



PHONAK
life is on

AI in Hearing Aid Processing●

A review of AI in everyday life, healthcare, and hearing care.

Rachel L. Lamb, AuD
Clinical Trainer



Learning Objectives

After this course, participants will be able to

- Define Artificial Intelligence (AI)
- Describe how current hearing aids employ AI
- Describe how AutoSense OS uses AI

AI in movies.

Did you know?

Metropolis (1927). False Maria



AI is changing the way we work

AI is forever changing our jobs and reinventing the way we work



ChatGPT passed the US medical licensing exam



Advantages of Artificial Intelligence

Automation

- Automate tasks
- Increased efficiency and productivity

Problem solving

- Solving intricate problems across various fields

Interactions

- More intuitive and personalized experiences

Learning and adaptation

- Learn from experience and adapt to new situations



AI in our every
day lives.

AI in our everyday lives



- Automating various tasks
- Enhancing convenience, efficiency, and security
- Automation of tasks (i.e. lighting, temperature control, and appliance usage)



- Lane departure warning
- Blind spot detection
- Adaptive cruise control
- Real-time driver assistance

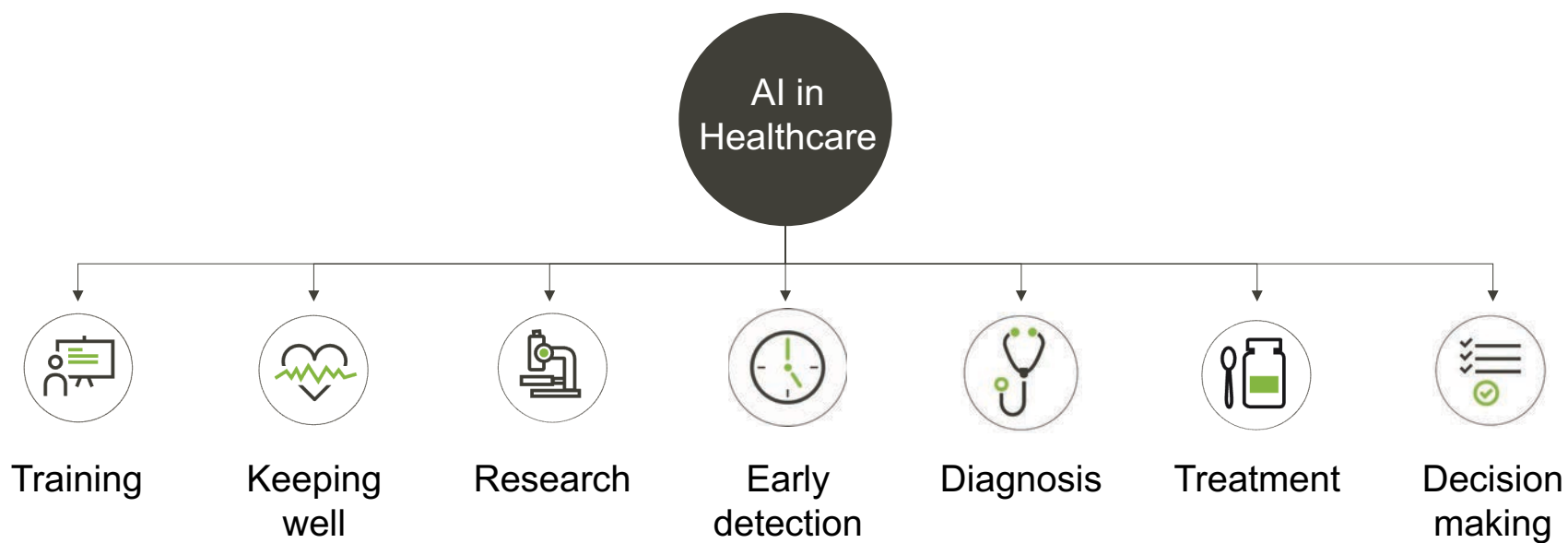


- Facial recognition and security features
- Text message word predictions
- Assistive accessibility functions
- Emergency health services if car accidents or other health-based incidents are detected



AI in healthcare.

Transforming healthcare





AI is used in healthcare in five main ways:

1

Early
detection and
diagnosis

2

Clinical
decision
support and
personalized
treatment
planning

3

Robotics and
rehabilitation

4

Apps, virtual
assistants
and chatbots

5

Training
and research

1. Early detection and diagnosis

AI-powered diagnostics enables:

Analysis of large, diverse data sources

High speed and accurate to information

Integration of personalized variables

Enhancing precision medicine



2. Clinical decision support

AI-powered diagnostics enables:

Pattern recognition from diverse medical sources

Improved communication methods and explanations

Personalized treatment plans



3. Robotics and rehabilitation

AI powered benefits include:

Enhanced Personalization

Precise Monitoring and Assessment

Increased Therapeutic Engagement

Intensive and Repetitive Training

Improved Accessibility and Cost-effectiveness



4. Apps, virtual assistants and chatbots

AI powered benefits include:

Preventative health measures

A reduction of dependence on traditional healthcare

Easy, 24/7 access to support

Empowered patients



5. Training and research

AI based medical training enables :

Personalized learning

Error detection and remediation

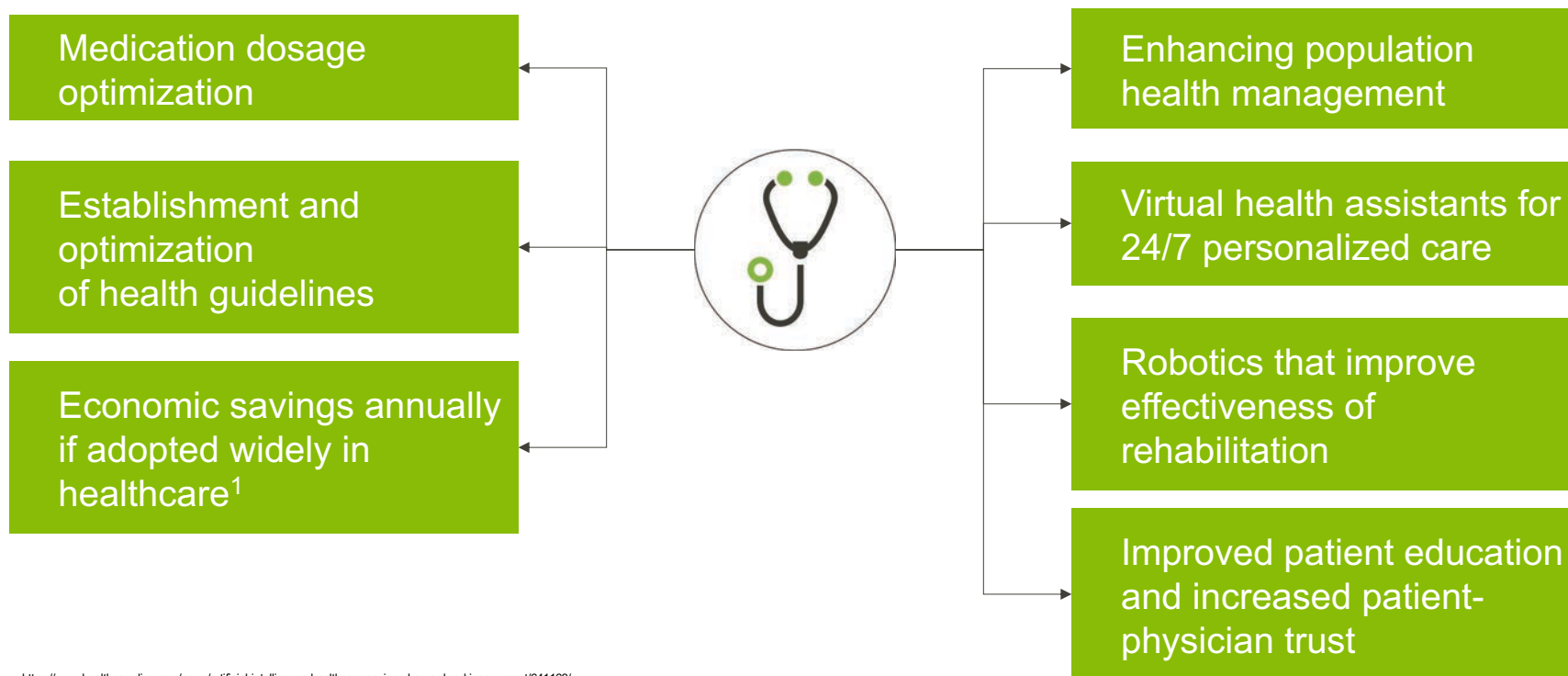
Virtual Learning

Access to large and diverse medical data sets
to inform new studies

Identify patterns and inform research
conclusions



AI will revolutionize personalized healthcare:



<https://www.healthcarediver.com/news/artificial-intelligence-healthcare-savings-harvard-mckinsey-report/641163/>

Patient perspective on AI in healthcare

In two recent studies of American patient perspectives of AI in healthcare;

- The majority of respondents think the use of AI in health and medicine **would reduce the number of mistakes made by health care providers**¹
- The majority of survey participants felt that AI would make health care **much better (10.9%) or somewhat better (44.5%)**²

JAMA Network Open

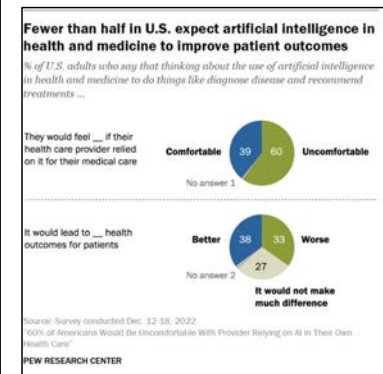
Research Letter | Health Informatics
Perspectives of Patients About Artificial Intelligence in Health Care
Othman Khutai, MD, MPH, Lawrence P. Casalino, MD, PhD, Yuting Qian, MS, Yuan Lu, ScD, Harlan M. Krumholz, MD, SM, Sanjay Arora, MD

Introduction
Applications of artificial intelligence (AI) in health care have increased in the past decade,¹ but little is known about how patients view these applications and whether they have concerns.² We conducted a nationally representative survey to understand public perceptions of the use of AI in diagnosis and treatment.

Methods
The survey was administered between December 3, 2019, and December 18, 2019, by an independent research firm using a hybrid probability-based, nationally representative online panel.

Table 1. Public Views About Artificial Intelligence in Health Care

	Respondents, No. (%)			Race and ethnicity ^a			Answer to question 1 ^b	
	Total (n = 925)	18–49 y (n = 113)	≥50 y (n = 792)	White (n = 513)	Other (n = 392)	Don't know (n = 178)	Other answer (n = 750)	
Overall, in the next 5 y, do you think AI will make health care in the United States?								
Much better	101 (10.9)	60 (53.1)	41 (5.1)	61 (11.4)	39 (10.0)	NA	NA	
Somewhat better	412 (44.5)	239 (214.8)	173 (21.9)	245 (47.8)	167 (42.8)	NA	NA	
Minimal change	179 (19.3)	105 (93.7)	74 (9.3)	110 (21.4)	69 (17.6)	NA	NA	
Somewhat worse	40 (4.3)	22 (19.5)	18 (2.3)	26 (5.1)	14 (3.6)	NA	NA	
Much worse	18 (1.9)	10 (8.9)	8 (1.0)	9 (1.7)	7 (1.8)	NA	NA	
Don't know	176 (19.0)	97 (85.8)	79 (9.9)	90 (17.5)	74 (18.9)	NA	NA	
How important do you think it is that you are told when an AI program has played a big role in your diagnosis or treatment?								
Not important	39 (4.2)	25 (22.1)	14 (1.8)	24 (4.7)	13 (3.3)	7 (1.8)	32 (8.3)	
Somewhat important	276 (29.6)	167 (148.7)	109 (13.8)	159 (31.0)	116 (29.6)	41 (11.3)	235 (61.3)	
Very important	611 (66.0)	341 (302.9)	269 (34.1)	364 (71.0)	227 (58.1)	128 (33.7)	483 (63.4)	
How important do you think it is that you are told when an AI program has played a small role in your diagnosis or treatment?								
Not important	125 (13.5)	83 (74.3)	42 (5.3)	77 (14.9)	45 (11.5)	10 (2.7)	115 (30.3)	
Somewhat important	379 (40.9)	230 (204.4)	148 (18.8)	221 (43.1)	149 (38.0)	61 (16.1)	318 (82.4)	
Very important	422 (45.5)	213 (190.3)	210 (26.7)	213 (41.6)	156 (39.6)	105 (28.2)	317 (82.3)	
How comfortable would you be receiving a diagnosis from a computer program that made the right diagnosis 90% of the time but could not explain why it made the diagnosis?								
Very uncomfortable	287 (31.0)	168 (150.4)	118 (15.0)	161 (31.2)	126 (32.1)	34 (9.3)	211 (55.8)	
Somewhat uncomfortable	375 (40.5)	207 (185.8)	168 (21.4)	231 (45.0)	137 (34.9)	72 (19.0)	303 (78.4)	
Somewhat comfortable	204 (22.0)	124 (110.7)	80 (10.2)	120 (23.4)	78 (19.9)	39 (10.3)	165 (42.8)	
Very comfortable	60 (6.5)	34 (30.1)	26 (3.3)	33 (6.4)	25 (6.4)	9 (2.3)	51 (13.2)	
How comfortable would you be receiving a diagnosis from a computer program that made the right diagnosis 90% of the time but could not explain why it made the diagnosis?								



- <https://www.pewresearch.org/science/2023/02/22/60-of-americans-would-be-uncomfortable-with-provider-relying-on-ai-in-their-own-health-care/>
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9069257/>

Patient perspective on AI in healthcare

- 60% of respondents reported being uncomfortable **if their health care provider relied upon AI for their medical care**¹
- It is also important to inform patients of when AI is being used,
 - 66% of respondents indicating it is very important for them to be informed**
 - 29.8% stating it was somewhat important**².

JAMA Network Open

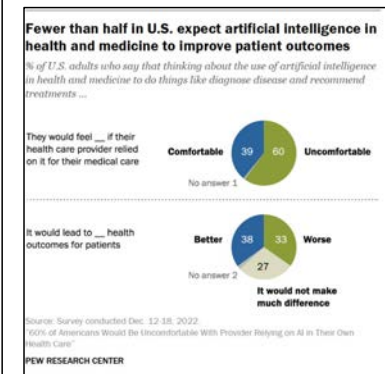
Research Letter | Health Informatics
Perspectives of Patients About Artificial Intelligence in Health Care
Othman Khutai, MD, MPH, Lawrence P. Casalino, MD, PhD, Yuting Qian, MS, Yuan Lu, ScD, Harlan M. Krumholz, MD, SM, Sanjay Arora, MD

Introduction
Applications of artificial intelligence (AI) in health care have increased in the past decade,¹ but little is known about how patients view these applications and whether they have concerns.² We conducted a nationally representative survey to understand public perceptions of the use of AI in diagnosis and treatment.

Methods
The survey was administered between December 3, 2019, and December 18, 2019, by an independent research firm using a hybrid probability-based, nationally representative online panel.

Table 1. Public Views About Artificial Intelligence in Health Care

	Respondents, No. (%)			Race and ethnicity*			Answer to question 1†	
	Total (n = 925)	18-49 y (n = 113)	≥50 y (n = 792)	White (n = 551)	Other (n = 359)	Don't know (n = 176)	Other answer (n = 750)	
Overall, in the next 5 y, do you think AI will make health care in the United States?								
Much better	101 (10.9)	60 (53.1)	41 (5.0)	61 (11.4)	39 (10.0)	NA	NA	
Somewhat better	412 (44.5)	239 (214.8)	173 (21.4)	245 (44.5)	167 (46.9)	NA	NA	
Minimal change	179 (19.3)	105 (93.7)	73 (9.1)	110 (20.0)	69 (18.4)	NA	NA	
Somewhat worse	40 (4.3)	22 (19.5)	18 (2.3)	26 (4.7)	12 (3.4)	NA	NA	
Much worse	18 (1.9)	10 (8.9)	8 (1.0)	9 (1.6)	7 (2.0)	NA	NA	
Don't know	176 (18.9)	97 (85.8)	79 (9.9)	90 (16.3)	74 (20.3)	NA	NA	
How important do you think it is that you are told when an AI program has played a big role in your diagnosis or treatment?								
Not important	39 (4.2)	25 (22.1)	14 (1.8)	24 (4.4)	13 (3.7)	7 (4.0)	32 (4.3)	
Somewhat important	276 (29.8)	167 (148.7)	109 (13.7)	159 (28.9)	116 (31.4)	41 (23.3)	235 (31.3)	
Very important	611 (66.0)	341 (303.2)	269 (34.1)	368 (66.6)	227 (64.9)	128 (72.7)	483 (64.4)	
How important do you think it is that you are told when an AI program has played a small role in your diagnosis or treatment?								
Not important	125 (13.5)	83 (73.4)	42 (5.3)	77 (14.0)	45 (12.8)	10 (5.7)	115 (15.3)	
Somewhat important	379 (40.9)	239 (214.8)	140 (17.7)	221 (40.1)	158 (44.0)	61 (34.7)	318 (42.4)	
Very important	422 (45.6)	211 (188.3)	210 (26.5)	253 (45.9)	156 (43.2)	105 (59.7)	317 (42.3)	
How comfortable would you be receiving a diagnosis from a computer program that made the right diagnosis 90% of the time but could not explain why it made the diagnosis?								
Very uncomfortable	287 (31.0)	168 (148.7)	118 (15.0)	161 (29.3)	126 (35.4)	54 (31.3)	231 (30.8)	
Somewhat uncomfortable	375 (40.5)	207 (186.3)	168 (21.4)	231 (41.9)	137 (38.3)	72 (40.9)	303 (40.4)	
Somewhat comfortable	204 (22.0)	124 (110.6)	80 (10.2)	120 (21.8)	78 (22.3)	39 (22.2)	165 (22.0)	
Very comfortable	60 (6.5)	34 (30.1)	26 (3.3)	33 (6.0)	25 (7.1)	9 (5.1)	51 (6.8)	
How comfortable would you be receiving a diagnosis from a computer program that made the right diagnosis 90% of the time but could not explain why it made the diagnosis?								



1. <https://www.pewresearch.org/science/2023/02/22/60-of-americans-would-be-uncomfortable-with-provider-relying-on-ai-in-their-own-health-care/>
2. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9069257/>

Patients want to be **informed** when AI is being used, and they **don't** want a clinician that **solely relies** upon AI.





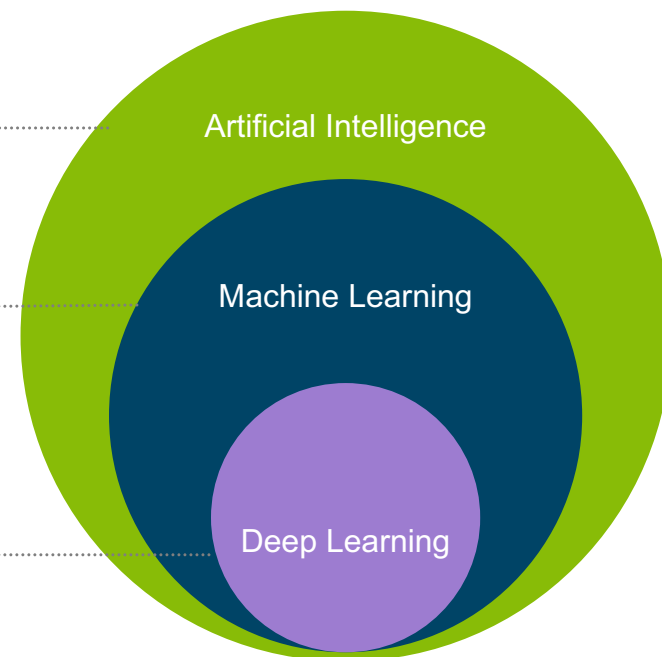
What is Artificial
Intelligence?●

Artificial Intelligence definitions

Ability of a machine to imitate human behavior

A subset of artificial intelligence in which a system learns automatically and enhances its performance through the analysis of provided data

An advanced subset of machine learning that employs intricate algorithms, such as deep neural networks (DNN), to closely emulate the human brain, enabling the system to learn and respond to information with increased complexity and precision



In other words



Artificial intelligence

describes any system that has been designed to **mimic human behavior** but doesn't reflect how it works.

Example: A smart home speaker that can tell time or set an alarm.



Machine learning

describes an AI system that **functions and learns from data**.

Example: A smart thermostat which learns its owner's temperature preferences, arrival time, outdoor weather information, etc., to set air-conditioning controls.



Deep learning

describes an advanced AI system that employs intricate algorithms, such as **deep neural networks (DNN)**.

Example: Facial recognition system on a smartphone that uses thousands of points of information to indicate and confirm a person's identity and allow them access to the smartphone.

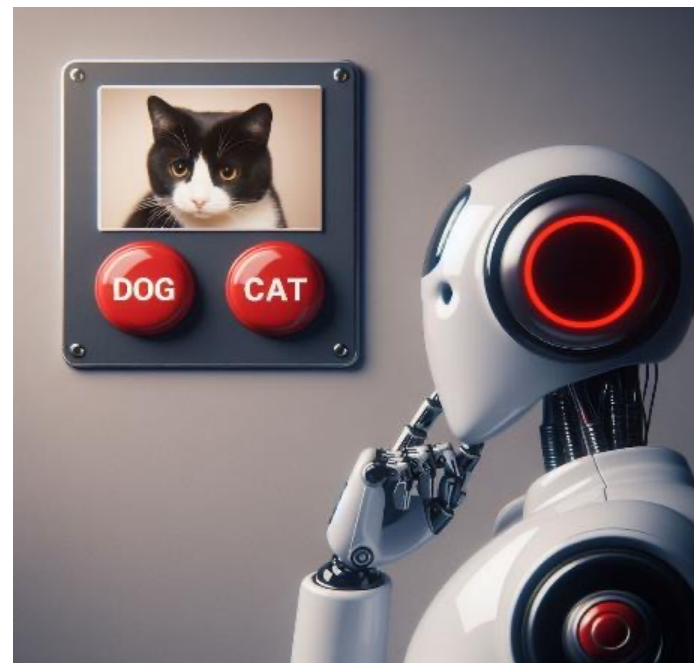


Machine Learning vs Deep Neural Networks ●

Machine Learning: Training

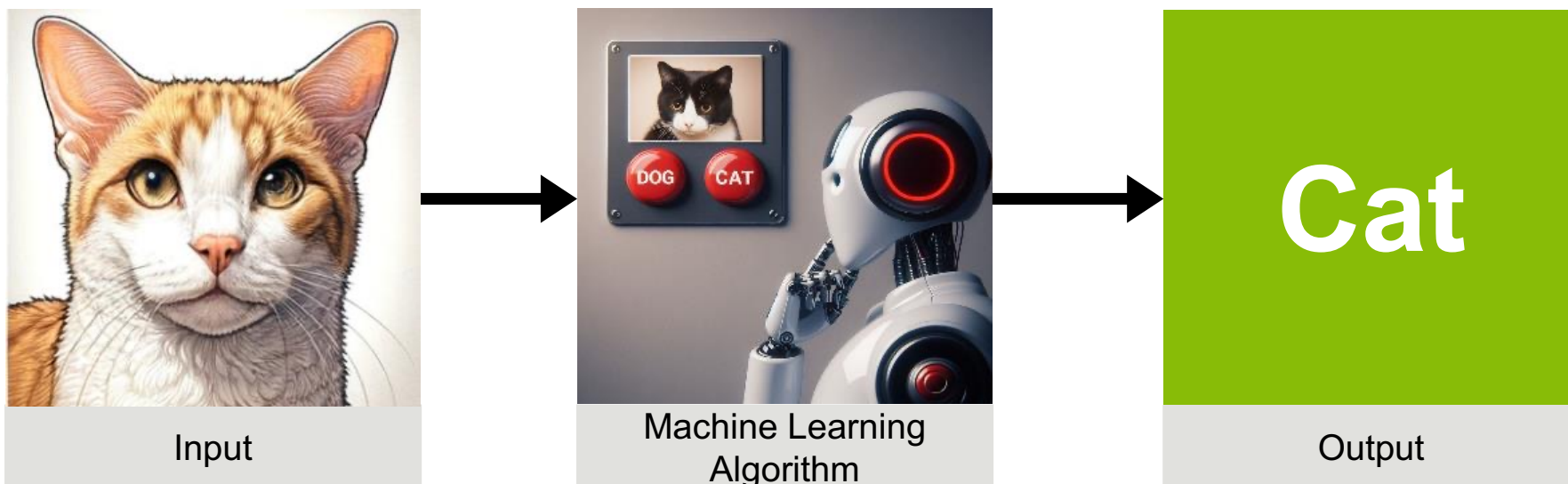


Visual examples for training

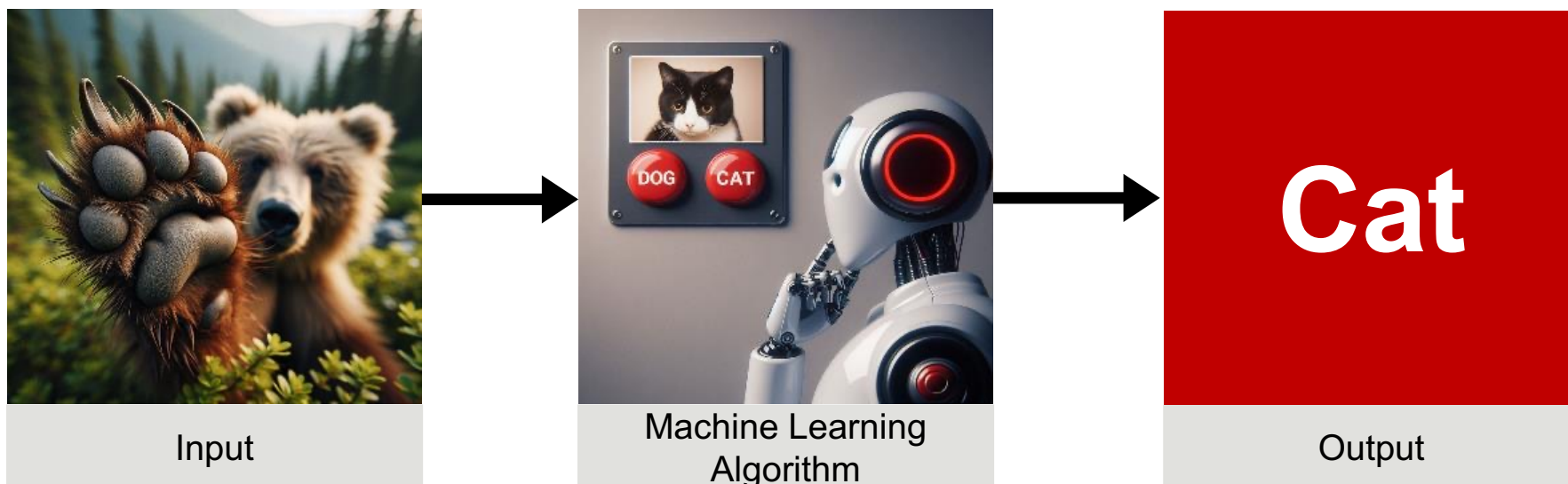


Machine learning algorithm

Machine Learning: Inference



Machine Learning: Inference

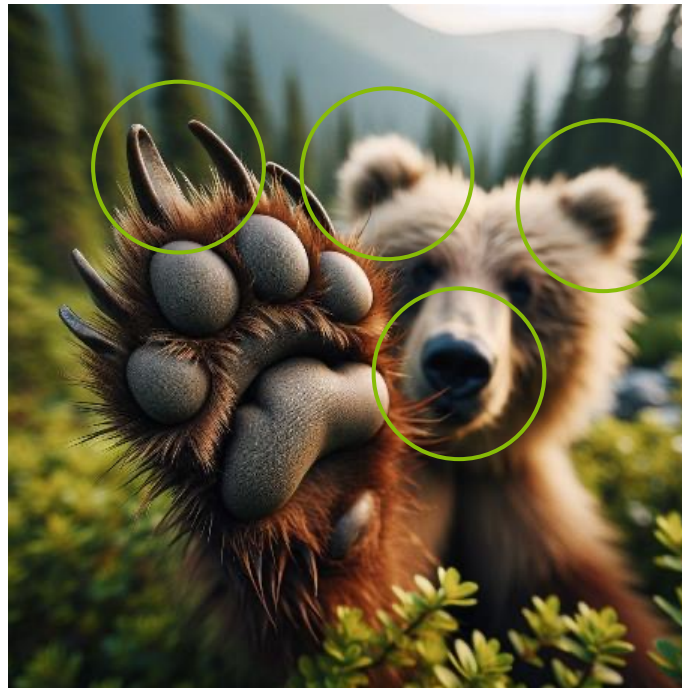


Machine learning vs. Deep learning

Machine learning

- Black nose
- Claws
- Two ears

Guess: "Cat"

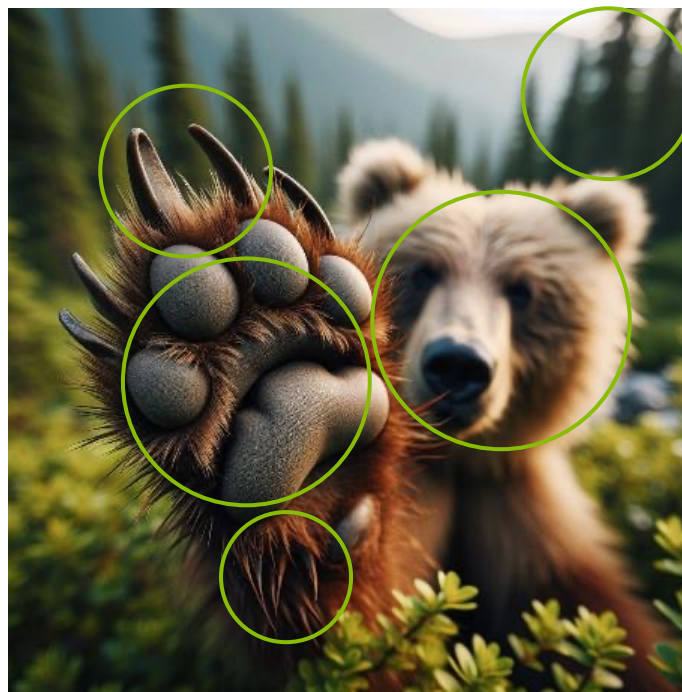


Machine learning vs. Deep learning

Machine learning

- Black nose
- Claws
- Two ears

Guess: "Cat"

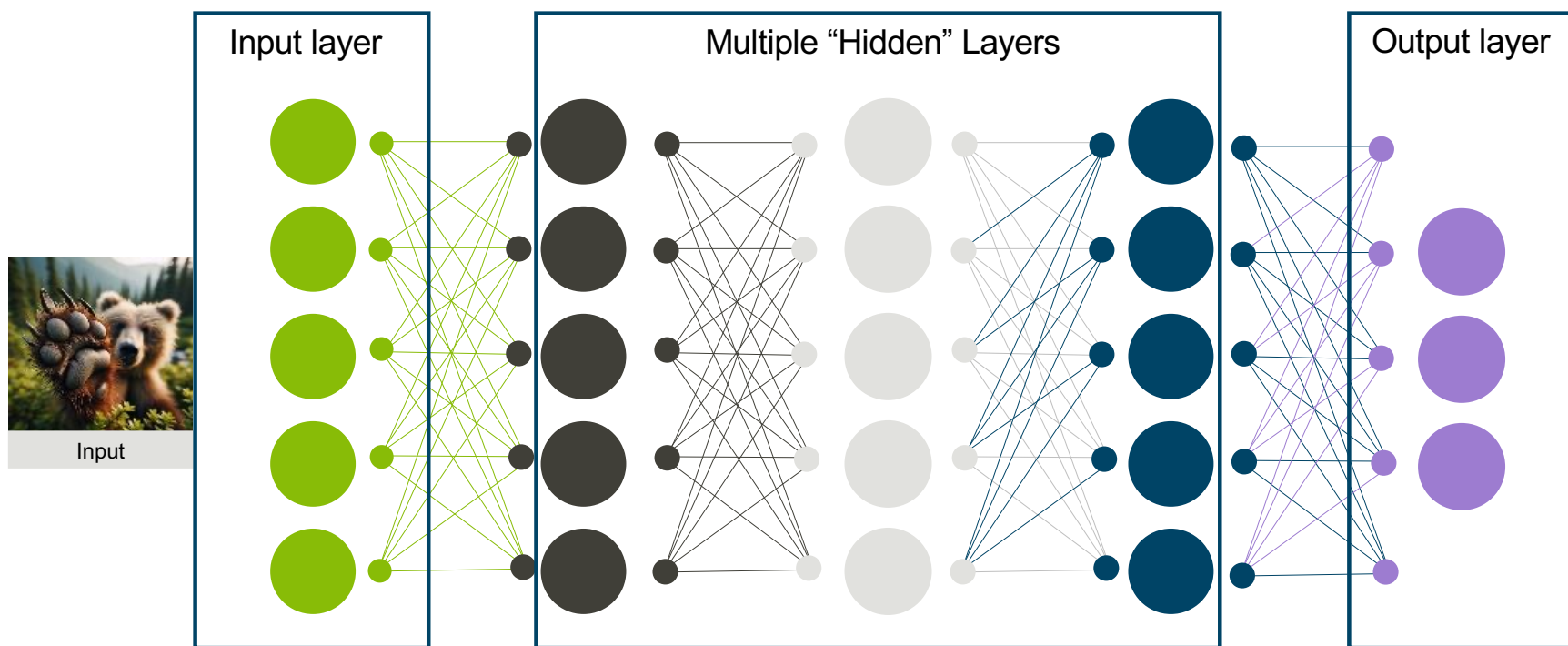


Deep learning

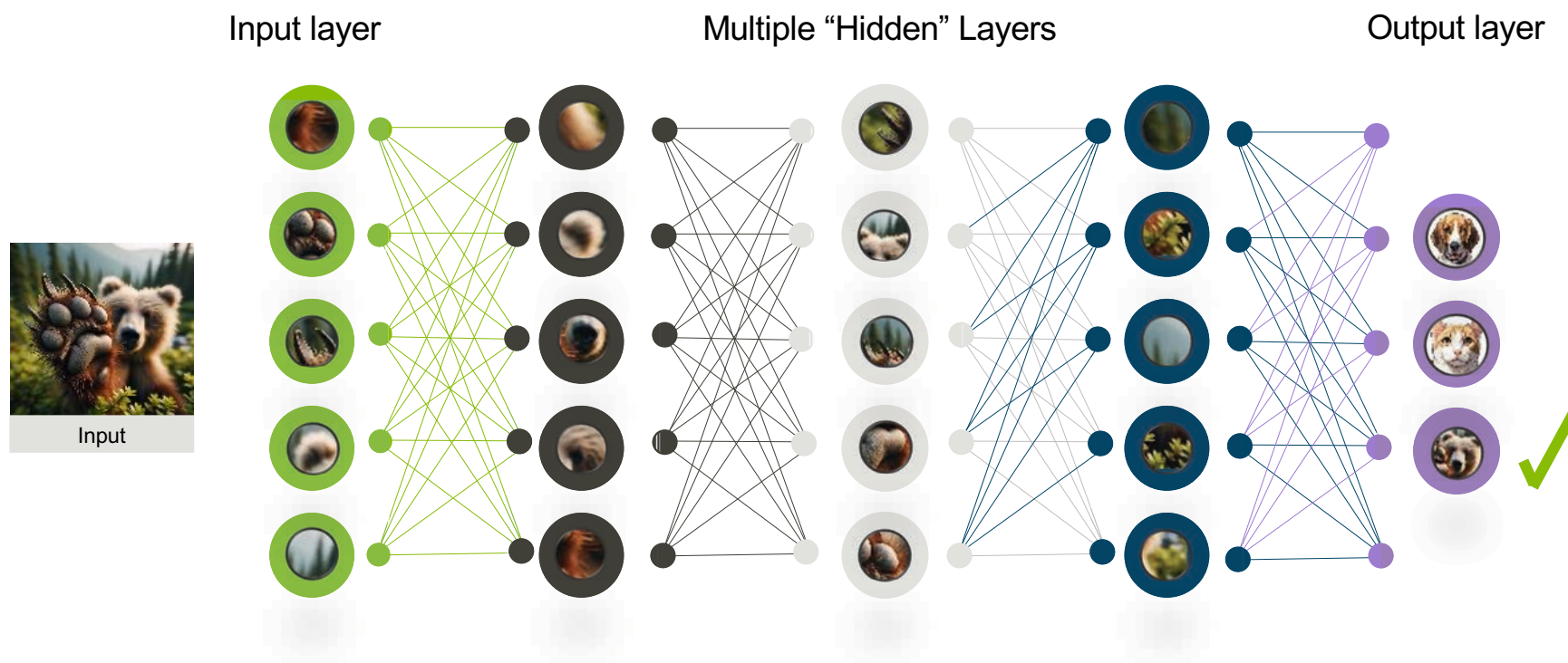
- Fur color and texture
- Paw size
- Claw number
- Head shape
- Background

Guess: "Grizzly bear"

Deep learning process



Deep learning process



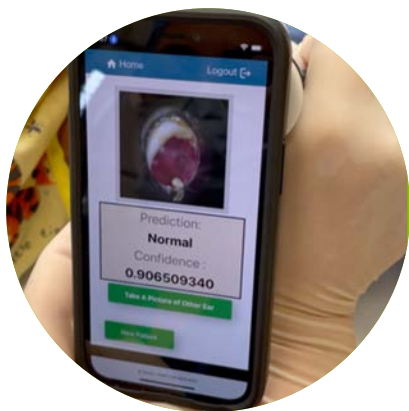


AI in hearing
healthcare.

AI in hearing care



1. Early detection & diagnosis



2. Tinnitus support



3. Hearing aid technology



Considerations for today's AI powered hearing aids

Machine learning



Advantages

- Requires less input information and processing power to operate
- Can enhance and learn over time

Disadvantages

- Requires more human input for learning and error correction when training
- Has less scope to learn

VS.

Deep neural networks



Advantages

- Can operate with no human input
- Greater simulation of human thought patterns

Disadvantages

- Requires significantly more information to function, learn and improve
- Requires significantly more processing power than machine learning

The required processing power to run a full DNN is not available in a hearing aid package

Automatic behavior

Hearing aid automatic systems can be developed or trained using AI.
Common features that are trained by AI are:

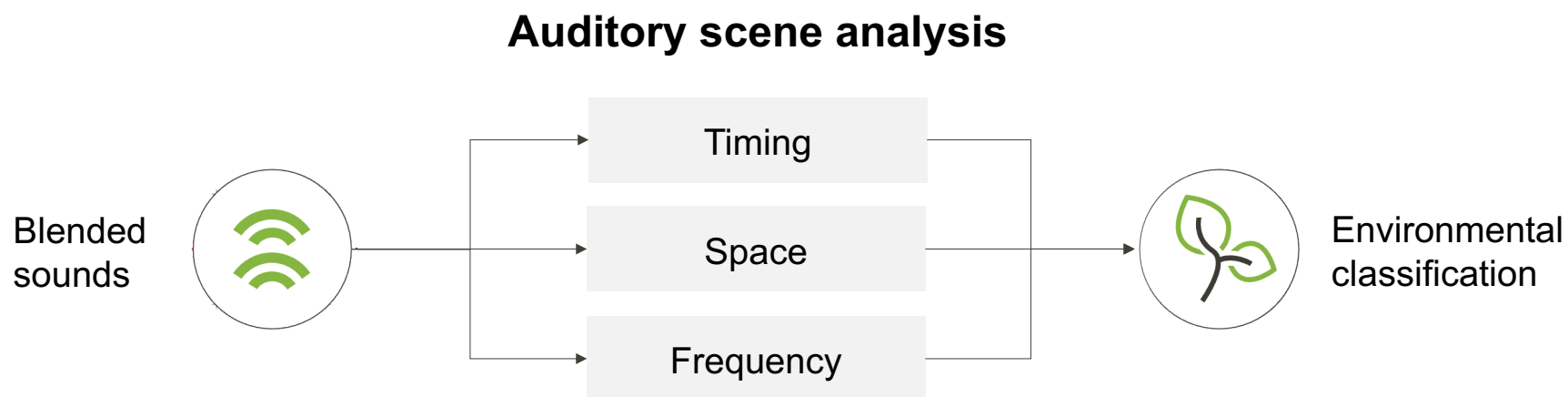
Environmental classification

utilizing specific
characteristic features of a
situation to categorize it.

Program steering

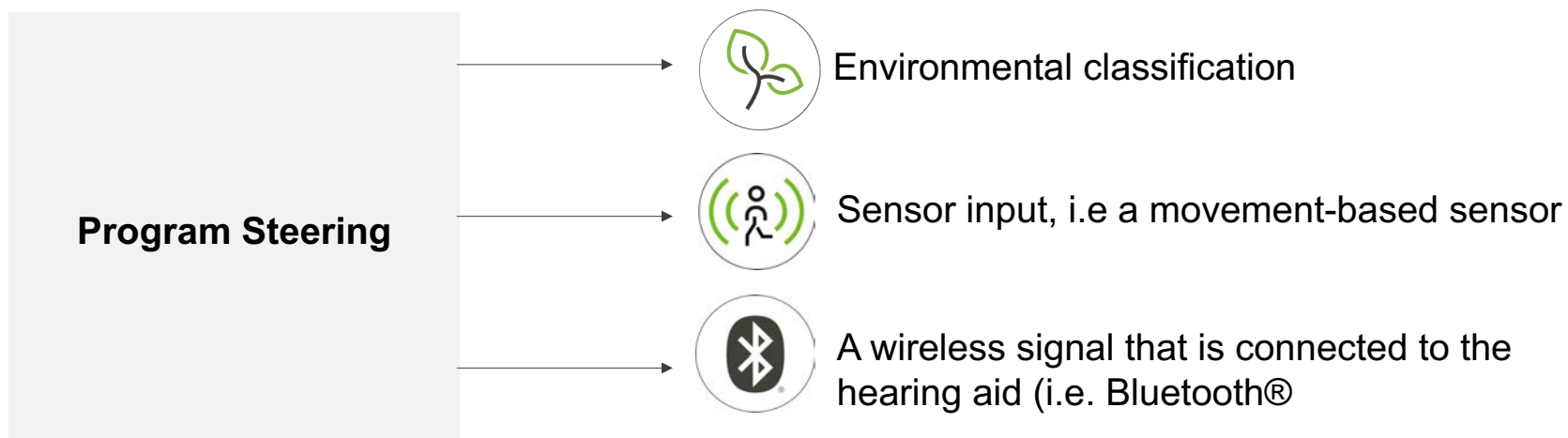
how a hearing aid changes
its features in response to
classifying a change in
environment

What is Environmental Classification?



What is Program Steering?

Program steering refers to the way a hearing aid adapts its features based on an external input. This input could be:



Today's AI powered hearing aids

The current AI technologies found in hearing aids are either

- Efficient machine learning algorithms
- 'Small' Deep Neural Networks
- Utilizing cloud-based servers for 'heavier' AI processing through an app

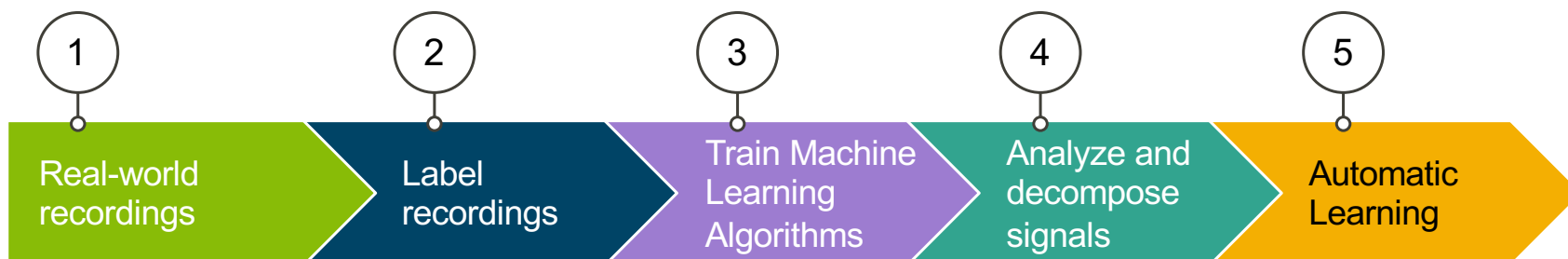


Efficient Machine learning algorithms

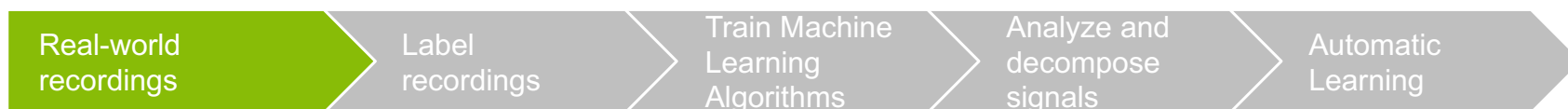
Machine learning approach



How does AutoSense OS™ 5.0 utilize AI?



Step 1: Real-world recordings



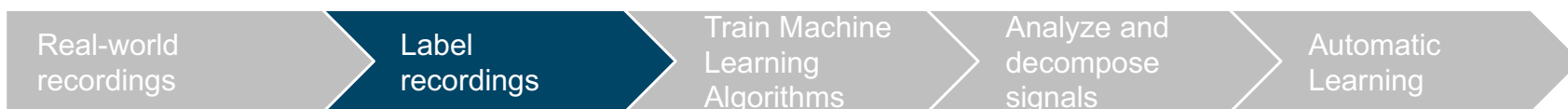
Gather a diverse set of **real-world recordings**.

Recording 1:	Recording 2:	Recording 3:	Recording 4:
			



What AutoSense OS environment would you classify for recording #1, #2, etc?

Step 2: Label recordings



Label Recordings: Tag the recordings with relevant labels indicating the environments they represent.

Recording 1:
Calm situation



Recording 2:
Speech in noise



Recording 3:
Music

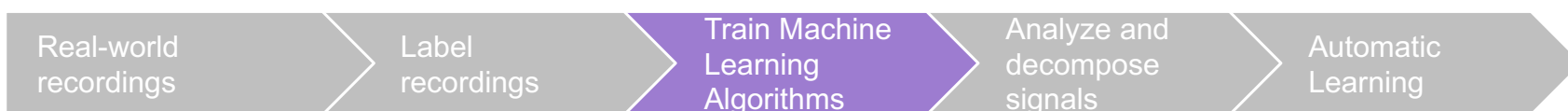


Recording 4:
Speech in car



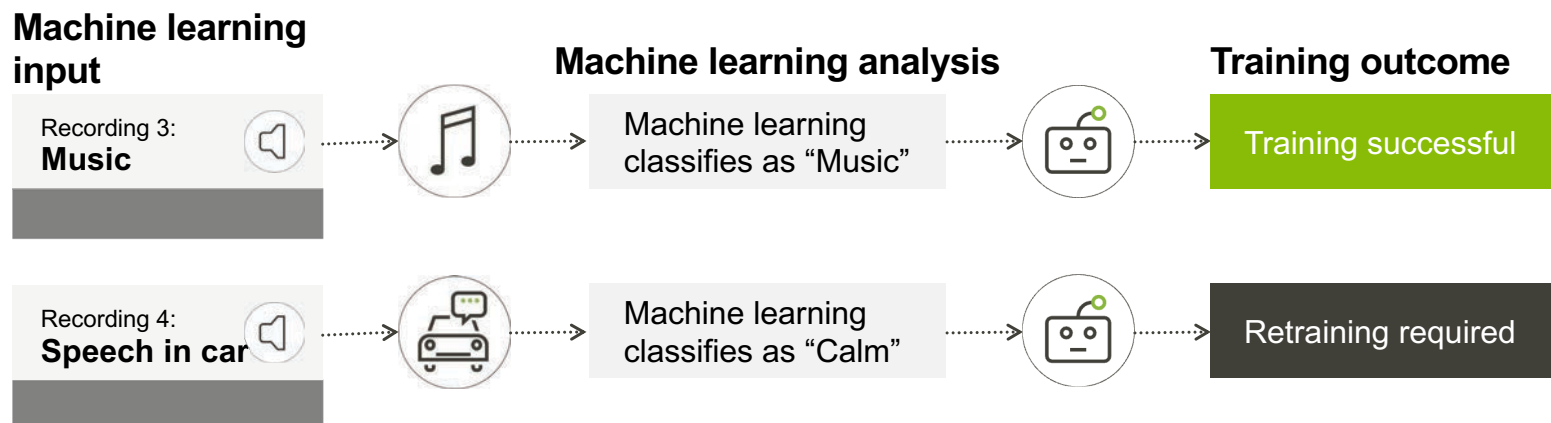
How close were you?

Step 3: Train machine learning algorithms

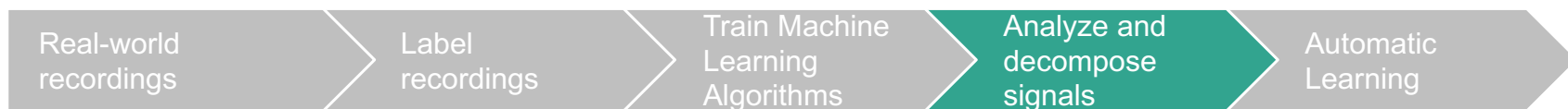


Train Machine Learning Algorithms: Train machine learning algorithms to accurately recognize different environments based on the labels.

Recordings: Tag the recordings with relevant labels indicating the environments they represent.

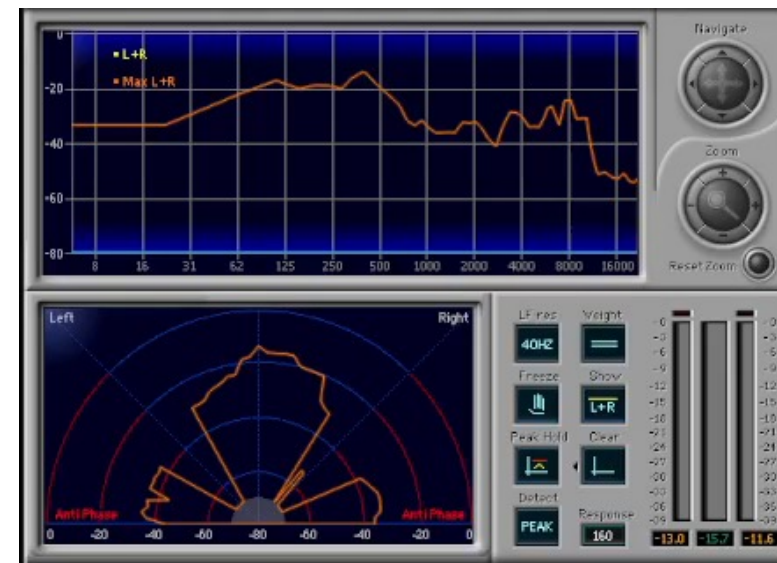


Step 4: Analyze and decompose signals

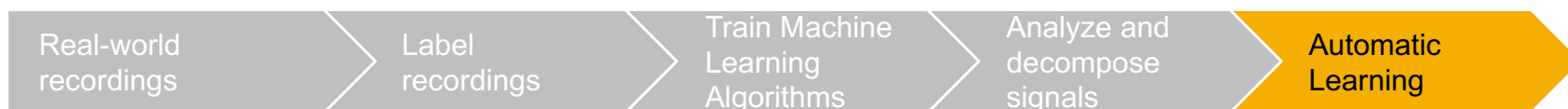


Analyze & Decompose Signals: Analyze the signals from the recordings and break them down into various features, such as spectral or temporal characteristics.

The system now automatically learns the features that best represent different situations.



5. How does AutoSense OS 5.0 utilize AI?

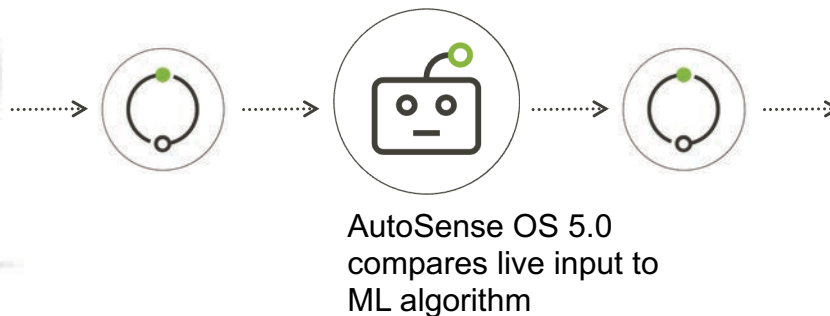


Automatic Learning: During use, the features of the live environment are calculated and compared to the machine learned environments, allowing AutoSense OS 5.0 to determine the live situation accurately.

AutoSense OS 5.0 Input



Environmental Classification



Program Outcome



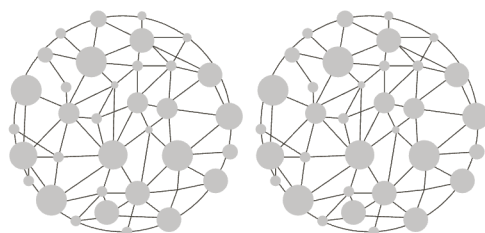
AutoSense OS 5.0 classifies as "Music"

“Small” deep neural networks

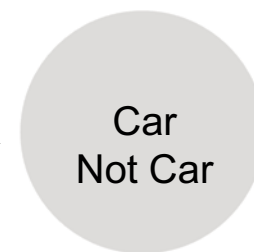
Deep learning approach



Input

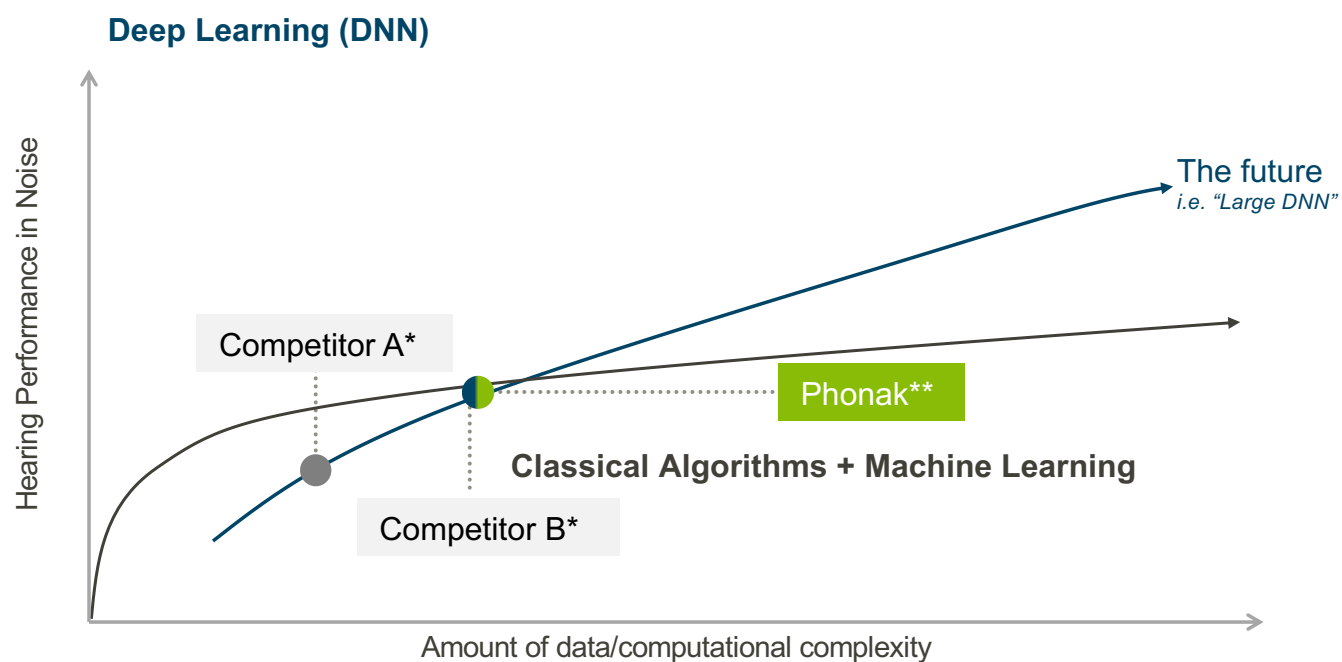


Feature extraction and
Classification



Output

Small DNN vs. Machine learning

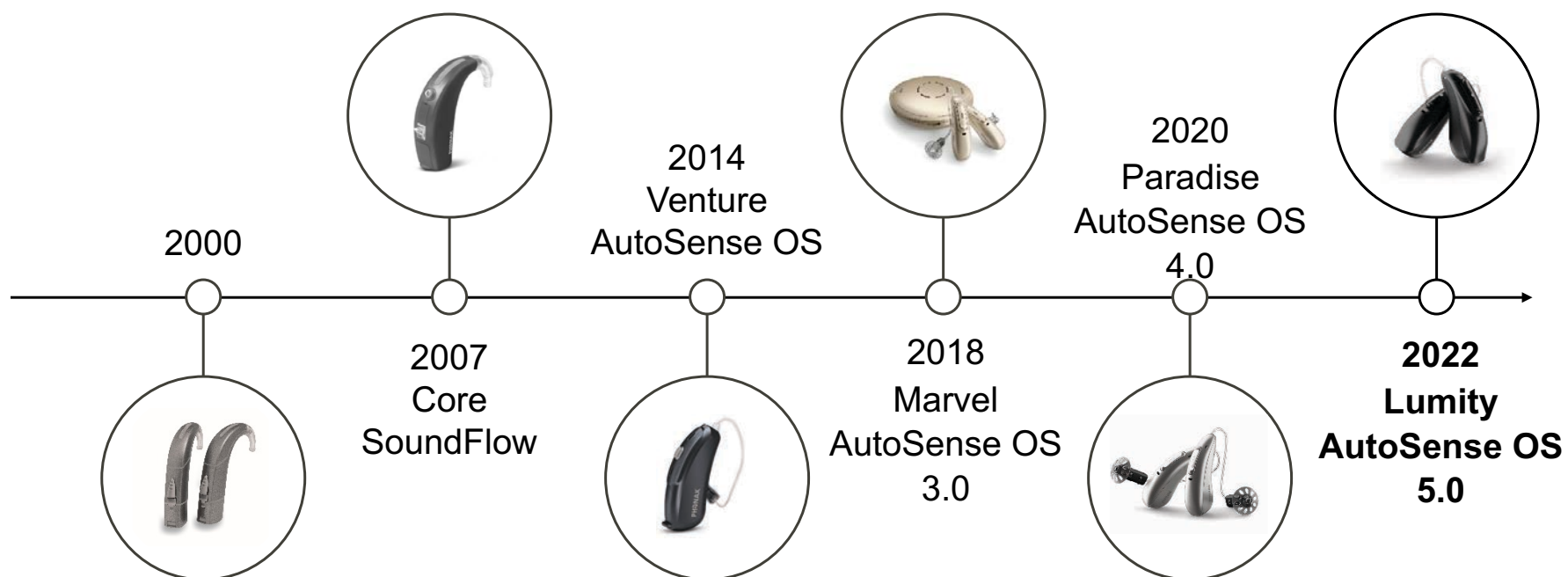


*Small DNN

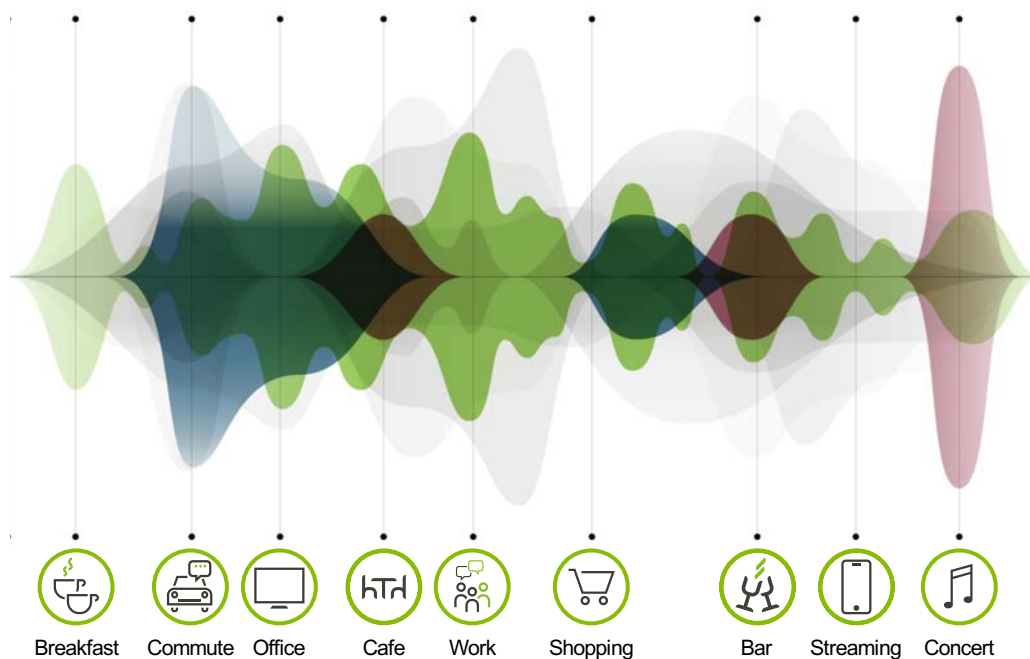
**AI-based Machine Learning

Based on internal benchmarking data. Contact claims@phonak.com for more information

Innovating in the AI field for 24 years



24 years of AI industry experience



200+ unique setting combinations

to meet the individual needs of patients



700 scans per second

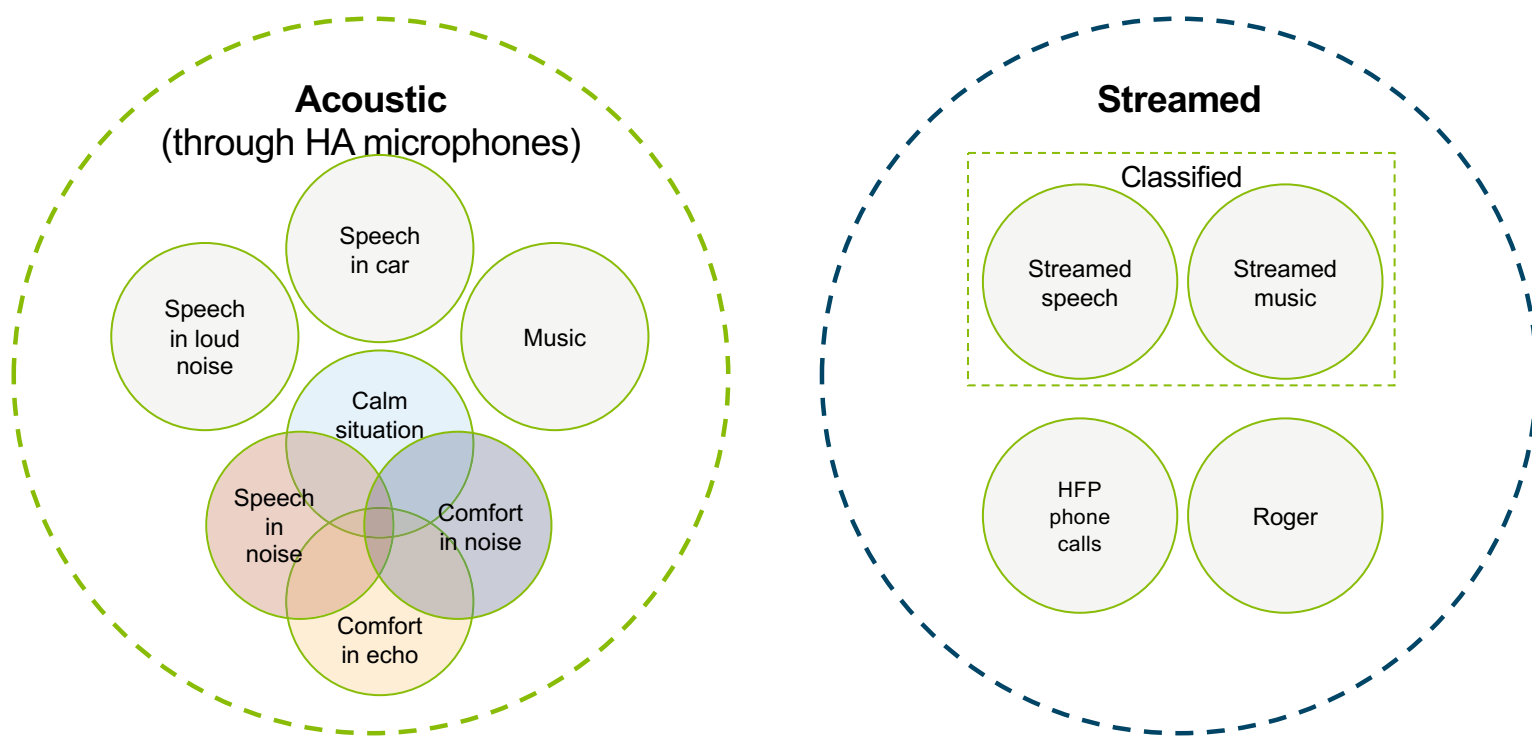
for real-time adjustment to the environment



24 years of experience in machine learning

using real-world sound recordings

AutoSense OS: Blending & Classification of signals



AutoSense OS 5.0: Benefits patients & providers

Accurate, reliable and consistent
program selection automatically

Streamlined & simple fitting process

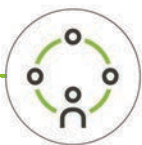
Customizing hearing aid performance
that is easy and effective





Future AI
opportunities.

AI in audiology



Your patients still need and want your support from a strong relationship and rapport – you are the expert and their trusted advisor



Your patients want to see you combine your experience with AI



Opportunities with AI



New approaches to diagnostic assessments that are more reliable and sensitive to hearing loss



Improved techniques for hearing aid verification and calibration



New innovations in the way hearing aids and their digital eco system (apps, virtual assistants, etc) work to improve patient support

Hearing aid features that push boundaries in automatic performance, environmental classification and performance in noise.

Opportunities to improve satisfaction

Sound quality and hearing aid performance are key drivers for satisfaction.

When compared, the biggest difference between hearing owners and non-owners is their satisfaction following conversations in noise



In addition, other situations with large differences include:

Conversations in large groups



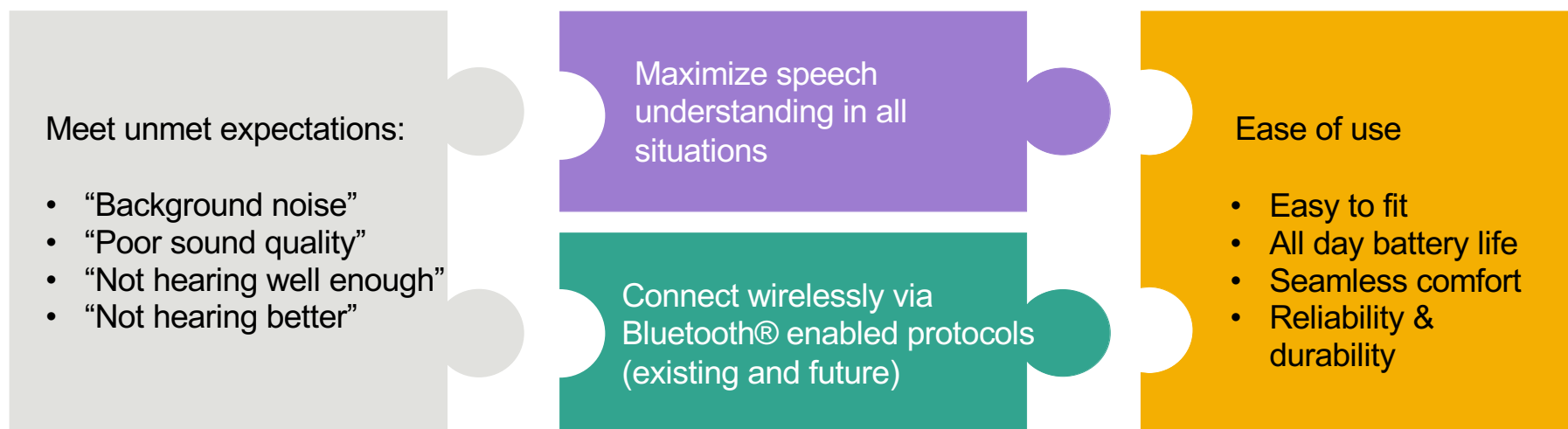
When watching television with others



Conversations with small groups

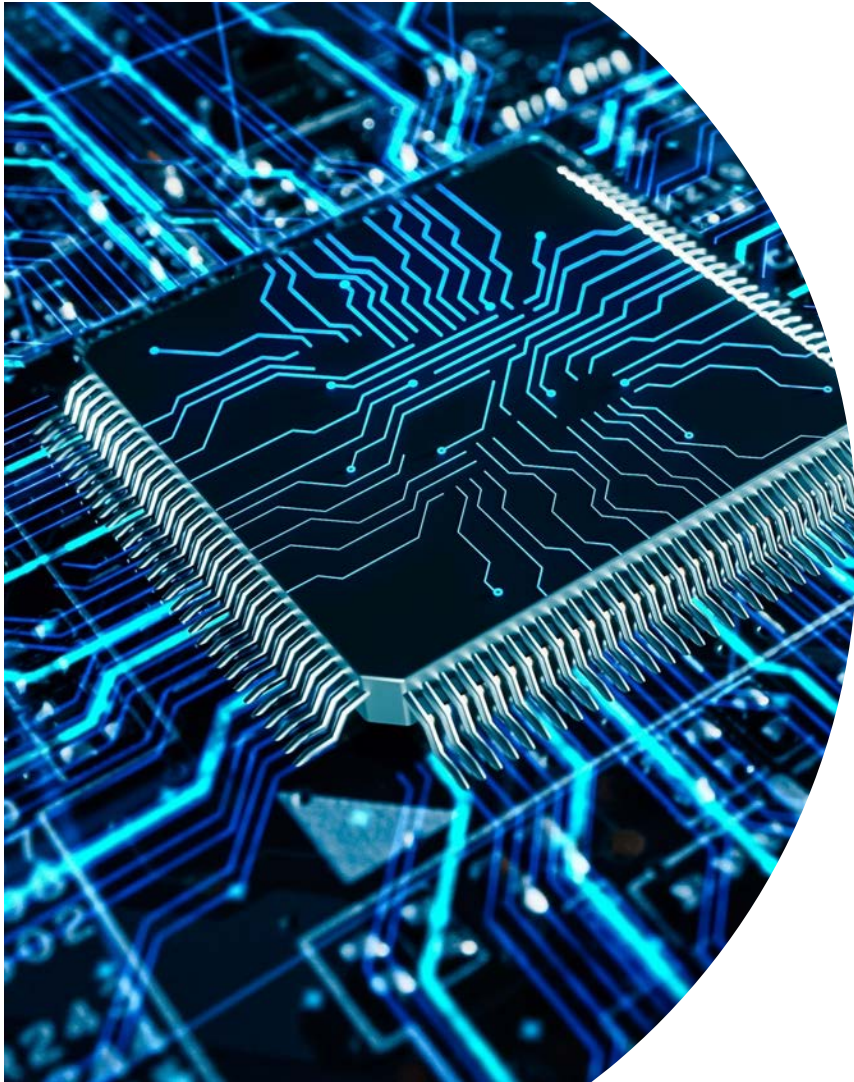


What can be done to drive satisfaction further?



Picou EM. MarkeTrak 10 (MT10) Survey Results Demonstrate High Satisfaction with and Benefits from Hearing Aids. Semin Hear. 2020 Feb;41(1):21-36. doi: 10.1055/s-0040-1701243. Epub 2020 Feb 10. PMID: 32047346; PMCID: PMC7010487.

The Bluetooth® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc. and any use of such marks by Sonova AG is under license.



We believe the next great leap in satisfaction will be provided by AI ●

Case study: Denoising

Sample 1 without AI denoising



Sample 1 **with** AI denoising



Sample 2 without AI denoising



Sample 2 **with** AI denoising



Powerful de-noising capabilities but requires the power of a smartphone

Tomorrow's hearing aid features that utilize AI

Machine learning

- Efficient algorithms
- Optimised over a long development time period
- Best suited for environmental classification



Deep Neural Networks

- Power intensive
- Superior potential for background noise removal
- Best suited for speech enhancement

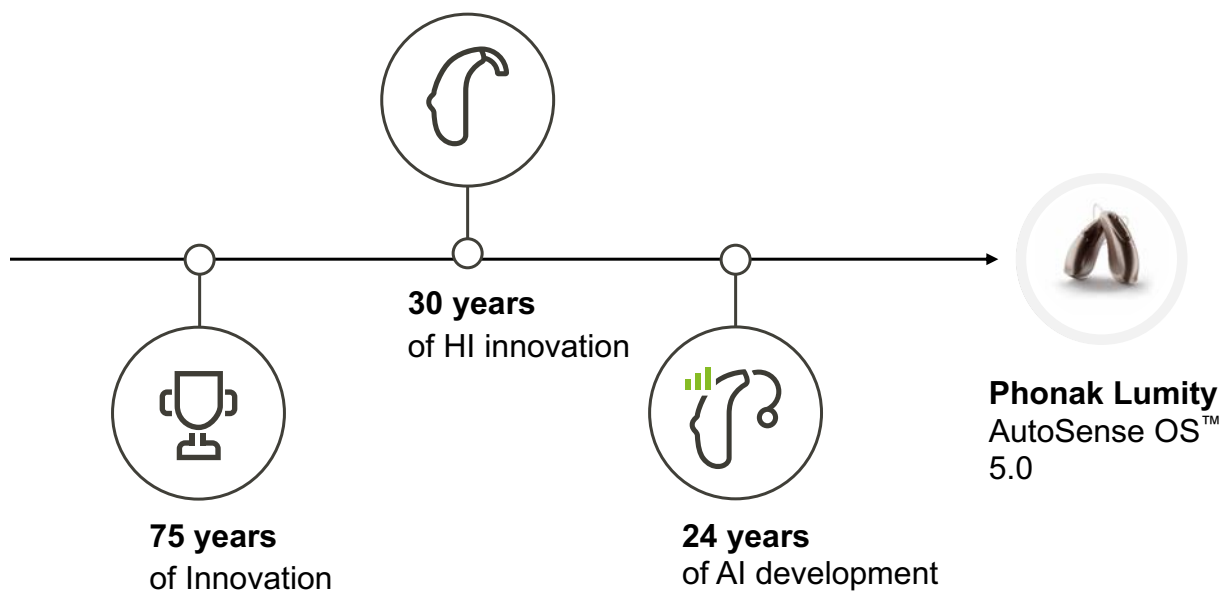
A hybrid AI approach to improve hearing aid performance

Next generation Artificial
Intelligence from the
hearing aids.

Next level Audiological
Intelligence from HCPs.



Your partner in innovation





Together,
we change lives .