

The Application of IoT in the Development of Smart Pianos and Its Potential for Inclusive Music Education Scenarios

Yu Dong

School of Music, Huizhou University, Huizhou 516007, Guangdong, China

Abstract: With the deep integration of IoT technology and the digital music industry, smart pianos, as an excellent representative of the intelligent transformation of traditional musical instruments, are changing the pattern of music education and cultural life. At present, there are problems with the traditional piano teaching system, such as a high entry barrier, uneven distribution of excellent teachers, and no timely correction of students' practice. Problems above can be solved by the use of IoT technology. The technical architecture of smart pianos, device development and practical applications are taken as the subject of this paper, and the basic technological foundation of the perception layer, network layer and application layer is explored, and how to implement it in typical scenarios such as home-based music education, public aesthetic education service, and age-friendly cultural care program is considered. Research has shown that the Internet of Things technology can enhance the hardware of pianos and also create a three-way interaction system of "human-piano-network" to ease the difficulty of learning and improve the efficiency of resource utilisation. In the future, the new development direction of smart pianos will be based on human-machine collaboration and ecosystem connection to support the spread of universal aesthetic education.

Keywords: Internet of Things; smart piano; technical architecture; context-specific applications; national aesthetic education

1. Introduction

The traditional musical instrument industry is being reshaped by the new era. The smart piano is an outcome of the combination of Internet of Things technology and instrument production, and it has been released widely. There are many problems with the traditional piano teaching model: Most of the teaching resources are concentrated in the first-tier cities; many areas without professional teachers cannot receive timely training; the learning process is too long and the feedback is slow, leading to a low retention rate of beginners; and there are other constraints such as night-time noise and geographical isolation that make remote teaching difficult. The general way to build a smart piano is through the application of IoT technology; therefore, all sorts of sensors, wireless networks, cloud services, etc., can be used to collect and analyse real-time performance data of traditional musical instruments, and they will no longer be independent devices. Most of the current research has been focused on the application of AI algorithms and has not explored the IoT architecture or all kinds of scenarios. Technology development and applications, as well as the underlying logic for implementation and application models and practical value, will be presented in this paper to provide some ideas for the development of the smart instrument industry[1].

2. The core technical architecture of smart pianos empowered by IoT technology

2.1 Perception Layer: High-Precision Sensor Array and Data Acquisition

The perception layer is to obtain the performance data of a smart piano in the physical world, and its main function is to convert playing operations into digital signals. The first system has only one point of conductive rubber contact, so it is a small detection range and has a long lag. New high-end models have more sensors, and there are various types of triangle-shaped Hall effect sensors that can be used for high-speed detection of key operation. The three types of sensors that will be used in the whole system are a pedal sensor, a string vibration sensor and an ambient audio sensor. The Pearl River Piano AI series is equipped with more than 200 sensors and has a latency of 0.1 ms and a sampling resolution of 96kHz/24-bit for fine measurement of key pressure. The DSP will process the raw data and then send it over the network to be used by the network layer in the cloud[2].

2.2 Network Layer: Multi-Protocol Interconnection and Cloud Data Synchronization

The Network Layer Links the Physical Pianos to the Cloud Service. The two connection modules of the smart piano

are Bluetooth and Wi-Fi; Bluetooth 5.0 is a low-power type that is suitable for local control by terminal devices, and Wi-Fi is used to send and receive data from the cloud. The piano is in the smart ecosystem; it will send user data to the cloud, and then both teachers and parents can view this information online. According to IDC data, more and more people are buying smart pianos in their homes and they can be linked to smart homes. Many pianos are arranged in the institutional area to form a network that can be centrally managed by teachers.

2.3 Application Layer: Intelligent Services and Extended Ecological Value

The intelligent keyboard's function area aims to provide life-enhancing services. Using performance data, cloud-based AI analyzes music speed, mood, and finger usage to generate a visual practice report with timely feedback. A Deep Learning model trained on outstanding teachers' data accurately assesses children's singing in the ONE competition.

The Application Layer also hosts a content ecosystem and social activities. The cloud music library continues to expand with licensed scores for download and study, while online communities allow users to share works and interact, forming learning networks[3].

3. Practical Applications of Intelligent Pianos in Various Scenarios

3.1 The Context of Family Music Education

At present, the home is the main place for using smart pianos, and about 67% of the sales of smart pianos in 2024 are for families with children aged 4 to 12. This group of people is very eager for interaction, entertainment and remote practice support. Under the traditional mode of home-based piano instruction, parents generally lack professional music knowledge and are unable to provide good direction; thus, they often have to take weekly offline lessons but fail to ensure consistent quality of practice. Smart pianos can provide a platform for learning-by-example and instant fault correction to address the issue that there are not enough professional teachers available for children at home.

If there are any problems in the performance, the system will alert us and provide correction suggestions to alleviate boredom from long, monotonous training. According to market research, about 37 per cent of people now use the AI coaching function to increase their study efficiency, and for new learners, if they keep learning for more than six months, about 68 per cent are able to retain what they have learned. The quiet practice function can address the problem of home use; that is to say, one can exercise wearing headphones without disturbing neighbours and make full use of spare time, such as at night or in the early morning. By 2025, the proportion of domestic smart pianos with silent practice functions will be 65.8%, up by more than 12 percentage points from three years ago[4].

3.2 Public Aesthetic Education and Institutional Teaching Settings

Smart pianos have shifted music teaching from individualized to collective, standardized learning. The ONE Smart Piano Classroom is deployed in 16 countries, with pianos connected to a network for remote monitoring and material distribution. The curriculum adds interactive elements like games and group performances to engage young learners. Remote teaching via smart pianos addresses aesthetic education gaps in underserved areas, using cloud streaming for instruction by teachers from first-tier cities. By 2024, smart pianos will comprise 28% of educational institution purchases, primarily for standardized curricula and remote teaching. With aesthetic education in the high school entrance exam, more schools use smart piano classrooms for regular and after-school activities, making them essential for school-level aesthetic education.

3.3 Age-Friendly and Cultural Elderly Care Scenarios

Smart pianos are increasingly used in various life aspects, with growing elderly demands for culture and care creating new industry opportunities. Pearl River Piano's Aimosen brand has launched age-friendly smart products, showcased at the 2026 Shanghai Senior Expo, combining technology with human-centered care. Hardware features simplified interfaces, fewer buttons, and larger, higher-contrast displays. Software includes senior-tailored music libraries and teaching modes to lower learning barriers and emphasize entertainment and socialization. Senior colleges and community centers will be main implementation bases. Functions like automatic accompaniment and one-key adjustment enable non-musical older adults to easily experience music joy, enriching their cultural lives, while group activities promote social interaction and boost spirits.

4. Conclusion

IoT technology has revitalized traditional pianos, with innovations in both basic architecture and application scenarios. High-precision sensors digitize player movements, multi-protocol networking connects devices to the cloud, and application-layer services offer educational, entertainment, and social benefits. Smart pianos support home learning, teaching, and elderly care, reducing music learning barriers, optimizing resources, and making education more accessible. However, challenges

remain: self-sufficiency in high-end sensors and core algorithms needs improvement, data standards lack consistency, and content ecosystems are not fully professional or rich. Future advances in 5G, edge computing, and AI models will enable more natural AI interaction, open ecosystems, and personalized learning. The industry must boost R&D, strengthen standards, and innovate applications to promote aesthetic education and cultural development.

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