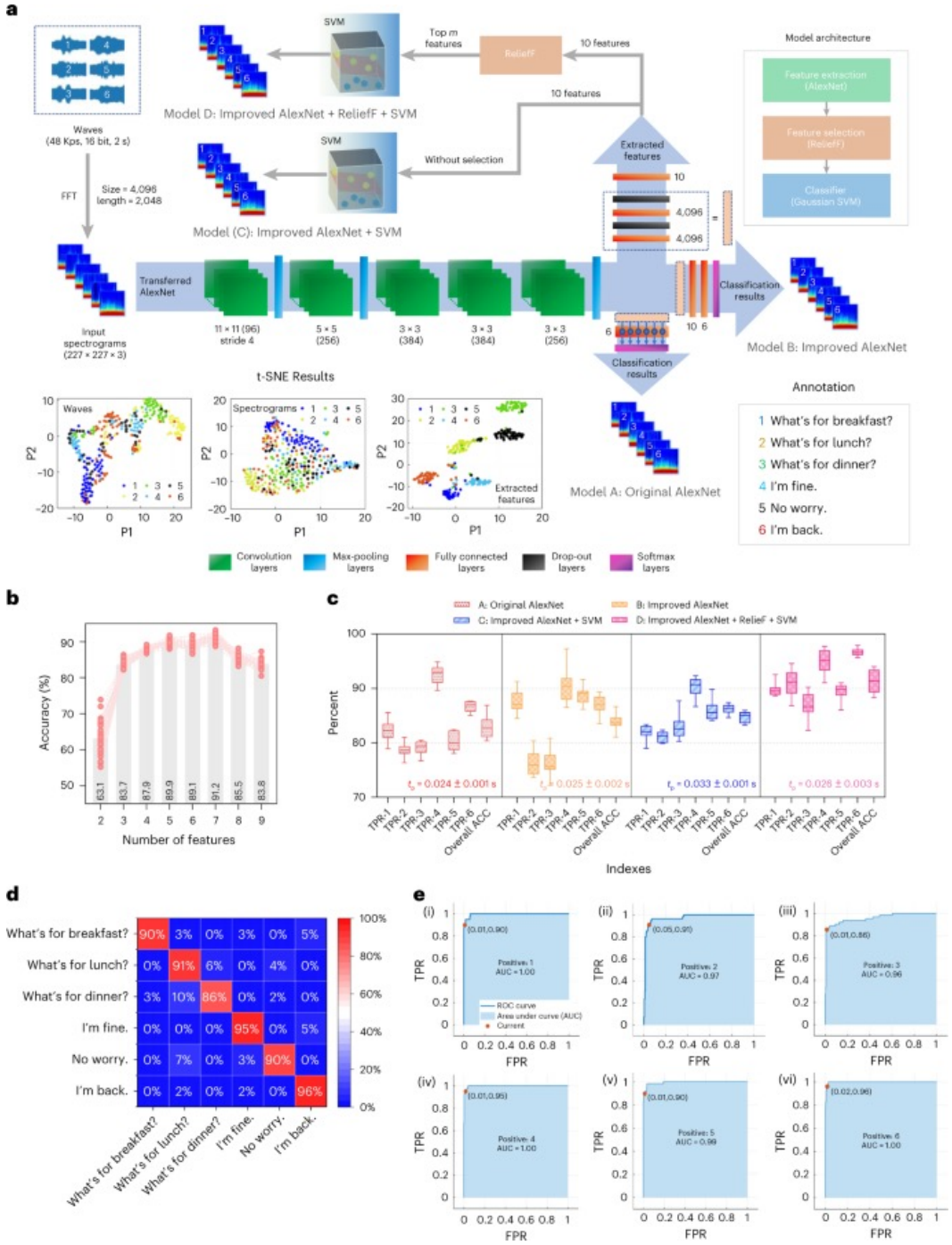


Nature Machine Intelligence **volume 5**, pages169–180 (2023)

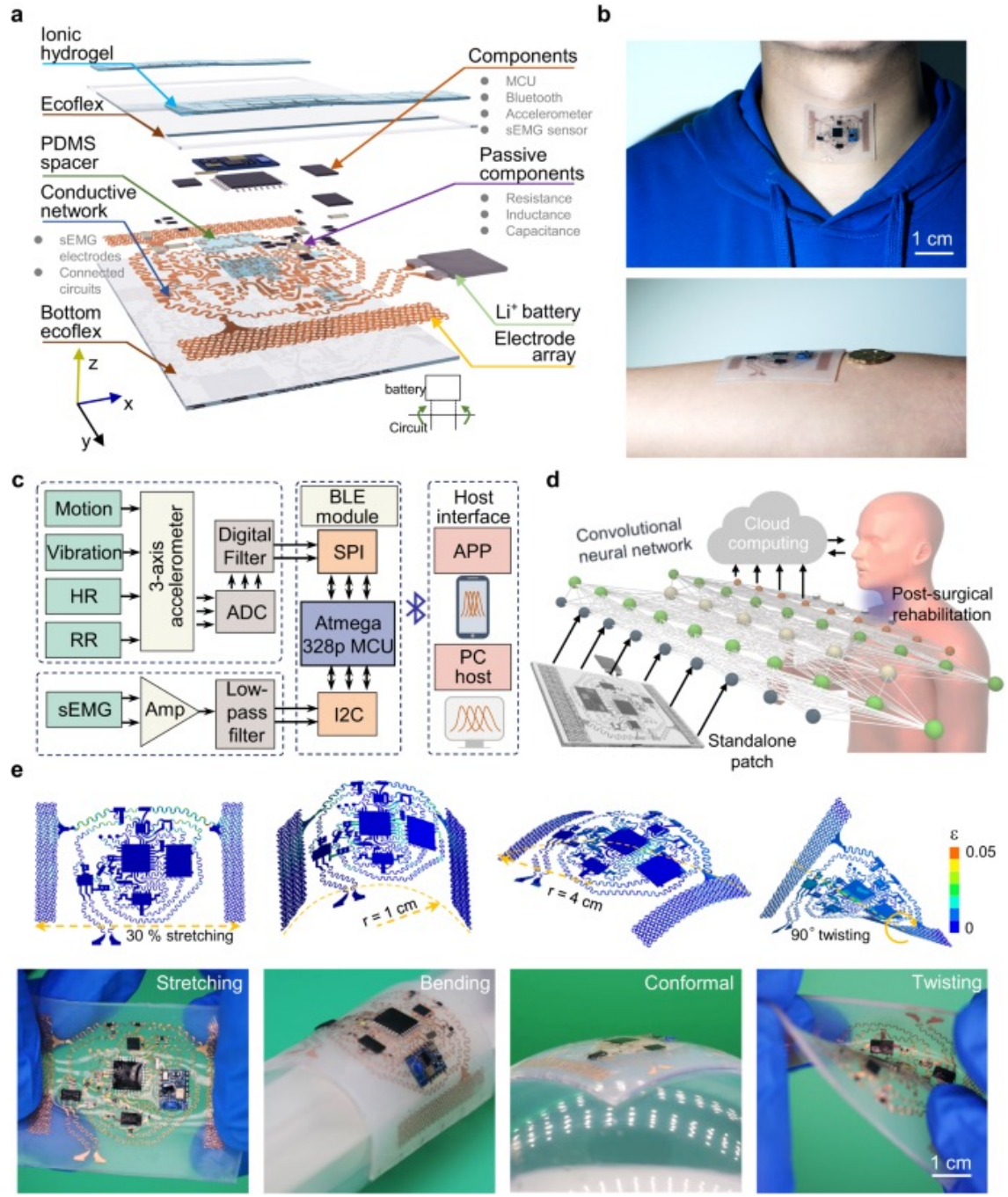

a
Commercial pressure sensor
Artificial throat
Side view
Front view
Side view
Front view
b
Artificial throat*
Dataset 1: Tones
Dataset 2: Vowels
Dataset 3: Words
*Note: Datasets 1–3 were acquired from healthy people.
Microphone
Dataset 4:Tones
Dataset 5: Phenomes
Dataset 6: Words
Dataset 7: Phenomes (with filter#)
Butterworth filter
Dataset 8: Element (Cherry Test†)
Varied amplitude of gaussian noises
Voice spectrums under different noises
†Note: Dataset 8 was acquired with varied environmental noises ranging from 50 to 80 dB.
#Note: Butterworth filter of ORDERS 1, 2 and 3, respectively.
c
d
Frequency (Hz)
8,192
0
F0
F1
Motion
Background
Time (s)
0.35
0.70
1.05


a
b
c
2 μm
×10^8
3.5
3.0
2.5
2.0
1.5
1.0
0.5
a.u.
d
ΔR/R
Strain (%)
Single layer
Double layer
e
ΔR/R (%) suspended
ΔR/R (%) contacted
Frequency (Hz)
Suspended
Contacted
f
ΔR/R (%)
Intensity (%)
g
Sound pressure (Pa)
Distance (cm)
Average
20 kHz
15 kHz
10 kHz
7.5 kHz
h
Sound pressure (Pa)
Input power (W)
7.5 kHz
15 kHz
7.5 kHz
15 kHz
i
SPL (dB)
Frequency (kHz)
Experimental
Theoretical
j
Mean energy spectrum (a.u.)
Frequency (Hz)
MES (a.u.)
F (Hz)
Microphone
Artificial throat
Strain sensor
k
Type
Frequency (Hz)
This work
Triboelectric
Triboelectric
Piezoresistive
Piezoresistive
Piezoresistive
Piezoresistive
Piezoresistive
Piezoelectric
Piezoelectric
Ion-fluid
Crack
Crack
Crack
Band
A
B
C
D
E
F
G
H
I
J
K
L
M


a
Setting
Collect
Waves
Spectrograms
Data conversion
b
DATASET: sentences
我还好 I'm fine × 42
我回来了 I'm back × 62
不着急 No worry × 42
早上吃什么 What's for breakfast × 59
中午吃什么 What's for lunch × 56
晚上吃什么 What's for dinner × 53
Dataset sentences were acquired from patients who received laryngectomy.
Waves
Spectrograms
Deep-learning classification
AlexNet
Used as initialization
Replaced layers
c
Confusion matrix
What's for breakfast? 77% 0% 0% 8% 0% 15%
What's for lunch? 12% 82% 0% 0% 6% 0%
What's for dinner? 11% 0% 74% 11% 5% 0%
I'm fine. 0% 0% 0% 100% 0% 0%
No worry. 0% 11% 11% 6% 72% 0%
I'm back. 0% 0% 0% 13% 0% 88%
What's for breakfast?
What's for lunch?
What's for dinner?
I'm fine.
No worry.
I'm back.
100%
80%
60%
40%
20%
0%


a
Waves
(48 Kps, 16 bit, 2 s)
FFT
Size = 4,096
length = 2,048
Input spectrograms
(227 × 227 × 3)
Transferred AlexNet
11 × 11 (96) stride 4
5 × 5 (256)
3 × 3 (384)
3 × 3 (384)
3 × 3 (256)
SVM
Top m features
ReliefF
10 features
Model D: Improved AlexNet + ReliefF + SVM
Without selection
Model (C): Improved AlexNet + SVM
Extracted features
4,096
Classification results
Model B: Improved AlexNet
Model architecture
Feature extraction (AlexNet)
Feature selection (ReliefF)
Classifier (Gaussian SVM)
Model A: Original AlexNet
t-SNE Results
Waves
Spectrograms
Extracted features
P1
P2
Annotation
1 What's for breakfast?
2 What's for lunch?
3 What's for dinner?
4 I'm fine.
5 No worry.
6 I'm back.
Convolution layers
Max-pooling layers
Fully connected layers
Drop-out layers
Softmax layers
b
Accuracy (%)
Number of features
63.1
83.7
87.9
89.9
89.1
91.2
85.5
83.8
c
A: Original AlexNet
B: Improved AlexNet
C: Improved AlexNet + SVM
D: Improved AlexNet + ReliefF + SVM
Percent
Indexes
TPR-1
TPR-2
TPR-3
TPR-4
TPR-5
TPR-6
Overall ACC
d
What's for breakfast?
What's for lunch?
What's for dinner?
I'm fine.
No worry.
I'm back.
e
TPR
FPR
ROC curve
Area under curve (AUC)
Current

a Exploded diagram of the integrated device system. **b** Optical images of the standalone stretchable device patch attached to the laryngeal skin (top) and forearm (bottom). **c** Block functional diagram showing the processing steps of the acceleration and surface electromyography (sEMG) signals, including signal processing, controlling, communication, and display. **d** Schematic showing the use of a machine learning network and the standalone stretchable patch in laryngeal post-surgical rehabilitation. **e** Finite element analysis (FEA) and corresponding experimental results of the patch under mechanical deformations.



Continuous monitoring

- Post-surgical treatments of the human throat often require continuous monitoring of diverse vital and muscle activities.
- However, wireless, continuous monitoring and analysis of these activities directly from the throat skin have not been developed.
- fully integrated standalone stretchable device platform that provides wireless measurements and machine learning-based analysis of diverse vibrations and muscle electrical activities from the throat.
- We demonstrate that the modified composite hydrogel with low contact impedance and reduced adhesion provides high-quality long-term monitoring of local muscle electrical signals.
- We show that the integrated triaxial broad-band accelerometer also measures large body movements and subtle physiological activities/vibrations.

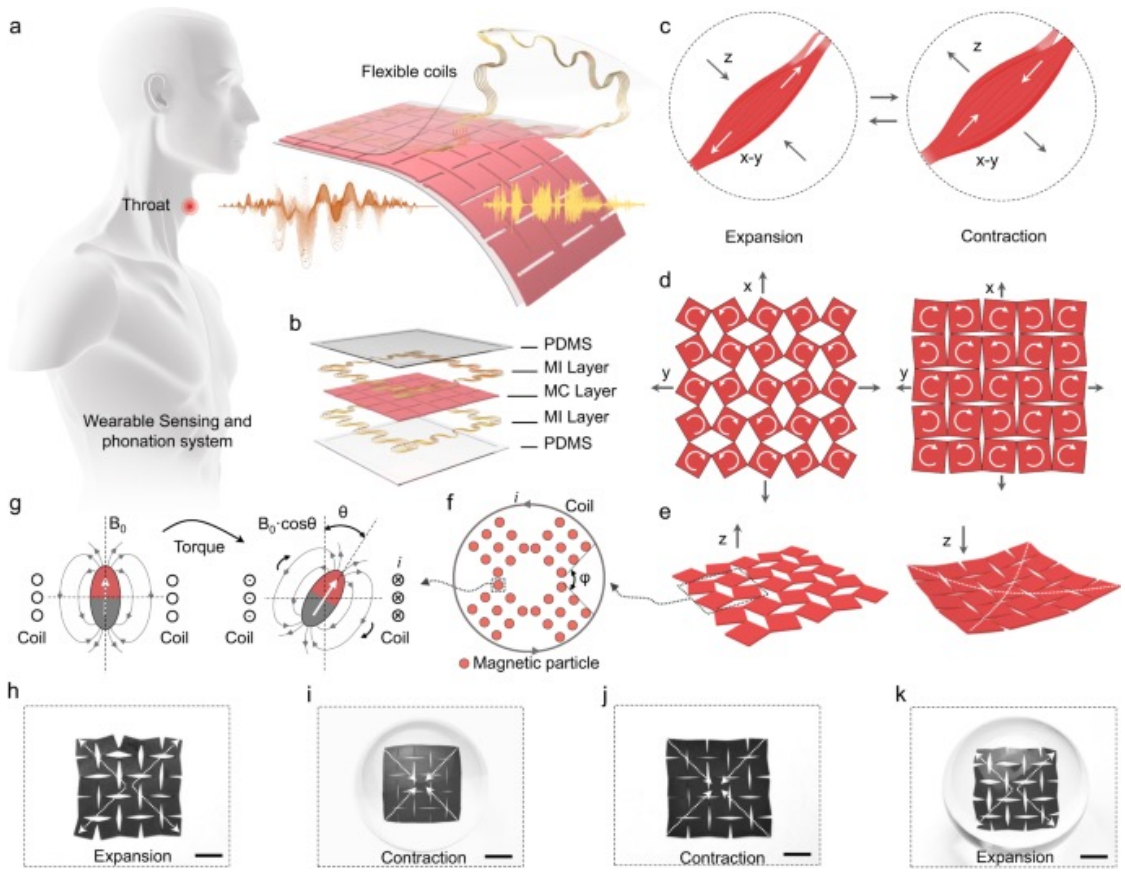
Google AI could soon use a person's cough to diagnose disease

An ultralight, flexible, and biocompatible all-fiber motion sensor for artificial intelligence wearable electronics

- New-generation human body motion sensors for wearable electronics and intelligent medicine are required to comply with stringent requirements in terms of ultralight weight, flexibility, stability, biocompatibility, and extreme precision.
- Conventional sensors are hard to fulfill all these criteria due to their rigid structure, high-density sensing materials used as the constituents, as well as hermetical and compact assembly strategy.
- an ultralight sensing material based on radial anisotropic porous silver fiber (RAPSF), which has been manufactured by phase separation and temperature-controlled grain growth strategy on a modified blow-spinning system. The resistance of RAPSF could be dynamically adjusted depending on the deflected shape.

npj Flexible Electronics **volume 6**, Article number: 27 (2022)

Speaking without vocal folds using a machine-learning-assisted wearable sensing-actuation system



Voice disorders resulting from various pathological vocal fold conditions or postoperative recovery of laryngeal cancer surgeries, are common causes of dysphonia.

A self-powered wearable sensing-actuation system based on soft magnetoelasticity that enables assisted speaking without relying on the vocal folds.

The wearable sensing component can effectively capture extrinsic laryngeal muscle movement and convert them into high-fidelity and analyzable electrical signals, which can be translated into speech signals with the assistance of machine learning algorithms with an accuracy of 94.68%.

Nature Communications **volume 15**, Article number: 1873 (2024)

Challenges and Ethical Considerations

data privacy,

interpretability of algorithms,

potential biases in datasets

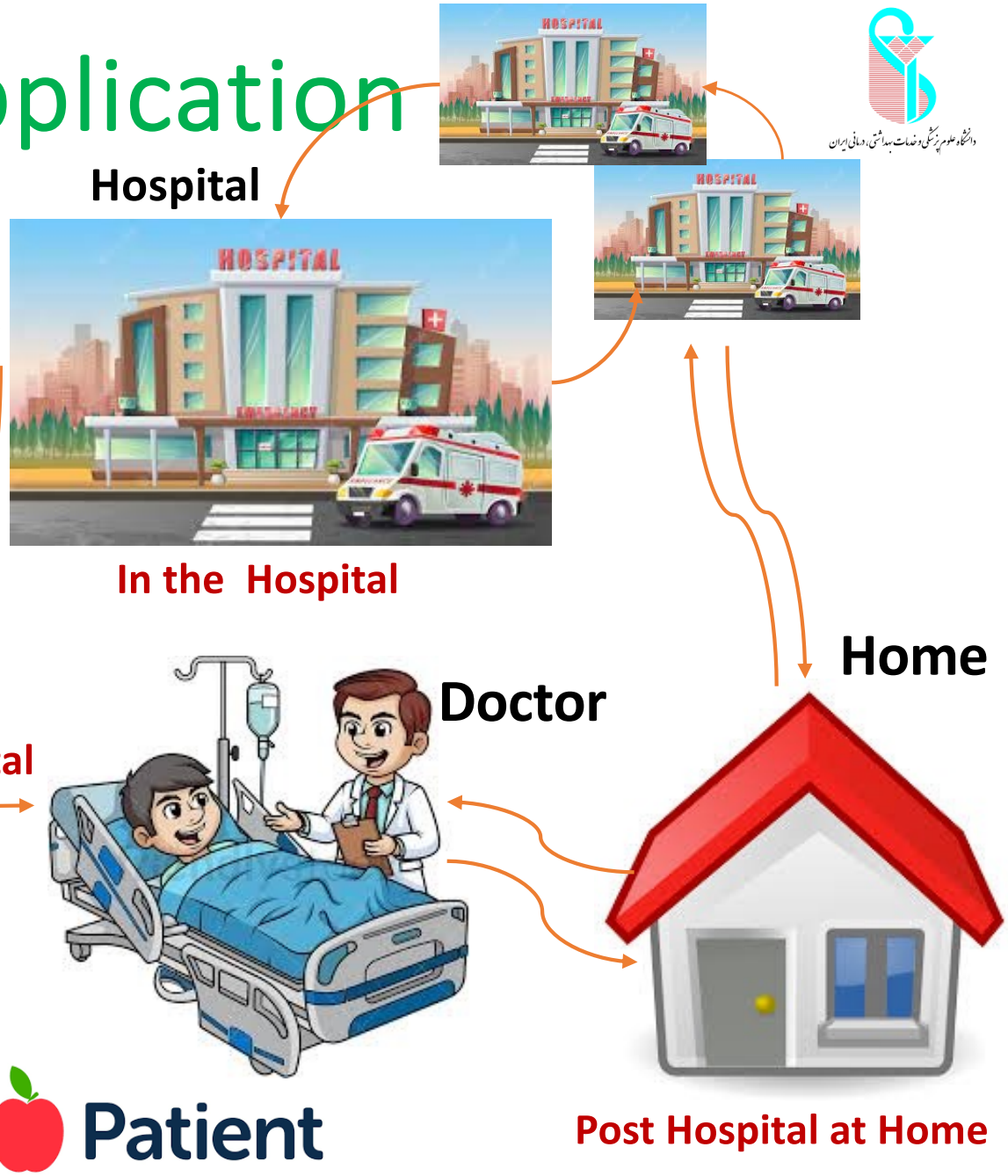
Medical Approval

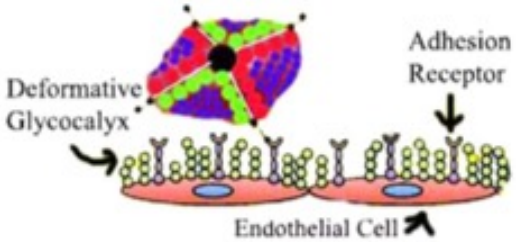
Note that!!

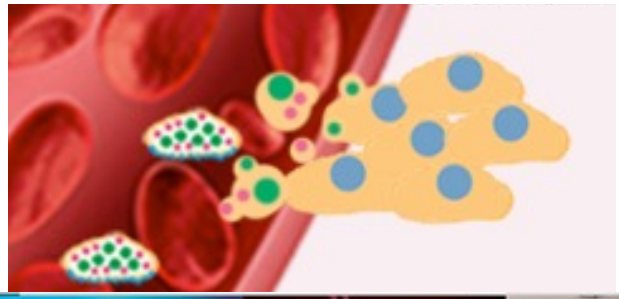
- AI is not a replacement, It is an assistance.

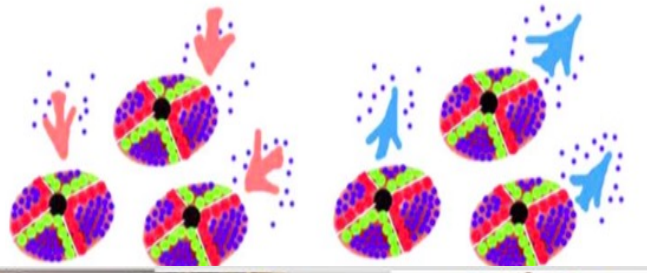
8-AI Medical Application

Prevention	Screening
Early Detection	Diagnosis
Recurrence Prediction	Critical Decision Making
Treatment Selection and Analysis	Mortality and Morbidity Prediction
Triage	…









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Research Interest:
Artificial Intelligence, Artificial Intelligence in Medicine, Complex Systems, Biomimicry, Cognitive Science, Swarm Intelligence, Nanomedicine, Targeted Drug Delivery, Early Detection of Disease, Swarm Nano Robotics, Cancer Research, Fuzzy Logic and Control, Soft Computing, Neural Networks, Machine Learning, Multi-agent Systems, Distributed Decision Making, Biomarkers, Biophysics, Nature Inspired Algorithms, Computational Cellular/Molecular Biology, Protein Folding

Artificial Intelligence for Good (AI for Good)