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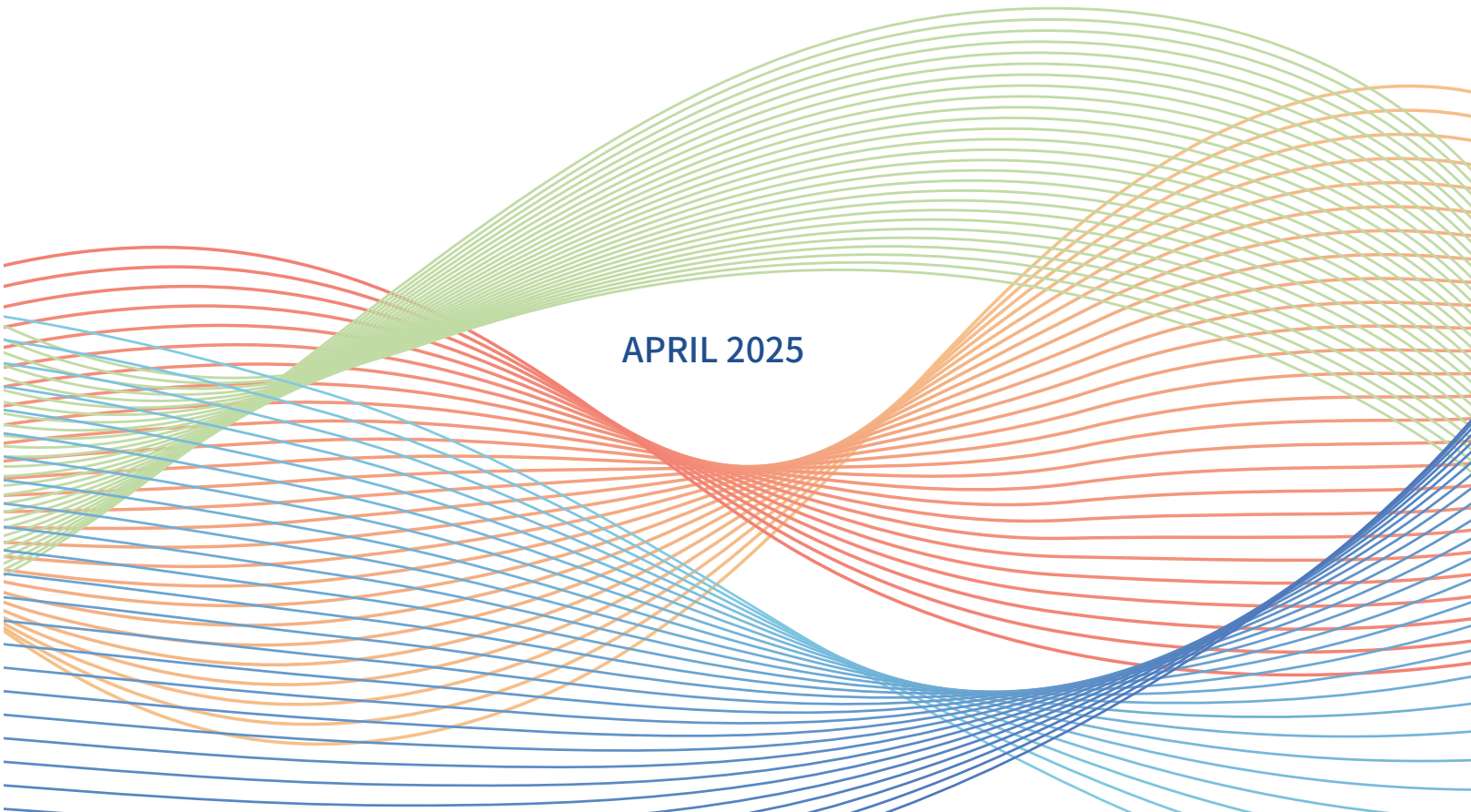
# Innovative Applications of AI in the Residential Sector

BEKE BrainLink



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# Foreword

With the rapid development of AI, innovative applications in the residential sector are reshaping the industry ecosystem and leading the future of living with unprecedented depth and breadth. In various dimensions such as residential design and construction, marketing services, home living, and community management, AI has not only enhanced the comfort, safety, and convenience of living environments but also driven the transformation of the housing industry towards smarter, greener, and more age-friendly solutions. This report combines the latest domestic and international practical achievements and case studies to systematically review the current applications and future trends of AI in the residential sector, providing references and insights for the innovative applications of AI in this sector.

# Contents

# I、Current Status of Innovative Applications of AI in the Residential Sector

## (I) Intelligent Creativity and Design

With the development of technologies such as BIM and large model of image generation, AI has been widely applied in the sectors of architectural design and home decoration design. In the sector of architectural design, AI applications have broken through the limitations of traditional design. Through data-driven approaches and algorithm optimization, AI can assist designers in generating a large number of design options in a short period of time, improving design efficiency. By utilizing deep learning and neural networks, AI can understand the designers' intentions, automatically adjust design parameters, and generate designs that meet the requirements, reducing errors and repetitive tasks, thereby significantly enhancing both design efficiency and quality. At the same time, AI is not just an auxiliary tool. By rapidly learning and mastering specialized knowledge in vertical sectors of the construction industry and integrating insights across different sectors, it has broken traditional boundaries and sparked creative inspiration. For example, under the support of AIGC technology, CSADI (Central South Architectural Design Institute) has developed its own architectural creative visualization software, which enables functions such as turning hand-drawn sketches into renderings within a coffee break and "one-click skin change" for buildings. Glodon's Aec GPT, an AI large model for the construction industry, inherits the foundational capabilities of open-source base models, covers industry-specific capabilities with access to hundreds of thousands of high-quality industry data, and offers specialized abilities in automation, analytical decision-making, and assistive generation. In the home decoration design sector, AI efficiently provides solutions and the ability to make repeated revisions, leading to the reconstruction of home decoration design service tools and processes, and improving delivery efficiency. For example, KE Holdings Inc. has launched its first AIGC home decoration design product, "SheNiu", based on its self-developed "DreamHome" large model. This product features various generative image functions, including real-life photos, floor plan images, and reference images, providing users with more decoration inspiration and offering a home decoration experience where "what you imagine is what you see, and what you see is what you get". Shangpin Home Collection has created an AI design factory that leverages deep learning to understand user preferences, generating personalized home design solutions, and seamlessly integrating the design and production workflows. Some decoration enterprises have integrated large models such as DeepSeek, further driving the intelligent transformation of home decoration in areas such as customer service and design.

## (II) Smart Hardware and Smart Construction Sites

In the processes of construction and home decoration, intelligent solutions have redefined construction workflows and techniques. In the construction process, technologies such as AI, IoT, the Internet, VR, and sensing are applied to manage construction processes, enabling universal connectivity and effective collaboration between building structures, construction machinery, wearable devices, and key nodes. In this process, intelligent devices have further enhanced the efficiency and safety of construction. For example, smart cameras can monitor both internal and external conditions on the construction site, identifying suspicious individuals and abnormal behaviors; smart wristbands can track workers' heart rate, body temperature, and fatigue levels; smart

workers' head posture and fatigue; and intelligent construction robots can transport materials, lay bricks, spray, and weld, reducing manual labor and improving construction efficiency. In the home decoration construction process, issues such as long construction periods, complex workflows, and difficulty in monitoring the renovation have always been a concern for home decoration consumers. On the one hand, AI has reshaped home decoration site management. Through smart cameras, it enables functions such as unmanned construction monitoring, material entry recognition, smoking detection, workwear identification, cleanliness monitoring, and process recognition, along with digital management. This helps service providers improve construction quality and project timeline management efficiency. On the other hand, by empowering video data integration and analysis with AI, home decoration consumers can track renovation progress and supervise the quality of the work. Based on AI vision algorithms, daily or weekly construction site video reports can be generated, interpreting the renovation progress and achieving a "no need to supervise the renovation" experience. In addition to smart cameras for home decoration, many other smart hardware devices have also played an important role. For example, handheld 3D smart scanners can automatically generate accurate blueprints with precise dimensions and structures. The multimodal "AI work badge" can independently summarize and refine service content, complete system records, and provide analysis and suggestions for service improvement across multiple dimensions. Smart panoramic recorders achieve standardized home decoration acceptance in 3D through a "human + AI inspection" approach.

## (III) Intelligent Assistants and Smart Marketing

AI has led to the development of a series of smart marketing tools and assistants in the residential sector, helping service providers expand their business and assisting consumers in making decisions. For example, "price" is a key consideration for home buyers, sellers, or renters. Valuation tools can assist house buyers and sellers in making rational decisions. The property valuation tool provided by the U.S. Zillow website, for instance, uses advanced algorithms to offer relatively accurate estimated property values by considering factors such as location, size, year of construction, and surrounding amenities. In China, KE Holdings Inc., relying on its property database and advanced algorithms, can provide accurate and reliable property price estimates, with an accuracy rate of up to 80%. "Sunlight" is a key consideration for house buyers. Lever aging technologies such as machine learning, neural networks, image recognition, and digital twins, KE Holdings Inc.'s daylight simulation application, "3D Building Models", can comprehensively and realistically simulate the sunlight experience for different floor plans throughout the year, as well as the impact of neighboring buildings on sunlight exposure. VR and augmented reality technologies have made immersive remote property viewing possible. With scene generation algorithms based on reinforcement learning, the residential sector has achieved immersive VR property tours, allowing users to experience a comprehensive, realistic viewing experience without leaving their homes. With the support of generative artificial intelligence and natural language processing, intelligent voice assistants in the residential sector can now answer consumers' questions in real-time and provide round-the-clock online services. They help real estate agents, home decora

tion designers, rental stewards, etc., to improve consumer satisfaction. Moreover, they can provide tailored support according to the characteristics of different service providers, accelerating the professional growth of service providers. The application of AI for personalized recommendations has also been implemented to some extent in housing transactions. For example, real estate brokerage agencies recommend properties based on users' behavior trajectories and language expressions. At the same time, they select agents who know both properties and users better, achieving intelligent matching among agents, properties, and consumers.

## (IV) Smart Home and Intelligent Space

As the basic carrier of people's daily lives, the living space is undergoing an unprecedented intelligent transformation, which is profoundly affecting people's living styles. After the IoT enables the interconnectivity of household devices and real-time collection of information data, smart home has become one of the most widely used areas of AI in the residential sector. For example, smart door locks are equipped with fingerprint, password, or facial recognition, which enable residents to ditch the hassle of traditional keys and have a more convenient and extremely secure way of accessing their homes. The intelligent lighting control system can dynamically adapt the brightness and color temperature of the light in response to environmental changes and time variations. It can accurately create an indoor lighting environment that matches people's moods. The intelligent temperature adjustment device uses intelligent algorithms to understand the living habits of residents. It can adjust temperature parameters in a personalized way, ensuring that the temperature in the living space is always at the perfect level for the human body. Smart speakers or smart gateways can use natural language processing to control household appliances, curtains, etc., through voice commands.

Smart cameras can monitor the indoor environment in real-time and predict risks through behavior analysis. Once abnormal situations such as an elderly person remaining still for a long time or a fire alarm are detected, they will send an emergency notification and link with other devices to take corresponding measures. Smart monitoring devices can monitor the operating status of household devices in real-time, provide early warnings for device failures or abnormal energy consumption, and reduce maintenance costs. Smart home appliances such as air conditioners, water heaters, and rice cookers with remote-control functions allow people to adjust the indoor temperature and prepare delicious food in advance before they get home, enhancing the convenience of life. In addition, as people's demand for a healthy living environment increases, integrated control systems of smart home have gradually become a standard feature in newly built residences. Through intelligent sensing, intelligent regulation of temperature, humidity, and light, filtering of water scale, and continuous supply of fresh air, these systems intelligently create a healthy indoor environment. The greater connection and intelligent interaction between the living space and people make homes more comfortable and efficient.

## (V) Intelligent Property Management and Communities

Currently, the innovative applications of AI in intelligent property management and communities have penetrated multiple sectors such as security, management, control, and services, significantly enhancing operational efficiency and residents' living experiences. In intelligent surveillance and security, smart access control systems integrated with facial recognition and license plate recognition enable contactless access. Smart cameras in some properties utilize AI algorithms to analyze surveillance footage, detecting abnormal behaviors such as suspicious intrusions, fire hazards, illegal parking in fire

lanes, falls, or prolonged loitering, while automatically collecting evidence and triggering alerts. Via AI-powered machine vision and image sensing technologies, property management can achieve precise detection and recognition of electric bicycles entering elevators, effectively warning against unauthorized entry incidents in elevator areas. For intelligent community services, AI customer service agents employ natural language processing to promptly address resident inquiries and handle maintenance requests or payment transactions. AI systems analyze high-frequency fraud patterns within communities to deliver targeted anti-scam alerts. Through big data analysis and large models that match residents' behavioral patterns, interests and demands, personalized share of customized information and community events can be implemented, fostering resource sharing and social interactions among residents. In intelligent management and control, smart environmental monitoring systems continuously track and regulate environmental factors, such as temperature, humidity, air quality, and noise levels within property areas. Intelligent parking systems utilize sensors to monitor space utilization rates, dynamically adjusting parking space allocation, traffic flow routes, etc. Monitoring systems of intelligent devices integrate sensors with AI predictive models to assess the operating status of devices in real-time, proactively identifying potential malfunctions. Some smart gateways have optimized equipment scheduling strategies to minimize operational risks and extend service life. Furthermore, AI plays a pivotal role in enhancing community safety and disaster response capabilities, such as AI-assisted allocation and coordination of medical and epidemic prevention resources during COVID-19.

# II、Cases of Innovative Applications of AI in the Residential Sector

Taking the large model product, "SheNiu", of home decoration design based on AIGC technology as an example. It systematically elaborates on the problems faced by "SheNiu" in solving the intelligent problems of home decoration design and the corresponding solutions, providing more references for the scenario-based implementation of AI in the residential sector.

## (I) Application Scenarios

The rapid technology advancements and the continuous improvement of people's living standards have presented new demands for home space design services. Consumers hope to vividly experience what their dream decoration effect would look like in their own homes at the early stage of home decoration design. When purchasing a house, they also expect to see in real-time the renovated effect of an empty or old house. Designers aim to quickly present renderings based on consumers' needs, so as to solve problems such as difficult and slow rendering production, which lead to a long communication process and poor user experience. The industry's demand for quickly obtaining decoration renderings has gradually become prominent.

The main application scenarios of "SheNiu" are as follows: Consumers can generate decoration renderings through various image-generation methods such as generating images from real-shot photos, floor plans, and reference pictures to gain inspiration for decoration. After successful image generation, they can change to a specific style for image generation and independently edit the generated renderings. Designers can quickly generate decoration renderings based on consumers' requests by generating images from sketches or on-site inspection photos of properties. Real estate agents can quickly generate decoration renderings of second-hand houses during the process of showing houses to consumers, allowing consumers to instantly see the renovated effect of the houses.

## (II) Application Pathways

### 1.Building the Beike DreamHome image-generation model

AIGC image-generation models are primarily focused on general sectors. However, due to the low signal-to-noise ratio of datasets and lengthy diffusion processes, their performance is limited in the vertical field of home decoration. The renderings generated by these models often have a dated styling, and the inference time is relatively long, making commercialization challenging. In the sector of interior design, precise control over key elements such as doors, windows, walls, ceilings, and floors is essential, including their spatial layout and dimensions. Therefore, when modeling for this sector, spatial depth, lines, and semantic segmentation are utilized to achieve better spatial control. Nevertheless, both academia and industry are currently grappling with two critical challenges. First, excessive creativity leads to weak control. Second, excessive control can inhibit creativity. Achieving visually compelling renderings while maintaining precise spatial layout control presents a major technical challenge. "SheNiu" has developed a controllable image-generation model for decoration scenarios based on a proprietary large model, achieving layout control while preserving creative potential.

**(1) Developing a controllable image generation product structure and model architecture**

From the perspective of product structure, the model layer can leverage long-term accumulated insights in visual understanding of indoor space to enable rapid

capability transfer and iteration in the large model era. By leveraging spatial and semantic control models, we impose targeted constraints on the foundational generative large model to strike a balance between its creative potential and the precision required for home decoration design renderings. At the prompt layer, we can continuously enhance semantic control to deepen domain-specific understanding of interior design workflows. This empowers designers by establishing foundational capabilities like style dictionaries, ensuring generated outputs are both theoretically grounded and aligned with professional design principles. The strategy layer can capitalize on extensive floor plans and site survey data to generate comprehensive floor plan solutions, rapidly providing image generation methodologies. The house type + facade solution achieves end-to-end capability in transforming 2D floor plan vectors into 3D elevations/panoramas, establishing a complete pipeline from scratch.

The comprehensive model architecture encompasses data, capability, application, and evaluation layers. Predicated on a fine-tuned base model, the system integrates data and capability outputs across various scenarios, with the objective of exploring the transformative potential of visual AI in interior design contexts.

**(2) Establishing a comprehensive interior design rendering data tagging framework to ensure generation quality**

To develop a sufficiently refined dataset with precise image-text correspondence, a comprehensive data tagging framework was constructed. By meticulously screening millions of data points across more than 20 analytical dimensions and applying nuanced tags, while simultaneously conducting experimental research to determine optimal caption acquisition methodologies to maximize dataset image-text alignment and elevate model performance capabilities.

Leveraging these granular classifications and tags, the system enables arbitrary condition-based filtering of image collections across multiple quality levels, including parameters such as image blur, luminosity, watermark presence, and other critical attributes. Meanwhile, a multi-phase dataset system with varying quality tiers is established to curate the highest-quality images, enabling final model fine-tuning that corrects the sample distribution to an optimal localized sector. Additionally, incorporating a controlled ratio of generic scene data can effectively mitigate overfitting in vertical-specific scenarios.

**(3) Establishing an end-to-end pipeline from 2D layouts to 3D models and finally to renderings, enabling full-space visualization directly from floor plans.**

"SheNiu" pioneered an end-to-end pipeline integration, successfully translating "2D vector diagrams > 3D vector diagrams > Renderings", thereby empowering users to articulate their ideal living spaces with unprecedented flexibility and efficiency.

The 2D vector reconstruction (Raster to Vector) phase primarily relies on a proprietary R2V model to transform non-standard floor plans into standardized configurations.

The 3D floor plan vector construction (2D Vector to 3D) phase strategically utilizes prior architectural information such as floor heights and door/window dimensions to generate 3D floor plan vectors, employing rendering tools like Blender to visualizethese vectors and extract depth and supplementary spatial information.

**(4) Proposing a spatially controllable diffusion generation model to harmonize creativity and control**

The research introduces an innovative approach to controllable image generation, a spatially adaptive diffusion generation model (termed "Indoor Scene Generation Enhanced by Structural Estimation"). By modeling interior architectural semantic and structural information as supervisory signals, the methodology ensures the generation of imaginative design renderings while maintaining stringent spatial structure consistency.

### 2. Achieving balance between large model computational power and user experience

Large models typically contain more parameters and deeper network structures, requiring more computational resources during forward propagation (model prediction), often resulting in increased return time. Large models demand substantial computational resources (CPU, GPU, memory, etc.), and resource insufficiency can further extend return time. Traditionally, CPU-based services respond quickly, with immediate obtaining of results upon users' request, whereas large model services require inference time before generating output. Currently, users are accustomed to GUI-based operations and have high expectations for system responsiveness. Unrestricted user traffic may cause model service downtime, while traffic interception might compromise user experience, necessitating an effective balance solution.

"SheNiu" effectively resolved the balance between model computational power and user traffic through an image generation task scheduling approach. By implementing queuing and dynamic flow rate release, the system adjusts user-side traffic and model inference capabilities. The most significant challenge involves perceiving model computational power to estimate anticipated image generation waiting time, which is addressed by "SheNiu" through dynamic flow rate calculation strategies.

## (III) Application Outcomes

"SheNiu" significantly outperforms generic generation models across technical indicators including semantic control, aesthetic quality, spatial structure, spatial layout, and furniture rationality. The interior design rendering generation effect leads the industry, providing a crucial lever for promoting intelligent and personalized residential services. Users can quickly generate decoration renderings by uploading house images or floor plans, experiencing one-click application of multiple decoration styles to their space, and obtaining critical design inspiration. When communicating with consumers, renovation professionals can leverage "SheNiu" to rapidly generate design renderings - not only boosting operational efficiency but also gaining AI-powered design inspiration to enhance creative workflows". Real estate agents can now enable buyers to visualize their future homes during property tours, effectively addressing a key pain point in house buyers decision-making process. As of February 2025, "SheNiu" has been launched in over 50 cities including Beijing, Shanghai, Guangzhou, and Chengdu, serving over 3 million users and generating more than 80 million images.

# III、Trends of Innovative Applications of AI in the Residential Sector

With continuous AI advancement and application scenario expansion, AI will further integrate with residential sector processes, developing more systematic, autonomous, personalized, and sustainable applications to construct more efficient, humane, and sustainable living experiences.

## (I) Scientific Planning and Intelligent Development

Based on establishing and improving multi-dimensional data infrastructure including urban housing data, population data, transportation data, and commercial district activities, and through cross-application and innovative data element integration, AI applications in scientific planning and residential development sectors will demonstrate broader and deeper trends. In scientific planning, big data analysis and continuously evolving deep learning technologies will support multi-dimensional collaborative residential planning, assisting decision-makers in optimizing living space site selection and surrounding facility layout to create more equitable, inclusive living environments. By simulating urban population density, AI can promote balanced distribution of housing with employment and educational resources, optimizing social housing site selection and scale. Utilizing natural language processing to analyze unstructured text from social media and community forums can capture genuine residential demands of marginalized and minority groups. Advanced AI algorithms also promise autonomous planning, further enhancing residential planning transparency and scientific rigor. In intelligent development, through extensive residential data mining and analysis, the C2M (Consumer-to-Manufacturer) housing development concept will find better practical implementation. AI large models can comprehensively identify emerging residential needs and trends, precisely insights into residential behaviors and requirements across different population groups, designing housing products matching current and future needs, and even achieving "personalized housing strategy" through intelligent design, truly aligning housing products with precise housing demands.

## (II) Whole-Home Smart Systems and Future Spaces

Current smart home systems primarily rely on post-installation products and devices, with different smart products operating relatively independently, suffering from insufficient compatibility and complex operations. In the latter stage of smart home development, as product ecosystems gradually improve and "one-stop" integrated decoration becomes prevalent, whole-house intelligence will open new developmental spaces, fundamentally transforming people's home living experiences. During architectural design, construction, and decoration stages, by pre-embedding sensors, implementing unified communication protocols, and integrating intelligent control centers, systems can achieve coordinated operation from single-point devices to whole-house devices, and from whole-house devices to residential buildings, enabling boundless interaction through foundational interconnectivity. The intelligent home manager, serving as a control hub, can not only help family members control intelligent devices and integrate lighting, temperature control, noise reduction, entertainment, and household appliances into comprehensive life scene experiences, but also master family members' habits through deep learning and data analysis. It can proactively regulate home environments based on family characteristics and member activities, and even automatically arrange meal plans and order ingredients according to family members'

conditions, becoming a humanized "life manager" that truly integrates intelligence into daily living. A more comprehensive smart home product ecosystem will provide further support for family members, such as tracking sleep quality through smart mattresses and managing dietary intake with intelligent dining utensils. Residential-function large models interconnected with urban public infrastructure models for gas, electricity, heating, drainage, and flood prevention can also realize intelligent living payment functions.

## (III) Personalized and Customized Services

With the diversification and refinement of residential needs, personalization and customization will become key to enhancing residential product and service added value. During the property viewing and house-hunting stages, Manus' current general-purpose AI Agent can already autonomously make decisions, execute tasks, and even complete operations when assisting users in selecting a home. In the future, with rapid model and computational power iterations and accumulation of vertical sector data capabilities, professional AI Agents will possess longer, more complex thinking chains and autonomous tools invocation capabilities. By comprehensively analyzing user browsing records, purchase histories, and conducting in-depth dialogues, professional AI Agent can provide more personalized, customized solutions, precisely depicting the house buyers' demands with finer granularity, and even achieving automatic matching based on model quantification and underlying data. Simultaneously, AI cross-border integration often expands adaptability and flexibility. In recent years, 3D printing technology application in residential sectors has become increasingly widespread, with examples like Italy's Tecla House and Texas' House Zero constructed using 3D printing, with walls layer-stacked from clay or eco-friendly materials. The combination of AI design-factories and 3D printing technology can realize integrated "design-production-installation" flexible manufacturing, making house design more freely personalized and house construction more precise and efficient.

## (IV) Smart Machines and Robots

Currently, smart machines primarily operate through manual controls or voice commands. With rapid development in deep learning, pre-trained large models, and robots, future intelligent machines will be capable of autonomous control and human interaction, opening new scenarios in property management, housekeeping, elderly care and other sectors. For instance, AI smart cameras can automatically identify non-community members and proactively assess safety risks based on personnel behaviors; smart machines, such as 24-hour patrol vehicles, can intelligently optimize patrol routes, detecting community ground litter, illegal parking, high-altitude object throwing, sparks, and unusual odors for timely maintenance; intelligent device maintenance robots can perform detection and repair of potential faults in pipelines and equipment; currently implemented "hip-assist exoskeletons" may develop independent environmental perception capabilities in the future, helping users make intelligent decisions and enabling more elderly individuals to venture out of their homes and into communities. As embodied intelligence carriers, robots can be implemented in more residential scenarios. Family robots can assist in breakfast preparation and whole-house cleaning; elderly care robots can chat with seniors based on their preferences and physical conditions, monitor health status, and provide daily care; children's educational robots can tutor learning, accompany play, cultivate interests, and support growth; and online shopping packages can be delivered by community robot managers, making enclosed communities more secure and convenient.

## (V) Low-carbon Living and Sustainable Development

The residential sector is a significant resource consumer and carbon emission source. With increasingly severe global warming issues and rising environmental awareness, sustainable development will become a crucial direction in residential sector. AI will play an increasingly vital role in building energy conservation, emission reduction, resource recycling, and promoting low-carbon lifestyles. Intelligent energy management systems can use machine learning algorithms to analyze real-time data from smart sensors and IoT devices, monitoring and analyzing building and household energy consumption, optimizing energy system scheduling and control, dynamically adjusting air conditioning, lighting, and other equipment to reduce energy consumption and lower energy costs, potentially facilitating broader zero-carbon building adoption. Smart recycling can optimize building and decorative material waste recycling and reuse processes, supporting circular economy development. Simultaneously, AI will accelerate eco-friendly material research and development, such as using machine learning to screen high-performance building material combinations and optimize material compositions. AI-driven lifecycle assessment models can predict material environmental impacts, enabling architects and engineers to choose sustainable alternatives. AI can also track and optimize material procurement and delivery routes, contributing to carbon reduction in supply chain management. 3D-printed buildings and furniture show promising potential in reducing construction waste, lowering energy consumption, and promoting sustainability through environmentally friendly materials.

## Conclusion

We believe that with the development and iteration of technologies like 6G, cloud computing, big data, machine learning, deep learning, computer vision, natural language processing, VR/AR, and autonomous unmanned systems, traditional residential models will continue to be disrupted by innovative applications, creating more inclusive, safe, and sustainable human living environments, and delivering more comfortable, convenient, and humanized residential experiences. It is hoped that this report's systematic review of the current status, trends, and innovative application cases of AI in the residential sector can serve as a valuable reference for AI-driven innovation in housing. By facilitating deeper integration of AI technologies with residential scenarios, these insights aim to empower the industry to expand intelligent exploration and comprehensively develop next-generation AI engines for modern living.

Simultaneously, we must continuously monitor challenges and risks in AI's innovative residential applications, such as ethical and data privacy protection, algorithmic bias, and actively seek solutions, including implementing cybersecurity protection measures, strengthening encryption and traceability technology research, establishing AI application ethical frameworks, enhancing residential industry self-regulation, to safeguard technological ethical boundaries and promote the technology advancement toward benevolence.