



White Paper of the Industry Development and Technology Application of Acoustic Intelligence in China

Shuhai Information Technology Co., Ltd.

CAICT Cloud Computing & Big Data Research Institute

Key Laboratory of the Ministry of Industry and Information Technology of Artificial Intelligence Key Technology and Application Evaluation

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Preamble

Sound is one of the physical phenomena earliest studied by humans. Acoustics is a cross-level basic discipline, and has created a series of new and unique interdisciplinary directions such as infrasonics, medical acoustics, bioacoustics, marine acoustics, and environmental acoustics by intersecting with modern science and technology. With the mature application of new generation information technology such as artificial intelligence, big data and cloud computing, they are gradually cross-integrating with traditional acoustics, and acoustic intelligent technology has begun to show considerable commercial value and huge development potential.

In the White Paper, we conduct in-depth research on the concepts, industries, technologies, applications and prospects related to acoustic intelligence. The White Paper mainly consists of four parts: Part I Concept explains the concept of acoustics and acoustic intelligence; Part II Industry Development introduces the overall situation of the industry in China and key areas; Part III Technology Application mainly introduces the current development of acoustic intelligent technology and the practical cases of industrial application innovation; and Part IV Outlook introduces the development trend of the acoustic intelligence industry and puts forward relevant suggestions.

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Part I. Concept

(I) Concept of Acoustics

As a very common and intuitive phenomenon in nature, sound is an important source of human information, and can be divided into voice, music and general audio/ambient sound. Voice is the sound carrier of language. The voice signal belongs to the compound tone, and its basic elements are pitch, intensity, length, timbre, etc. Music is a complex art form created by humans, composed of a variety of musical sounds, including singing, compound sounds from various orchestral and plucked instruments, a small amount of compound sounds from ambient sounds, and some noisy music from percussion instruments. General audio or ambient sound refers to a huge number and variety of sounds in nature and daily life, such as the sound of wind, thunder and waves in nature, the noise of mechanical equipment, animal noises, the sound of human heartbeat, cough and pulse, the sound of gunshots, cannons, explosions in the military field and so on.

Acoustics refers to the science that studies the generation, propagation, reception and effect of sound waves, is one of the earliest sub-disciplines of physics studied in depth, and is closely related to the ear, one of the most important sensory organs of human beings. Theoretically, acoustics studies the production, propagation and reception of sound; In application, acoustics studies how to obtain pleasant effects, how to avoid noise that hinders health and affects work, how to improve the sound quality of acoustic instruments, and so on.

In a long historical stage before human beings invented writing and were able to impart culture, ideas, and knowledge through reading with their eyes, hearing assumed the historical responsibility of cultural inheritance. In the expression and communication of information such as thinking and intention, language (resorting to hearing) has many advantages over words (resorting to vision), and it is more natural, more instinctive, more casual and more immediacy. Therefore, the language is more convenient. In addition, the sound wave has long propagation distance and strong penetration. This is why in the animal world, sound is often

used as the main way of information exchange. Voice information accounts for 20% of the information processed by human cerebral cortex every day, and is the most important link of communication.

Modern acoustics has strong permeability. Acoustics intersects with many other disciplines (such as physics, chemistry, materials science, zoobiology, geoscience, environmentology, etc.), engineering technology (such as machinery, architecture, electronics, communications, etc.) and artistic fields, plays unique and important role in these areas, and has gradually derived independent acoustic branches, such as linguistic acoustics, physical acoustics, bioacoustics, hydroacoustics, atmospheric acoustics, geoacoustics, psychoacoustics, etc.

With the development of science and technology, people have found many characteristics and functions of sound waves. Among them, some sound waves have an impact on hearing, and some sound waves have no impact on hearing, but are important for scientific research and production technology, for example, using the sound propagation characteristics to study the microstructure of the medium, using sound to promote chemical reactions and so on. Therefore, in modern acoustics, the research and application servicing for hearing have been further developed on the one hand, and on the other hand, many research and applications related to computers, physics, chemistry, and engineering technology have also been carried out.

(II) Concept of Acoustic Intelligence

In view of the importance of sound in information transmission and communication, and with the development of computer and artificial intelligence technology, the researches on how to convert the input of sound information into graphics context and other forms of information would have great value for both acoustics and artificial intelligence.

Acoustic intelligence is a new technical science that combines the basic theory of acoustics and the theoretical methods of artificial intelligence to create a new theory, method, technology and application system. The research results of acoustic intelligence technology and application are very important for the application of acoustic technology in smart buildings, robots and other automatic control fields. The value of such results are reflected in the following three aspects:

First of all, basic research on human hearing provides a new methodology for the problems encountered by acoustic intelligence technology in practical application scenarios. Taking

Wu Shuoxian, The Role of Sound and Sense of Hearing in the Heritage of Human Culture [J]. Art Science and Technology, 2000(03): 6-8

the “cocktail party effect” as an example, people can recognize the voice of one of them at the chaotic cocktail party is because when people relatively focus their attention on a certain content of speech, and ignore or pay no attention to the existence of masking sound, the human ear’s ability to distinguish information in the noise is greatly improved. In recent years, the Attention Model has been gradually applied to the artificial intelligence field. The Model aims to select more critical information for the current task from a large amount of information by simulating the attention model of the human brain. From the world top conference papers such as ICASSP and InterSpeech, Attention-related algorithms have appeared in the research articles of speech recognition or speaker recognition for many times since 2019, which shows that the application of Attention in the semantic neural network of speech is more extensive.

Second, the theoretical basis and method of acoustic signal processing and analysis are an indispensable part of intelligent voice technology. Voice interaction contains a very complex core technology chain, including acoustic processing, speech recognition, speech synthesis and semantic understanding and other core technologies. Acoustic processing is mainly to simulate the human ear to ensure that the machine can hear the voice of people in the real environment. In addition, compared with other biometrics, sound has the advantages of two-way interaction, naturalness, not easy to imitate and low aggression, and gradually plays an important role in intelligent application scenarios. For example, in the implementation of the security system around video monitoring, it is found that the acoustic sensing non-visual technology is a good complement to the improvement of security system, of which, acoustic data plays an irreplaceable role in environmental monitoring, equipment operation monitoring and early warning, accordingly, a new concept of acoustic intelligence is formed.

Finally, artificial intelligence technology represented by machine learning and deep learning has been widely used in the acoustics field, and also applied in the sub-fields of acoustics such as human language speech, animal sound, underwater sound source localization and so on. For example, in audio processing, the combination of machine learning and acoustics solves the problem of sound source localization and voice enhancement of the speaker, and is widely used in mobile phones, automobiles, hearing aids and smart homes; In shallow and sloping marine environments, models may be trained for different sea depths to avoid overfitting and achieve more accurate real-time marine sound source localization; In the bioacoustics field, machine learning models are trained by extracting information such as psychoacoustic parameters and time-frequency characteristics corresponding to the characteristics of animal sound, so as to statistically classify the distribution of biology and ecology.

Part II. Industry Development

(I) Policy Planning of Acoustic Intelligence Industry in China

In order to achieve the goal of building an innovative country and a world science and technology power, China has taken artificial intelligence as a major strategic goal and issued a series of relevant policies in industrial support and ecological construction. In terms of acoustic intelligence, the relevant national and local policies have also repeatedly highlighted to promote the deep integration of the artificial intelligence and the real economy by taking the acoustics as the core technology, and to explore the new paths and methods for cross-border integration in combination with the characteristics of the industry and region.

At the national macro level, guide the core capabilities and the overall industrial construction of acoustic intelligence from the top-level design. In December 2017, the Ministry of Industry and Information Technology printed and distributed the *Three-Year Action Plan for Promoting the Development of a New Generation of Artificial Intelligence Industry (2018-2020)*, proposing to develop new intelligent sensors with broad market prospects based on biology, gas, pressure, flow, inertia, distance, image, and acoustics, focus on taking the lead in breaking through core technologies such as intelligent sensors, and achieve mass production of acoustic sensors with a signal-to-noise ratio of 70dB and an acoustic overload point of 135dB in 2020; In April 2021, the *Opinions of the CPC Central Committee and the State Council on Promoting High-quality Development in the Central Region in the New Era* were issued, proposing to plan as a whole and guide the development of industrial clusters (bases) in the central region, construct China (Wuhan) Optical Valley and China (Hefei) Sound Valley along the Yangtze River, as well as strengthen to make coordinated efforts to protect and restore the environment, strengthen the prevention, control, supervision and management of noise sources, and improve the compliance rate of acoustic environment functional zones.

As to local industrial planning, develop simultaneously the technological innovation and model innovation by taking the development of industrial clusters as the path. In July

2021, Anhui Province issued the *Several Policies for Supporting the Innovative Development of China Sound Valley* and the *Three-year Action Plan for the Innovative Development of China Sound Valley (2021-2023)*, proposing to give full play to the decisive role of the market in resource allocation, give better play to the role of the government, use the market logic, and leverage capital power to support China Sound Valley to accelerate innovation and development. In June 2021, the Office of the Leading Group for Promoting the Integrated Development of the Yangtze River Delta issued the “14th Five-year” *Plan for the Integrated Development Plan of the Yangtze River Delta*, proposing to accelerate the construction of the Suzhou Acoustic Innovation Valley, build a technology research center for “six major acoustic fields”, overcome and transform a number of industrial generic key technologies, and accelerate the industrialization of acoustic technology. In November 2020, Changshu, Jiangsu Province, issued a series of talent and industrial support policies for Suzhou·China Acoustic Innovation Valley to explore the collaborative development model of scientific and technological innovation and industry, actively strive to create a national acoustic technology innovation center, and focus on building a national first-class acoustic industry technology highland and industrial agglomeration area with global influence and competitiveness.

(II) Overall Scientific Research Level of Acoustic Intelligence in China

At present, the cultivation of talents in acoustic intelligence in China is mainly in colleges and universities, and the disciplines are mainly divided into basic research on acoustics disciplines such as acoustic signal processing and acoustic signal analysis, and informatization disciplines such as computer and artificial intelligence. **In terms of basic research on acoustics**, the Acoustic Society of China is the main representative, which is a first-level professional society under the China Association for Science and Technology, has more than 4,500 members[∠], most of whom are engaged in the interdisciplinary study of information, electronics, machinery, oceans, life, energy and other acoustic fields. Universities and institutions involved include the Institute of Acoustics, Chinese Academy of Sciences, the Institute of Acoustics of Nanjing University, the Institute of Acoustics of Tongji University, the Institute of Applied Acoustics of Shaanxi Normal University, the School of Marine Science and Technology, NPU and the College of Underwater Acoustic Engineering, Harbin Engineering University. **In terms of artificial intelligence technology**, in April 2018, the Ministry of Education studied and formulated the *Action Plan for Colleges and Universities to Lead Artificial Intelligence*

[∠] Cheng Jianchun, LI Xiaodong, Yang Jun. Current Situation & Future Development Trend of Acoustics [M]. Science Press, 2021.

Innovation and studied to establish the artificial intelligence major. According to statistics, a total of 345 ordinary colleges and universities in China have successfully applied for “artificial intelligence” undergraduate major so far. Among them, some colleges and universities have set up branches around acoustic intelligence, such as the Auditory Intelligence Research Center of the Institute for Artificial Intelligence established by Tsinghua University in 2019, which is based on the core technology to reveal the perception and cognitive mechanism of human hearing, establish the computational theory and method for auditory intelligence, and propose the technology and algorithm for understanding the computer perception and sound.

In recent years, on the basis of the above-mentioned academic and industrial resource conditions, China has made important progress in the field of acoustic intelligence and achieved important breakthroughs in the branches of acoustic intelligence. Among them, the development of acoustic intelligent technologies such as speech recognition and natural language processing has been relatively mature and is in a leading position in the world. However, the development of the underlying technology of acoustic intelligence in China is still relatively weak, and some core technologies still need to be broken through. For example, China’s acoustic smart chips, acoustic intelligent sensors and other relevant technologies are still in the early stages, and there is still a long period of time to the maturity of the technology, which requires a long and continuous investment in technology research and development.

The development of the new-generation information technology industry and the trend changes in the domestic market will drive the accelerated development of the acoustic intelligence industry chain, resulting in a large number of needs for talent of acoustic intelligence related majors.

It is urgent to cultivate talents who have a solid and systematic foundation of applied acoustics and information science, master the corresponding electronic technology, computer technology and acoustic measurement technology, and can meet the needs of high-tech development and market.

(III) Market Prospect of Acoustic Intelligence Industry in China

Acoustic intelligence industry chain involves basic acoustic hardware equipment, acoustic intelligent technology services and scenario-based application solutions. From the market research of some industrial chain links, with benefits from the growth of intelligent demand, acoustics is rapidly integrating with environmental, medical and other industries in the real economy, and helping industrial transformation and upgrading, quality and efficiency

improvement through intelligent technology.

Acoustic hardware equipment is an indispensable part of the functional configuration of acoustic intelligent information equipment. According to the *Feasibility Study Report on China Acoustic Device Market 2021-2025* released by the Newsijie Research Center, in recent years, with benefits from the development of smart wearable devices, smart speakers, smart homes and other smart product markets, the market size of acoustic device has shown significant growth, and it is expected that from 2021 to 2025, China's acoustic device market will continue to grow at a compound annual growth rate of 15.6%, and will be up to RMB 46 billion in 2025. With the progress of science and technology in China, China's acoustic device enterprises have gradually moved from medium and low-end fields to medium and high-end fields, and the acoustic device industry shows a high-end and diversified development trend.

Intelligent voice is the main entrance of human-computer interaction, by which the sound is converted into text for machine processing. The empowerment of speech acoustics for speech recognition, speech synthesis and other technologies has driven the rapid development of acoustic intelligence industry. According to the statistics of the Prospective Industry Research Institute, the scale of China's intelligent voice market in 2019 was RMB 12.17 billion. With the continuous maturity of artificial intelligence technology and application iteration, China's intelligent voice market will maintain a growth rate of more than 25% in the future, and it is expected that the market scale might be up to RMB 28.5 billion in 2021, with a year-on-year growth rate of 44%. Meanwhile, there is a talent gap of 300,000 in China's artificial intelligence industry⁴, and intelligent voice related talents are scarce.

It can be seen that the emergence of advanced artificial intelligence technology and innovative products has driven the development of emerging markets, and has also spawned a large number of innovation and entrepreneurship opportunities in the acoustic industry chain, and there will be huge development space and opportunities in the next 5-10 years.

(IV) Regional Distribution of Acoustic Intelligence Industry in China

Acoustic intelligence is gradually realizing industrialization in China. At present, it is mainly distributed in the Yangtze River Delta, with Anhui and Jiangsu Provinces as the main representatives.

⁴ 2020-2021 White Paper on Development of China's Voice Industry [R/OL] China Voice Industry Alliance. 2021

China (Hefei) Intelligent Voice and Artificial Intelligence Industry Base (“China Sound Valley”) is a key ministerial and provincial cooperation project jointly built by the Ministry of Industry and Information Technology and the People’s Government of Anhui Province. In 2012, the Ministry of Industry and Information Technology and the Anhui Provincial Government signed the *Memorandum of Cooperation on Jointly Promoting the Development of the Voice Industry in Anhui Province*, which determined to build the “China Sound Valley” into a demonstration zone for the development of the voice industry in China, and promote the research and development of voice technology, the promotion and application of voice technology and the construction of voice industry parks. In order to increase the intensity of investment promotion, accelerate the process of industrial development, and promote the growth of industrial scale, the State, Anhui Province and Hefei City have allotted special supporting funds to support industrial development, and at the same time formulated a set of industrial policies, innovated and set up two major policy service systems of “financial innovation and market promotion”, and gave all-round support to the park environment, park facilities, and the settlement of family members of talents of the enterprises in the park. The park focuses on building the world’s leading intelligent interaction technology industrial base such as speech recognition and biometrics. By the end of 2020, 1,024 enterprises had settled in the park, with a turnover of RMB 106 billion[∠].

Jiangsu Province has cooperated with the Institute of Acoustics, Chinese Academy of Sciences, Nanjing University and other colleges and universities to promote the integration of acoustic intelligence industry. In 2017, the “Suzhou Industrialization Base of the Institute of Acoustics, Chinese Academy of Sciences” was officially established. The base is jointly built by the Institute of Acoustics, Chinese Academy of Sciences and the Suzhou High-tech Zone, aiming to establish an open public innovation service institution with the support of the government, combining production, study and research, and facing the market. The base focuses on technology research and development, platform construction, project incubation, project investment, achievement transformation and industrialization in the electroacoustic related fields of the Institute of Acoustics. In September 2020, Changshu City and Nanjing University signed the Strategic Cooperation Framework Agreement for “Suzhou · China Acoustic Innovation Valley”, which aims to build a national first-class acoustic industry technology highland and industrial agglomeration area with global influence and competitiveness, and is mainly committed to industrial incubation of 5G information acoustics, material acoustics, medical acoustics, marine acoustics and other fields.

∠ China Sound Valley Development Release [R] Anhui Provincial Department of Economy and Information Technology. 2021

Part III. Technology Application

The application architecture of acoustic intelligent technology consists of three layers, terminal layer, technology layer and application layer. The terminal layer is mainly responsible for the collection and operation of data, including sound acquisition chips and sensors. The technology layer is mainly responsible for data mining, learning and intelligent processing, and is the core of acoustic intelligent technology, including language acoustics, environmental acoustics, voiceprint feature recognition and so on. The application layer is mainly for realizing the

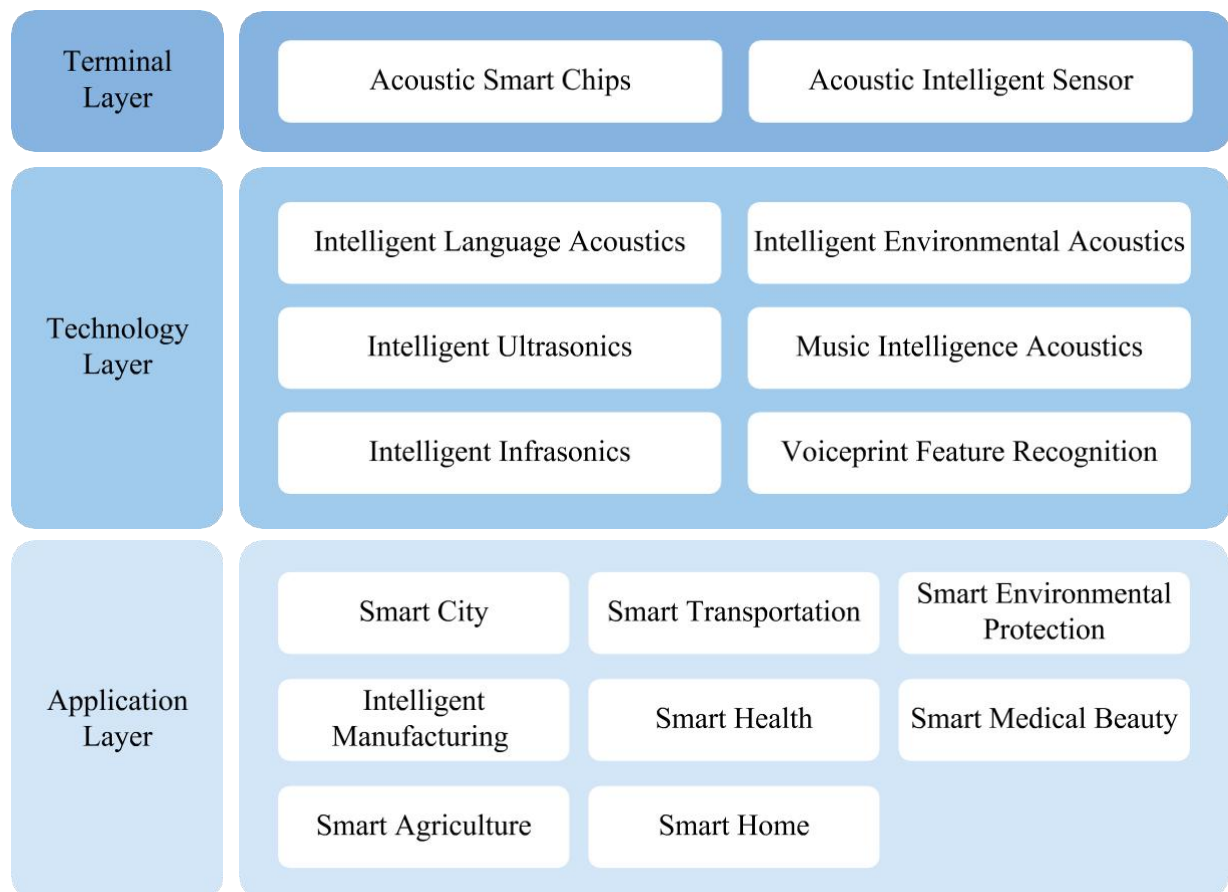


Fig. 1 Acoustic Intelligence Technology Application Architecture Diagram

integration and development of technology and industry and scenarios, and the application fields mainly include smart city, smart transportation, smart environmental protection, intelligent manufacturing, smart health, smart medical cosmetology, smart agriculture and smart home.

(I) Terminal Layer

1. Acoustic Smart Chips

Acoustic smart chips refer to chips that are with special acceleration design for the artificial intelligence algorithms and used in acoustic field. At present, smart chips are mainly intelligent voice chips. In the voice interaction device, voice chip is becoming more and more important relying on the advantages such as customization, low power consumption, high energy efficiency, terminal intelligence, cost advantage and so on. In the terminal, the voice chip is to process the multi-channel sound picked up by the intelligent voice device and transmit it to the cloud, and output the feedback result in the form of voice.

At present, intelligent voice chip has the following characteristics: (i) both computing power and low power consumption, adopting the CPU (central processing unit) that is most suitable for speech processing; (ii) highly integrated speech SoC, which has the microphone array interfaces supporting multi-channel, integrated Codec (Multimedia Digital Signal Codec) module/DSP (Digital Signal Processing) modules, and integrated WiFi/Bluetooth modules; (iii) the intelligent voice chip supports echo cancellation, noise suppression, sound source localization, speech enhancement and other technologies on the speech algorithm, or has good sound value adjustment function and; (iv) On-Device Machine Learning, the integrated neural network unit may use part trained model in the cloud to achieve local deployment and work.

In recent years, the state has attached great importance to the chip industry, and the development of intelligent chips has shown a booming trend in China. At present, the intelligent voice chip industry is dominated by traditional chip manufacturers, such as MediaTek, Texas Instruments, Conexant, Allwinner Technology, Hangzhou NationalChip, Amlogic Technology, Chengdu Chipintelli and other chip manufacturers, who have launched related voice chips, as well as artificial intelligence enterprises that provide speech processing algorithms and speech recognition engine services, such as Aispeech, Unisound, Mobvoi, etc. With the explosion of intelligent portable terminals, intelligent voiceprint terminals, and vehicle voice applications, there will be more acoustic intelligent chip enterprises.

2. Acoustic Intelligent Sensor

Acoustic intelligent sensor refers to the sensor with acoustic information processing function which has the ability to collect, process and exchange information, and is the combination of sensor integration and microprocessor products. The acoustic intelligent sensor belongs to the nerve endings of artificial intelligence, which is able to fully perceive the external environment. Compared with ordinary acoustic sensors, the acoustic intelligent sensor has the ability of information storage and transmission, self-compensation and calculation, self-test, self-correction, self-diagnosis, composite sensitivity and flexible communication, and also has the advantages of high precision, low cost, reliability and multifunction. Because the acoustic intelligent sensor is more flexible and efficient in operation and application, it is widely used in all walks of life.

At present, the microphone array is the main technical direction, which is composed of a certain number of acoustic sensors (generally microphones) with spatial configuration to sample and process the spatial characteristics of sound field. For ambient noise, the microphone array can enhance the speech through adaptive beamforming to extract pure speech from noisy voice signal; in case the speaker's speaking position is uncertain, the microphone array may calculate the spatial position of target speaker by sound source localization technology, track the speaker and realize the directional pickup of subsequent speech; for the voice phoneme overlapping and low recognition rate caused by indoor sound reflection, the microphone array can reduce reverberation and improve recognition rate through dereverberation technology.

(II) Technology Layer

1. Intelligent Language Acoustics

Language acoustics is a science that uses acoustic methods to study the generation, transmission, perception and processing of sounds related to human hearing and language, covers the signal detection, auditory processing, auditory perception, spatial auditory perception and speech perception, and is divided into the generation, analysis and perception of human language and the perception, recognition, synthesis and understanding of computer speech.

In recent years, with the rapid development of technologies such as big data, cloud computing, artificial intelligence and digital signal processing, the speech analysis, processing and application technologies related to language acoustics have also continued to advance, and have gradually become mature and been applied commercially. Typical technologies including

speech recognition, speech synthesis, and speech wake-up. **Speech recognition** is to convert the content in human speech into computer-readable input (usually text). A complete statistics-based speech recognition system is roughly divided into three parts: voice signal preprocessing and feature extraction, acoustic model and pattern matching and language model and language processing. **Speech synthesis** involves many disciplines and technologies such as acoustics, linguistics, digital signal processing and computer science. The main problem to be solved is how to convert text information into audible sound information, that is, let the machine speak like a human. **Voice wake-up** means that after certain wake-up word(s) has been specified, the terminal speech recognition function can switch to working state only after the user of such terminal device says the wake-up word(s) if the device has been turned on, automatically loaded resources and is in sleep state. Voice wake-up is used in a wide range of fields. Almost all terminals with voice interaction function need voice wake-up as the entrance of human-computer interaction, such as smart phones, smart homes and wearable devices.

2. Intelligent Environmental Acoustics

Environmental sound refers to the audible sound or audio sound existing in the human-centered environment. Environmental acoustics mainly studies the generation, propagation and reception of environmental sound, its physiological and psychological effects on human body, and the technical and management measures to improve and control the quality of acoustic environment.

At present, China is basically synchronized with developed countries in environmental acoustic measurement, evaluation and noise control technology, acoustic environmental standards, regulations and policies. In the field of noise control, China has involved in noise effect, noise evaluation, noise measurement, noise generation, noise propagation, noise control methods and noise control engineering. Especially in several aspects of noise control engineering, China has done very well, such as the R&D and application of microphone array, noise map and array muffler.

In recent years, deep learning methods have achieved rapid development. The intelligent noise reduction model formed by the combination of traditional signal processing and neural network algorithm has the advantages of strong computing power, small memory occupation, high robustness, adaptive support environment and high fidelity of human voice. It can effectively improve the noise reduction effect and ensure the fidelity of human voice at the same time. In the actual application scenario, the intelligent noise monitoring platform can analyze the collected sound raw data in real time, remotely monitor the status of the noise pollution source and track and monitor relevant environmental protection parameters. According to the data

returned remotely, the staff can also monitor the onsite noise environment without going to the site, and take corresponding measures to deal with noise anomalies in a timely manner.

3. Intelligent Ultrasonics

Ultrasonics is a branch of acoustics that studies various methods and technologies of generating and receiving ultrasound, the propagation characteristics of ultrasound, the interaction between ultrasound and matter, and various applications of ultrasound in the field of scientific research and production. At present, ultrasonics mainly involves two research directions: biomedical ultrasound and industrial ultrasound. Biomedical ultrasound mainly focuses on the application of ultrasound in medicine and bioengineering, including ultrasonic diagnosis, ultrasonic treatment, ultrasonic biological effect and ultrasonic processing. In recent years, the combination of biomedical ultrasound and artificial intelligence is one of the hotspots in the digital medical industry, and has made great progress in ultrasonic lesion diagnosis and differential diagnosis, disease prediction, correlation between macro image and micro pathology, treatment decision-making and so on. In 2019, initiated and convened by Shanghai Ruijin Hospital, more than 400 hospitals and nearly 1,000 ultrasound doctors in China established the “Chinese Artificial Intelligence Alliance for Thyroid and Breast Ultrasound”^①. The Alliance has established a thyroid and breast ultrasound database covering national multi-level medical institutions, and built a deep learning model based on large data ultrasound artificial intelligence research, which can realize accurate ultrasonic intelligent recognition to provide help for accurate diagnosis and treatment. In 2020, “Medica_AI”, a company in Zhongguancun Science City, developed the first AI detection system in China for assisting doctors in breast ultrasound, which realizes millisecond accurate grasping and identification of lesions, and effectively avoids missed detection caused by doctors’ visual fatigue and limited experience. In September 2021, at the 14th Congress of the Asian Federation of Societies for Ultrasound in Medicine and Biology (AFSUMB 2021) and the 21st Annual Meeting of Chinese Society of Ultrasound in Medicine (CSUM), the Ultrasound AI Industry-University-Research Alliance was officially established, and the Alliance will jointly formulate data standards for Chinese ultrasound artificial intelligence and jointly promote China’s intelligent medical equipment to the forefront of the world.

Industrial ultrasound involves the use of ultrasonic technology to quickly and accurately detect and diagnose a variety of defects in the workpiece, to carry out ultrasonic dirt layer dispersion cleaning, ultrasonic removal processing, surface finishing processing, welding processing and

^① Ultrasound Department Has Become a member of Chinese Artificial Intelligence Alliance for Thyroid and Breast Ultrasound [OL] Tianjin Medical University General Hospital. 2019

other special processing technologies. At present, the intelligent industrial testing equipment developed by combining artificial intelligence and industrial ultrasonic technology can realize the high-precision automatic detection of defects in various directions and different positions in the products without manual intervention, and ensure the 100% detection of product quality defects. In 2017, the scientific and technological innovation achievement “Key Technology of Industrial Intelligent Ultrasonic Testing Theory and Application” jointly completed by China General Nuclear Power Corporation and the entities including Southeast University, Wuhan University and Guangdong Power Grid Electric Power Research Institute won the second prize of the State Scientific and Technological Progress Award. This subject established a sound field analysis theory and method system for intelligent testing, independently developed 23 series and more than 80 sets of ultrasonic testing devices and realized engineering application. In 2020, the Key Laboratory of Noise and Vibration of the Institute of Acoustics, Chinese Academy of Sciences and Tsinghua University jointly provided a feasible solution for remote sensing and multi leakage point positioning of underground pipeline leakage by combining intelligent image fusion technology with acoustic method according to the frequency dispersion and radiation characteristics of urban water supply pipeline leakage acoustic signal. The relevant research results were published in the international journal *Sensors*.

4. Music Intelligence Acoustics

Music acoustics refers to the study of various physical phenomena related to the sound used in music. Because music depends on the physical phenomenon of mechanical wave, the cognition and understanding of the nature of sound, its characteristics on all sides and the causes and consequences of mechanical wave will affect the technology, technique and artistic level of human beings using material materials and means for creating music, and also affect the correctness and profundity of human cognition of the physiological and psychological feelings and reactions of their auditory organs to sound and music.

In recent years, music artificial intelligence is gradually rising, which is a typical interdisciplinary field. It takes digital music as the research object, including song generation, automatic music arrangement, and music information retrieval and so on. Song synthesis is based on speech synthesis, but it needs to consider a variety of music elements such as music melody, rhythm, strength, timbre, structure, emotion, artistic skills and so on. Automatic music arrangement is, by virtue of deep learning, to arrange chords and various parts on the basis of known main melody, including drum, bass, guitar, keyboard, string music, etc., so as to make it a complete work. Content-based music information retrieval has been practically applied to the field of entertainment including listening to recognize, humming/singing retrieval, cover

retrieval, music style classification, music recommendation, etc. to the field of music education and scientific research including computational musicology, solfeggio and music theory assisted teaching, vocal music and various musical instruments assisted teaching, digital audio/music library, etc., and to daily life, psychology, medical treatment, intellectual property and other fields.

5. Intelligent Infrasonics

Infrasonics is a technology to study the generation, propagation, reception, effect and application of infrasound waves in media. The characteristics and laws of natural phenomena can be further understood by studying the characteristics and generation mechanism of infrasound waves produced by these phenomena. The location, size and other characteristics of the sound source measured may be detected through the received infrasound wave radiated by it. For example, we can detect the relevant parameters of infrasound sources by receiving the infrasound wave produced by earthquake, debris flow, landslide, mine collapse, nuclear explosion, rocket fired artillery or typhoon; people study the law of aurora activity by measuring the characteristics of infrasound waves produced by aurora.

The combination of infrasound technology and artificial intelligence technology may be practically applied to geological exploration, analysis and monitoring and other scenarios. In March 2021, the team of Zhang Jie, a professor of University of Science and Technology of China cooperated with China Seismological Bureau to launch the world's first artificial intelligent earthquake monitoring system. The system, based on millions of earthquake data collected in the database, can quickly process the ongoing earthquake data through data comparison, collection and intelligent analysis. The system can not only infer the fracture direction and speed of the fault, but also help to predict the possible distribution of tsunamis and strong aftershocks.

6. Voiceprint Feature Recognition

Voiceprint feature recognition technology, also known as voiceprint recognition, refers to extracting corresponding features or establishing corresponding models by analyzing and processing the collected voice signals. Because each person's biometrics are unique and different from others, and remain stable in a certain period of time, and are not easy to forge and fake, the extracted voice features may be put into the model for training to finally look for the target with the highest or closest score. The result is safe, reliable and accurate. In recent years, voiceprint recognition is rapidly developing towards deep learning and end-to-end. One of the most typical is the sentence-based practice, but there is still a lot of work to be done in

network structure design, data enhancement, loss function design, etc., and there is still much room for improvement. [∠]

Voiceprint recognition is widely used in important national fields such as public security anti-terrorism, financial payment, social security certification, security inspection and customs clearance. In some application scenarios with high security requirements, two or more biometric technologies are often used for verification. The Ministry of Public Security has focused on the construction of voiceprint library. In November 2018, the People's Bank of China officially released the financial industry standard, *Technical Specification for Biometric Based Security Application for Mobile Finance*, which means that biometric technology has been recognized by financial regulators, also solves the standard problem for biometric technology to enter the field of mobile finance.

(III) Application Layer

1. Smart City

The use of abnormal sound and key words in intelligent voice technology for monitoring and directional sound wave dispersion technology can not only automatically alarm in case of emergency, but also warn the personnel in the alarm area to leave, so as to achieve the effect of instantaneous expulsion. In addition, it can avoid the excessive behavior of individual relevant personnel due to emotional fluctuation, resulting in other undue losses. By applying the biometric technology to related products and solutions, which can recognize a speaker's identity through voice, the user acceptance should be higher and the acquisition cost should be lower. Biometric technology can also realize remote identity recognition, and the application of which in public security technical investigation, judicial correction, smart home, social insurance and financial industries has accelerated. The acoustic intelligent technology can be used to detect and accurately locate the leakage of urban pipe network, so as to improve the maintenance efficiency and reduce the cost.

At present, sound monitoring, early warning and expulsion technology has been applied in the field of urban security, but it has not been popularized on a large scale. With the basic completion of the construction of "Tianyan" and "Xueliang" projects in China, video monitors have been basically deployed, and audio monitors will be the next focus. Biometric technology has been extended to various fields of people's daily life, such as criminal investigation and criminal tracking in public

[∠] Auditory Intelligence Research Center of the Institute for Artificial Intelligence, Tsinghua University, White Book on Development of Voiceprint Recognition Industry in China (2019). 2019

security and justice, platform identity authentication and voice location service in e-commerce, computer room door ban and identity security authentication in other important places, supervision and management of pension payment, and voiceprint lock control systems such as voice password lock for various accounts and car voice control lock. Biometric technology meets the security requirements of remote identity authentication, online transaction, payment and other financial services, and has been widely used in financial fields, including securities transaction, bank transaction and credit card identification. The acoustic leak detection technology for urban water supply and gas pipe network is also in the exploration period and on the eve of the booming period. In May 2021, Shanghai Municipal Engineering Design Institute (Group) Co., Ltd., and Tongji University, together with relevant units, had prepared and completed the *Technical Standards for Acoustic Leak Detection and Evaluation of Urban Water Supply and Gas Pipe Network*, and issued the Standards to solicit opinions from the whole society.

In non-visual scenes, abnormal dangerous situations can be early perceived and identified through the collection, identification, calculation, analysis, scene restoration, monitoring and

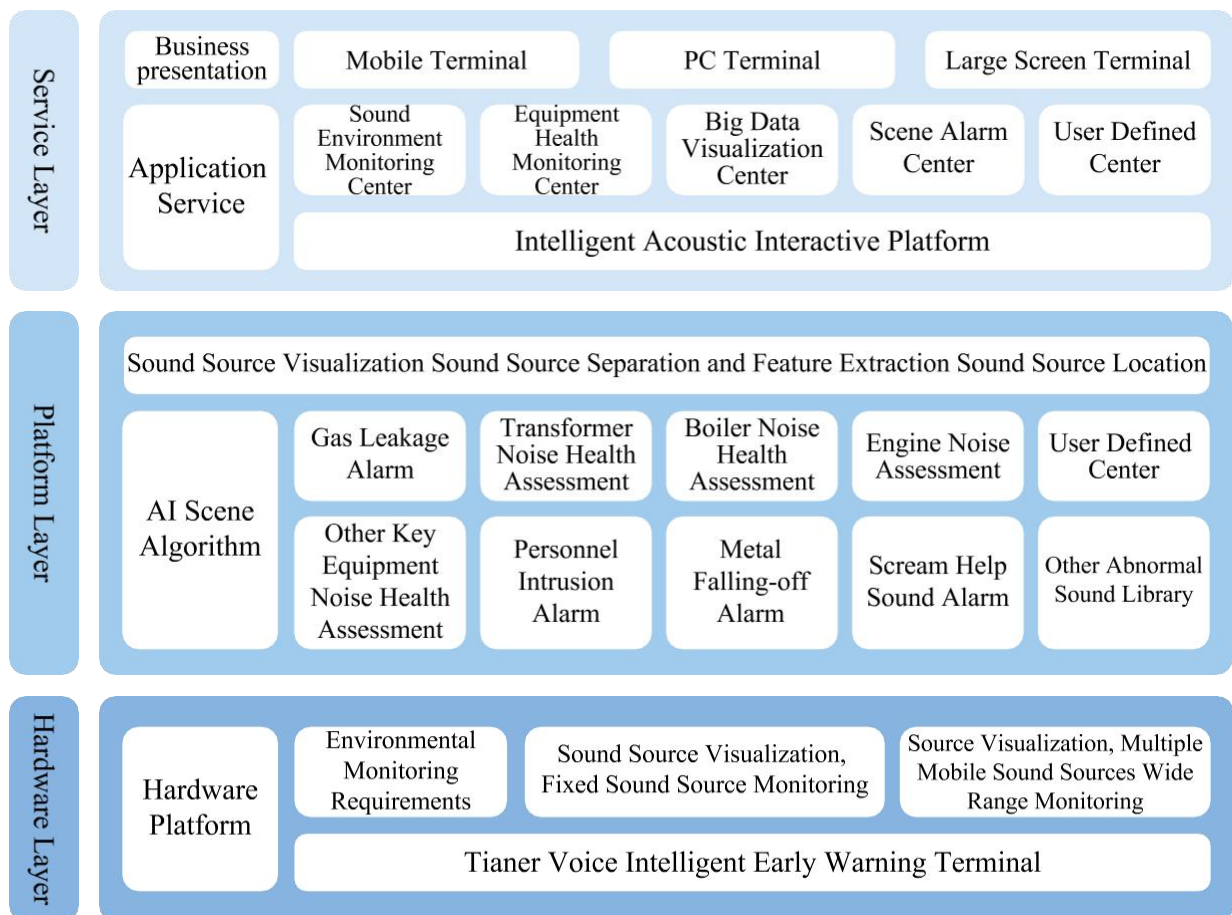


Fig. 2 Architecture of Shuhai Tianer System

early warning analysis of sound data, so early warning and intervention or deterrence effects can be taken to reduce the incidence of dangerous situations. Shuhai Tianer Early Warning System has the characteristics of strong anti-noise ability, wide recognition range, continuous improvement of accuracy and customizable services. It has been well used in public places such as campus, nursing home, family, hotel and KTV with high privacy protection requirements but dangerous situations.

2. Smart Transportation

Faced with increasingly complex traffic environment, the scientific management of new technologies such as “Acoustic +”, “Internet +” and “Artificial Intelligence +” will greatly reduce the cost of traffic management and greatly improve the efficiency of work. Acoustic intelligent technology provides comprehensive applications and solutions in a series of scenarios such as noise control, intelligent voice warning, emergency broadcasting, etc., empowering intelligent transformation and upgrading of transportation.

The directional voice early warning system uses the directional sound technology to support the perception and timely early warning in case of emergencies, deliver voice information, broadcasting and other contents to the current region and target population in a directional and accurate manner. Through early warning, the efficiency of road traffic and driving safety would be ensured, and the occurrence of safety accidents may be reduced, so as to improve the level of highway safety monitoring and emergency handling, and enhance the preventive, timely and efficient nature of traffic management.

The honking capture system, by using the sound source positioning and acoustic imaging technology, may carry out real-time detection, high-precision positioning, automatic investigation and handling of honking vehicles in a specific area, and completely reproduce the whole process of motor vehicle honking to make the car honking “visible”, so as to provide scientific means for traffic police to control disorderly honking behavior, help cultivate drivers’ good driving habits, alleviate traffic noise and contribute to the construction of a civilized city. The industry solution of the honking capture system provided by Audfly aims to realize the diversification and efficiency of road traffic law enforcement with acoustic high-tech. Combined with the existing monitoring systems of the traffic police for rule-breaking, and integrating the high-tech means of the honking capture system, such solution provides an authoritative scientific basis for the control of illegal honking, and assists the traffic police to quickly and efficiently enforce the law.

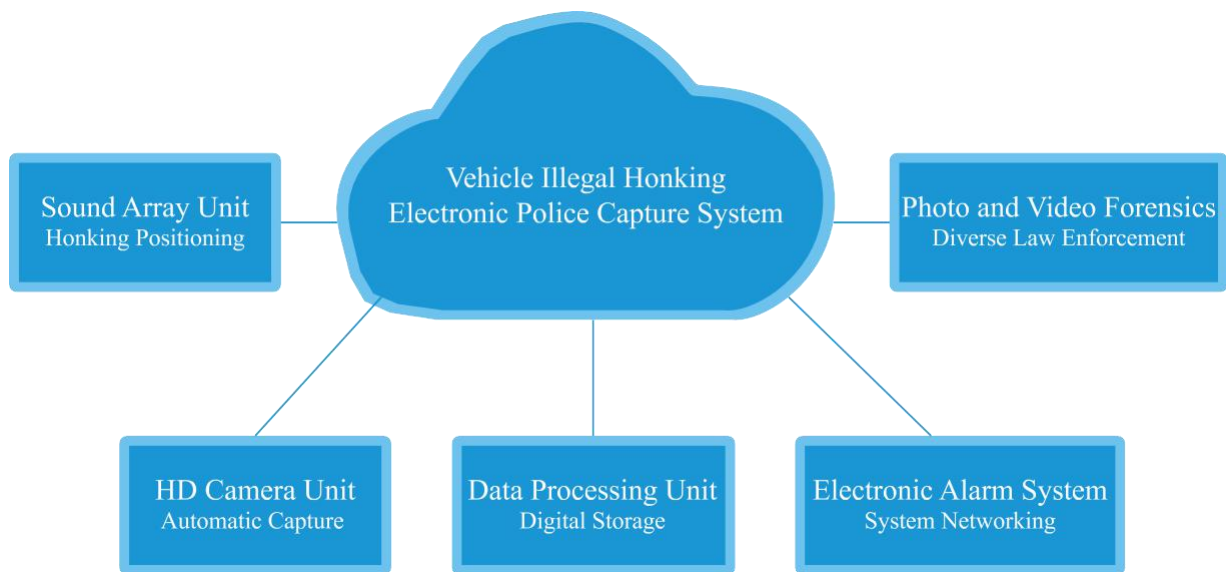


Fig. 3 Honking Capture System

3. Smart Environmental Protection

With the development of 5G, artificial intelligence, big data and other technologies and the continuous development of new infrastructure, acoustic intelligent technology is playing an important role in the subdivision field of acoustic environmental protection. The smart environmental protection noise map adopts the continuous automatic analysis method. The monitoring results of the noise map can reflect the continuous dynamic change of noise monitoring, have strong timeliness, are conducive to timely understanding of the noise situation and discovery of pollution accidents, provide accurate and timely data for environmental management and provide the municipal planning and environmental assessment workers with an efficient environment for urban noise prediction and planning. The directional sounding based on sound directional communication technology has very broad application prospects in environmental protection in transportation, community and other fields. It not only brings innovative application experience and value, but also brings sound environmental protection and noise pollution prevention and control management into people's daily life, so as to change people's life in modern society.

As there are more and more negative effects of noise in social life, to eliminate and control noise has become one of the problems that must be solved in the development of all walks of life. According to the *2017 China Environmental Noise Prevention and Control Annual Report* released by the Ministry of Environmental Protection, the nighttime noise compliance rate of 31 municipalities directly under the central government and provincial capital cities is only 59.7%. At present, the noise mapping technology has been relatively mature, and relevant

information release systems have been established in Beijing, Shanghai, Shenzhen, Hangzhou, Suzhou, Shanghai and other cities, successfully bringing some good social and environmental benefits. The application of directional acoustic technology in the field of environmental protection has been relatively mature in the United States, Britain, France and other developed countries. Although China started late, it has also made great progress with the enhancement of domestic people's awareness of environmental protection in recent years.

Combined with acoustics, artificial intelligence, big data and other technologies, the noise map may complete the integration of GIS data and professional software, and establish a regional noise map query and release information system. The system can easily manage various basic spatial data resources, organize data analysis models for urban map needs (including basic analysis algorithm library and special algorithm library), and realize any GIS task from simple to complex, such as sound source acquisition and management, map management, urban noise analysis, noise distribution map, noise sensitivity partitioning, visual modeling, cartographic layout and so on.

The urban noise map information system would improve the efficiency of data query, analysis, editing and retrieval based on the joint analysis and processing of spatial data and attribute data. The system adopts COM-based component software development methods. In business, the system is divided into several functional modules such as data acquisition and quality control, data editing management, query statistics, spatial analysis, data product services, visual modeling and thematic mapping, and database management; in the implementation of the internal functions, the system is divided into relatively independent functional components

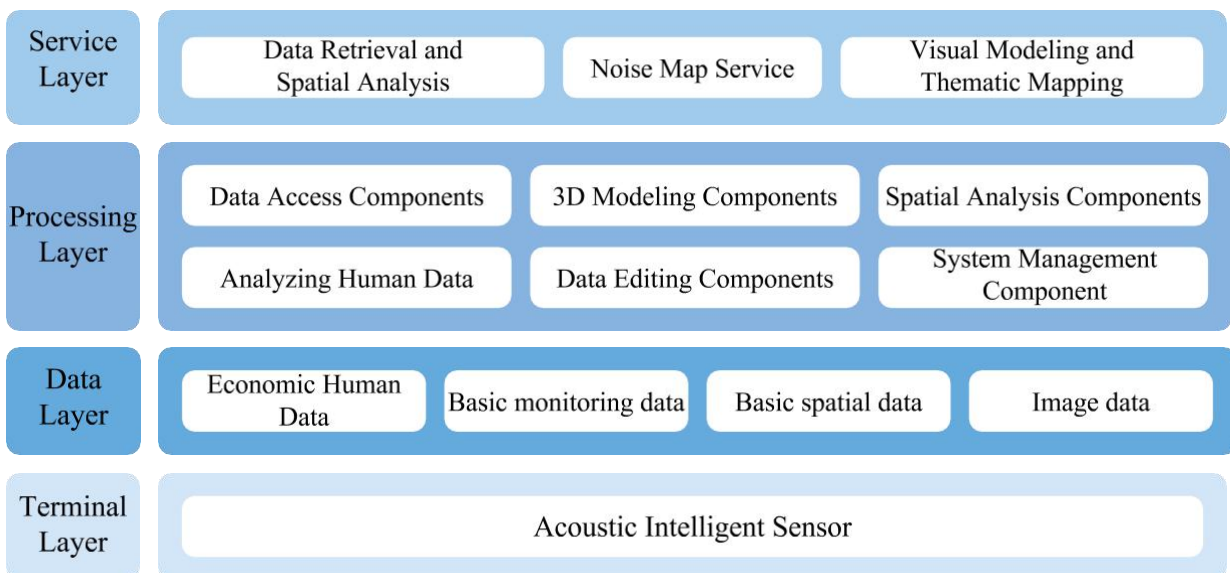


Fig. 4 Architecture of Urban Noise Map Information System

which would communicate with each other based on the interface. In the composition of the software system, the system adopts a three-tier structure, namely the data layer, the GIS processing layer and the service layer, which are respectively responsible for data management access, GIS business processing and user interaction, so as to improve the flexibility and maintainability of the system.

4. Intelligent Manufacturing

The application of acoustic intelligent technology in intelligent manufacturing mainly includes detection, monitoring, cleaning and so on. Ultrasonic test equipment can be widely used for the detection, positioning, evaluation and diagnosis related to industrial components. Ultrasonic monitoring equipment can be widely used for the abnormal detection of locomotives, motors and other equipment. Ultrasonic cleaning equipment can be widely used for the cleaning of industrial equipment. In addition, ultrasonic technology may also be used for crushing, filtration, dispersion, detection and other aspects, and has a wide range of application prospects in the packaging industry.

In recent years, ultrasonic technology will go through a higher level of development and be widely used. With the development of artificial intelligence, big data and ultrasonic technology, the ultrasonic technology will be more deeply and frequently used in the industrial field, and almost penetrate into most industrial sectors, including traditional industries such as iron and steel industry, machine manufacturing industry, construction industry, petrochemical industry, railway transportation industry, shipbuilding industry and aerospace industry, integrated circuit industry, nuclear power industry and other important sectors. In some cases, such as in-service testing of large oil tanks, ultrasonic technology has become the only viable means of testing.

The acoustic solution for fault detection of industrial equipment is to use the vibration acoustic linkage diagnosis system to extract the noise characteristics in mechanical motion and complete the real-time monitoring of the working state of industrial equipment; the supporting vibration analyzer would further analyze the fault source located by the acoustic detection to provide an accurate diagnostic result; the data module memory would store fault data to establish the diagnosis database. Integrating the deep learning method of artificial intelligence, the existing system can be applied to the diagnosis of unknown working environment. The platform provides accurate, predictive and real-time acoustic fault diagnosis and predictive maintenance services for key industrial application facilities and equipment. At present, there are specific project implementation cases in many scenarios such as power grids and rail transit.

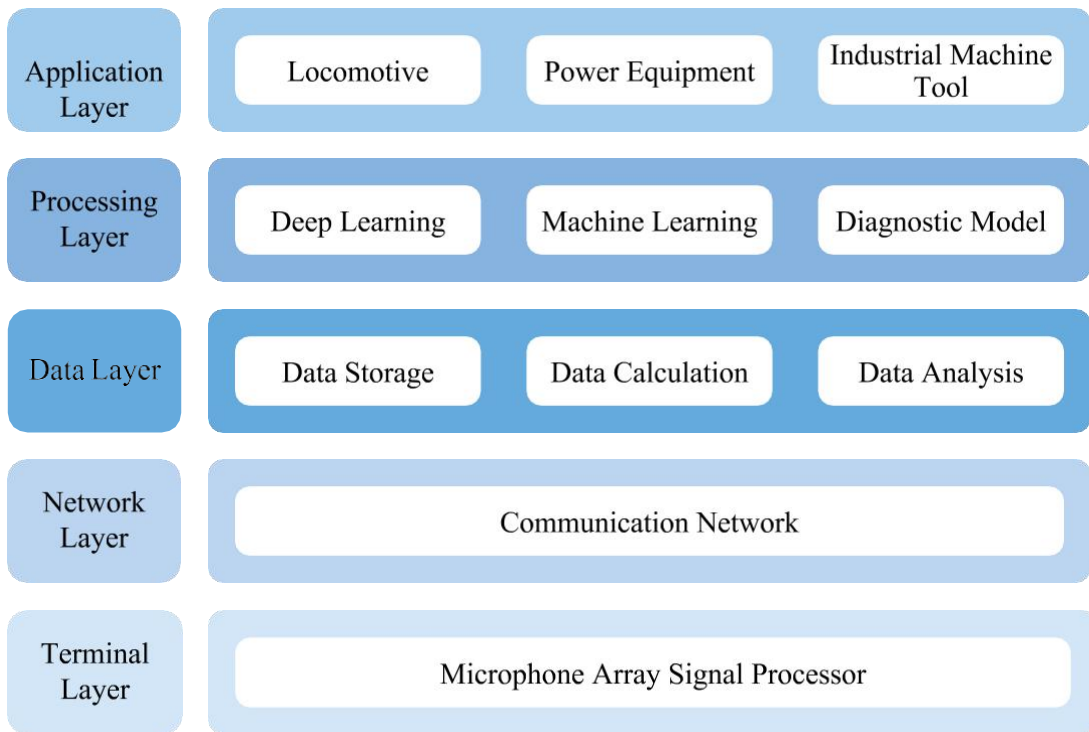


Fig. 5 Architecture of Acoustic Solution for Industrial Equipment Failure

5. Smart Health

The application of acoustic intelligent technology in health mainly includes disease diagnosis and treatment, health promotion and chronic disease treatment. According to the theory of traditional Chinese medicine, a sound-based disease diagnosis system may be developed by using big data and artificial intelligence technology, which can find diseases and health risks according to people’s sound characteristics. Using sound waves to trigger human resonance can effectively promote sleep, alleviate fatigue, and regulate neurasthenia, hysteria, anxiety, obsessive-compulsive disorder, phobia, depressive neurosis, hypochondriasis, cardiovascular and cerebrovascular diseases, metabolic disorders and other diseases.

From simple two-dimensional imaging to real-time three-dimensional and four-dimensional imaging, from the initial simple anatomical morphology imaging to the current functional imaging and molecular imaging, and from single diagnosis to diagnosis and treatment, the application scope of ultrasonic medicine has been greatly expanded. Ultrasonic diagnosis has been widely used in brain examination, obstetrics and Gynecology, fetal health care and so on. In clinical practice, ultrasound can be used to crush stones and blood clots, and has “peculiar” effects in the treatment of cancer, arthritis, myopia, hemiplegia and other stubborn diseases. In surgery, stronger ultrasound can be used as a non-invasive scalpel and is widely used in

medical treatment.

Many institutions at home and abroad are studying the combination of artificial intelligence and acoustic technology, including online and portable devices, for the diagnosis of various diseases and health risks, such as heart disease, respiratory disease and lung disease. Due to the lack of a large amount of data, the relevant products have not yet been officially applied. However, the treatment method of using sound waves and professional sound therapy products to promote sleep, relieve fatigue, regulate the body and mind has gradually been accepted by the public, and with very promising future prospects.

The wireless handheld ultrasound system, known as handheld ultrasound, turns the traditional bulky large ultrasound desktop into a portable, mobile-sized color ultrasound device, with powerful functions such as real-time composite imaging technology and automatic scanning. It can obtain high-quality images even in the face of difficult cases. According to the report of Signify Research, the global handheld ultrasound market is expected to exceed \$400 million by 2023.



Fig. 6 Wireless Handheld Ultrasound System

6. Smart Medical Beauty

The application of acoustic intelligent technology in medical beauty mainly includes ultrasonic knife, ultrasonic beauty instrument and focused ultrasound fat reduction and shaping machine.

The ultrasonic knife can directly reach the SMAS fascia layer through high-energy focused

ultrasound, and use the thermal effect to promote the regeneration and contraction of collagen, so as to achieve the effect of wrinkle removing, lifting and tightening. At present, no ultrasonic knife product has been approved to enter the market in China. Only Boao Super Hospital has introduced the product relying on the advantages of the licensed drug and equipment import policy of the Lecheng Pilot Zone, and the market scale to be developed is very large.

The ultrasound fat reduction and shaping machine uses the comprehensive mechanical and cavitation effects of ultrasound to act on the target adipose tissue and selectively destroy adipocytes to break them up to die, and then the dead cells and free fat are removed by phagocytes. Because the number of adipocytes is reduced, it produces a slimming and shaping effect. With the increase of consumers' attention to body shaping, the provision of more refined shaping services and the extension of potential consumers will jointly drive the rapid development of the market in the future.

Ultrasonic beauty instrument uses ultrasound to act on the face to make skin cells vibrate, produce micro massage effect and change cell volume, so as to improve local blood and lymph circulation, enhance cell permeability, improve tissue metabolism and regeneration, soften tissue, stimulate nervous system and cell function, and make skin shiny and elastic. The non-contact ultrasonic beauty instrument is a beauty instrument specially designed for household self beauty, and has the characteristics of intelligent tracking, flexible control and diverse functions. It can accelerate the metabolism of skin cells, act on the face to make skin cells vibrate and produce micro massage, so as to achieve the effect of beauty.



Fig. 7 Non-contact Ultrasonic Beauty Instrument

7. Smart Agriculture

Agricultural modernization is the foundation and support of national modernization. It is not only a new opportunity but also a new challenge for the development of “Agriculture, Rural Areas and Farmers”. The agricultural development model of high fertilizer (medicine and membrane) consumption, high water consumption and high energy consumption is becoming more and more unsustainable. However, acoustic intelligent technology can effectively solve the difficulties faced by agricultural development and bring green ecological food without chemical harm to human beings. Its social and economic benefits are very significant and the market prospect is very broad. The application of acoustic intelligent technology in agriculture mainly includes crop yield and quality increase, agricultural pest control, agricultural product processing, agricultural product testing, aquaculture and so on.

Acoustic wave has a certain impact on the growth of plants, and the acoustic wave fueling technology would improve crop yield and quality. In general, the acoustic wave fueling technology may increase the yield of leafy vegetables by 30%, and the yield of field crops by 20%[∠]. In addition, it can also significantly improve the sweetness of crops such as tomatoes and strawberries. Heilongjiang Jindao Agricultural Science and Technology Co., Ltd. and South China Agricultural University jointly established the research group for “Optimization Technology of Increasing Yield of Rice Seeds Treated by Ultrasound”, which has been tested in many regions of China, with an average yield increase of 13.16%.

The principle of agricultural acoustic wave deworming technology is mainly to use acoustic and biological principles to emit pulse modulated audio sine waves, and to destroy the auditory environment of sensitive insects by emitting intermittent and continuous active sound waves for a long time, causing them to be irritable and panicking, making them intolerable to the environment, so as to achieve the purpose of preventing and controlling diseases and insects.

The purpose of the drying link in the processing of agricultural products is to obtain better quality dry products. Acoustic drying technology can improve the internal structure of the material, increase the moisture migration rate and improve the quality of dry products. It can be combined with other drying methods, and has a broad market prospect.

Agricultural products testing is to use the acoustic characteristics of agricultural products to carry out nondestructive testing on their quality. According to the acoustic characteristics of agricultural products, we can judge their quality and classify them accordingly. The application of acoustics in the breeding industry includes promoting the growth of animals by playing

[∠] Physical Agriculture [OL]. Xiboer Technology. 2019

special music, diagnosing and intelligently alarming the physical condition of animals through sound, and inspecting animals with ultrasound equipment.

8. Smart Home

With the empowerment of 5G, artificial intelligence and other technologies, the form of smart home products will be in a comprehensive innovation, and a wider range of underlying interconnection protocols will be born. Human beings can use intelligent voice technology to directly talk with smart appliances such as TV, electric lamp, curtain, floor sweeping robot and intelligent microwave oven, and directly control the equipment through sound. With the gradual popularization of smart home, acoustic intelligence technology has been well applied in the fields of smart home, pension, distance education, and family security. With the development of intelligent voice technology, acoustic intelligence technology will give birth to more application scenarios facing the social problems that are gradually emerging in Chinese society, such as aging and sub-replacement fertility.

Smart voice box is a typical application of acoustic intelligence in the field of smart home. Users can control smart voice box through voice, which may provide sound resources, control basic smart home devices, and query surrounding, restaurant promotion information, road conditions, trains, air tickets, hotels and other information. Through powerful e-commerce platform that the voice box relies on, users can shop through the voice box, or obtain other types of services with the help of third-party applications, such as taking a taxi, booking air tickets and restaurants, searching logistics information and so on, which can further facilitate people's lives without opening their mobile phones. Based on the use scenario of the family, the smart voice box has also been designed with some very practical gadgets. For example, some smart voice boxes have gadgets such as calculator, unit conversion, traffic restriction query, constellation luck, message machine and so on. They are used for many purposes in daily life. Moreover, compared with people's commonly used smart phones, smart voice box can be used only by mouth, which is more convenient. Xiaoi voice box Mini is a smart voice box developed by Xiaomi Corporation, which can control all Internet of things devices at home only through voice interaction with it.

Part IV. Going Forward

At present, China's acoustic intelligent industry ecosystem has initially taken shape, the industrial layout of the upstream foundation layer is basically complete, the industrial layout of the technology layer is taking shape, and the industrial layout of the application layer is also expanding rapidly. With the continuous emergence and wide application of new generation information technologies such as 5G, artificial intelligence and cloud computing, acoustic intelligence in China will usher in a golden period of rapid development.

(I) Future Development Trend of Acoustic Intelligence

Acoustic intelligence technology is more mature, and the product application field would be more and more extensive. “Acoustics” is a highly permeable discipline, and deeply intersects with many fields such as artificial intelligence and big data. With the breakthrough and innovation of intelligent algorithm technology, it will provide new research directions and ideas for traditional acoustics. Taking speech recognition as a representative, the recognition accuracy of non-specific person speech recognition system with small and medium vocabulary has been greater than 98%, and the recognition accuracy of specific person speech recognition system is higher. In the future, in the research fields of environmental acoustics, ultrasonics, music acoustics and so on, intelligence technology would continue to enable, and derive all new products, such as smart voice box, smart headphones, home cinemas, mobile phone microphone systems, speakers, voice interaction/far-field pickup technology and other equipment and software technologies, which are the development and application direction of acoustic intelligence technology.

With the deep integration of acoustic intelligence and scene, the industry solutions will become more and more mature. With the development of technology and the intensive introduction of related policies, artificial intelligence technology has penetrated into various industries. In this situation, the combination of traditional acoustics and artificial intelligence

is also closer. Speech recognition, speech synthesis, software and hardware come one after another and would be widely used in various scenes. Taking smart medicine in the 5G background as an example, the realization of smart medical scenes such as remote consultation, remote ultrasound, remote surgery, emergency rescue, remote monitoring, intelligent guidance, smart hospital management, AI assisted diagnosis and VR ward visit would need the support of a large number of acoustic products. In addition, the in-depth application and data accumulation will also promote the acoustic intelligent products and solutions to become more mature and benefit the people, and the market scale will continue to expand, which is expected to exceed trillion in 2025.

The application of acoustic intelligence industry leads technological progress and promotes the rapid development of real economy. In terms of promoting entities to promote social economy, the acoustic intelligence technology would, on the one hand, give birth to a number of new acoustic intelligent products and industries, such as portable heart monitoring equipment and portable ultrasonic diagnostic equipment based on acoustic intelligence technology; It would put forward more diversified applications and requirements for sensors in complex environments such as automobiles. On the other hand, the acoustic intelligence technology would empower the industry, drive new growth points of smart home, promote the development of new retail business, improve industrial detection ability, and solve the problem of scene in non-visual environment.

(II) Suggestions on Development of Acoustic Intelligent Industry

At present, the forward-looking guidance of the national strategy, the collaborative innovation of industry, university, research and application, the strong traction of demand, the high openness of ecosystem and the strong support of the government jointly promote the development of the collaborative innovation mechanism of acoustic intelligent industry in China. The suggestions on how to speed up the development of acoustic intelligent industry are as follows:

I. Give full play to the role of government guidance and market leadership. The government should take the lead in formulating and improving the policy system of acoustic intelligent industry ecology, forming a set of industrial policy system with distinctive characteristics, clear levels, accuracy and practicality. At the same time, guided by market demand, give full play to the enthusiasm of enterprises, highlight the dominant position of enterprises in integrated innovation, engineering application, industrialization and pilot

demonstration, and support the cooperation among industry, university, research and application to jointly promote the new development mode of acoustic intelligence.

II. Accelerate the establishment of acoustic intelligent industry ecosystem alliance. The government department should take the lead in establishing the acoustic intelligent industry ecosystem alliance, building the acoustic intelligent industry ecosystem public service platform, establishing the acoustic intelligent industry service center, industrial talent service center and publicity and exchange center, and establishing and improving the alliance operation mechanism

III. Strengthen the training and introduction of acoustic intelligence talents. Accelerate the construction of a talent training mode integrating production, university, research and application, take universities and scientific research institutes as the main body, take enterprise demand as the guidance, and take science and technology parks and training bases as the platform to accelerate the training of acoustic intelligence talents. At the same time, encourage the leading acoustic intelligence enterprises to establish “enterprise universities”, build an acoustic intelligent business school system by taking the application and promotion of acoustic intelligent products and services as the starting point and popularizing applications to the whole society, jointly publish authoritative literature in the field and formulate industry standards or enterprise standards with industry experts and institutional experts, organize forums, new product launches and technical trainings to better serve practitioners in the field of acoustic intelligence.

IV. Innovate the way of financial support for industrial application. Fully mobilize social resources to promote industrialization and popularize the application, strengthen the connection between industry and finance, encourage industrial investment funds, venture capital funds and other social capital investment to jointly support the development of acoustic intelligence industry, and focus on the growth projects with proven business models and mature products in the field. In principle, the corresponding investment should be made for the high growth cycle entrepreneurship projects with independent and complete intellectual property system and the basis for small-scale product testing and supply in the stage of Angel round-A round investment.

V. Create an industrial innovation service system. The system is a service cluster formed closely around the industrial technology innovation chain and enterprise growth chain. It would work with the industrial chain enterprises to build specific spaces like theme industrial parks or regional headquarters bases with acoustic intelligence as the core, establish an industrial entrepreneurship and innovation carrier based on the existing industrial positioning

and resource base, and, by taking the innovative small and medium-sized enterprises with the characteristics of “new technology, new industry, new business form and new model” as the main service object, focusing on the core needs of the enterprise, build various innovative capital operation modes such as “fund + base” and “incubation + venture capital investment” based on spatial property services, with the connection of industry, university and research, policy services, science and technology finance, talent services, science and technology intermediary, investment incubation, market activities and entrepreneurial culture environment services as the main contents to better serve acoustic intelligent industry chain enterprises. Form a multi-level industrial innovation enterprise ecological service system through the integration of social and market service resources such as local governments, leading enterprises, large enterprises, universities, scientific research institutes and key enterprises.

SHUHAI INFORMATION TECHNOLOGY CO., LTD.

ADDRESS: Beijing Economic-Technological Development Area

WEBSITE: www.shuhaixinxi.comEMAIL:


mail@shuhaixinxi

TEL: 400-1769-789

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