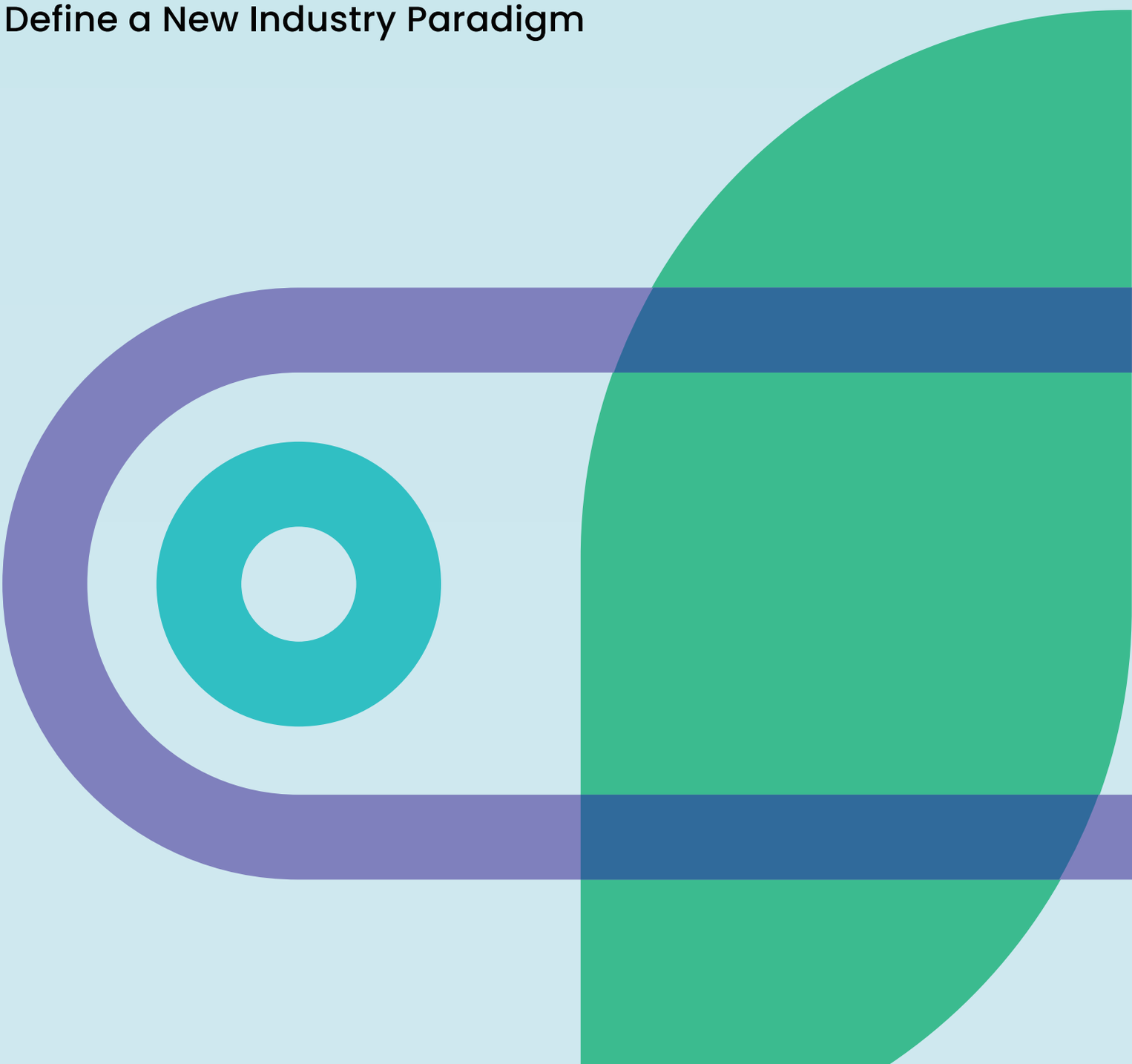
IDC | AIPER

Smart Yard Enters A New Era

AI and Ecosystem Collaboration Define a New Industry Paradigm



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CHAPTER 1

The Rise of Ecosystem-Driven Smart Yard Care

Introduction: The smart home industry is undergoing a paradigm shift from "single-device intelligence" to "ecosystem intelligence". Intelligent capabilities and cross-device ecosystem collaboration have become core drivers of industry development. According to the latest IDC industry report, the global smart home market exceeded USD 269 billion in 2025. Global shipments across all cleaning-robot categories surpassed 32 million units, representing a 20% year-on-year (YoY) increase. Against this broad-based industry growth, the outdoor private-smart yard segment stands out. Shipments of robotic lawn-mowers and pool robots exceeded 6.2 million units, with YoY growth above 18%, making it a new growth engine within smart homes. As a pioneering category for smart yard intelligence, robotic pool cleaners exhibit the most pronounced growth momentum. Global annual shipments are projected to surpass 6.3 million units by 2030, serving as a core enabler for smart yard ecosystems.

The rapid rise of pool robots[1] is fueled by overarching smart-home trends: intelligence and ecosystem integration define the direction of smart-home evolution. Breakthroughs in AI technology have greatly enhanced autonomous devices. Meanwhile, all-in-one ecosystem solutions break functional silos of standalone hardware and enable multi-scene, multi-device collaborative operation. This trend, already well-established for indoor use-cases, is rapidly expanding to the still-maturing outdoor segment. Traditional yard management — heavily reliant on manual labor and limited-function hardware — can no longer satisfy user demands. A smart-ecosystem revolution for Yard cleaning is underway. Integrated intelligent upgrades covering pool cleaning, lawn maintenance and smart irrigation represent the new industry direction.

The history of cleaning-robot development began indoors. In the early 2000s, iRobot launched its first consumer robot vacuum, marking the arrival of smart cleaning robots in households and opening the market for domestic intelligent cleaning devices. Over more than 20 years of iteration, home cleaning robots have evolved from random-pattern

*1. The "pool robot" is an abbreviation for pool cleaning robot. It refers to an intelligent underwater cleaning device that autonomously cleans the water surface, pool walls and pool bottom and performs related water quality management tasks, replacing manual labor in daily pool maintenance.

cleaning to smart hardware equipped with path-planning, AI-based visual recognition and intelligent obstacle-avoidance capabilities. Today the market exceeds USD 17.7 billion with global shipments of 32 million units. Technologies are highly mature, and these robots are deeply embedded within whole-home smart ecosystems to deliver scenario-based interoperability with other household devices.

Nevertheless, extending smart-cleaning capabilities from indoor spaces to outdoor yard is far from a simple technology port. Real-world constraints specific to outdoor environments explain why smart yard ecosystem development lags behind indoor smart homes:

- **Differences in environmental complexity:** Open-air outdoor conditions are subject to multiple variables including weather, terrain, lighting and underwater signal attenuation. Device protection ratings, communication standards and energy-consumption schemes cannot be directly reused from indoor ecosystems.
- **Differences in category maturity:** Smart yard applications span cleaning, irrigation, lawn care, security and other vertical segments. Each follows distinct technical paths and matures at uneven rates. Unified standards for ecosystem-level interoperability are yet to emerge; the industry still prioritizes functional improvements for individual products.
- **Differences in user-adoption stages:** Today's smart yard equipment buyers primarily value tool-grade performance that replaces manual work. Demand for scenario-driven multi-device interoperability has not yet scaled, prolonging the ecosystem-nurturing cycle.

Against this industry backdrop, smart robotic pool cleaners — the flagship category extending cleaning-robot technology outdoors — have entered a phase of rapid iteration. Driven by technical advances and improvements in global supply chains, innovative global robotic pool cleaner brands such as Aiper have emerged as new-generation industry leaders.

Rising ownership of private residential pools, especially across North America and Europe where swimming pools have become standard features for mid-to-high-end households, continuously fuels market demand and accelerates iteration for this outdoor cleaning category. Pool-cleaning and lawn-maintenance robots now constitute core growth drivers for the outdoor-robot market. IDC data shows global shipments of robotic pool cleaners exceeded 4.2 million units in 2025 and are forecast to top 6.3 million units by 2030. The vigorous growth of pool-cleaning robots unlocks new possibilities for outdoor smart cleaning. These products bring proven indoor-sector technologies including AI vision, path-planning and autonomous navigation into complex outdoor settings, delivering reusable technical frameworks and market insights for intelligent lawn-mowers, irrigation systems and other smart yard hardware. They also push smart-cleaning ecosystems outward from indoor living spaces toward broader outdoor environments.

From a macro perspective, the smart-home sector is transitioning from “standalone-device intelligence” toward “ecosystem intelligence”. User expectations have evolved beyond convenience delivered by individual devices toward holistic, integrated multi-scene smart experiences. Indoors, robot vacuums, air purifiers and other appliances interoperate within well-established unified ecosystems and consistent user interfaces. By contrast, outdoor yards — vital extensions of residential living space — remain relatively under-intelligent. Pain points include fragmented hardware, cumbersome workflows and limited smart functions. This intelligence gap between indoor and outdoor settings creates substantial opportunities for smart yard ecosystem development and propels the industry from “indoor-only smart homes” toward “full-domain intelligence”.

CHAPTER 2

Users Expect Effortless Automation and Seamless Integration

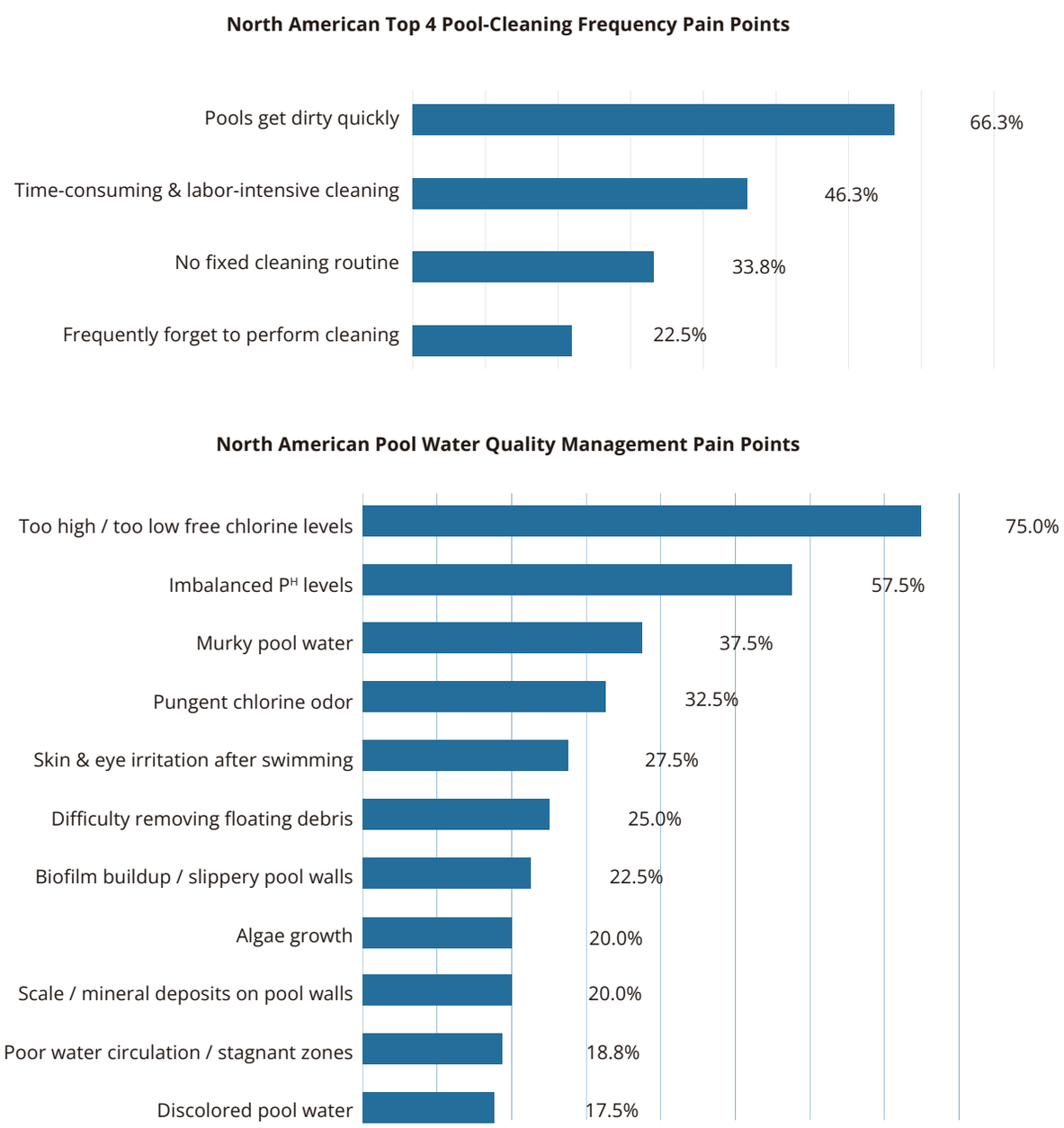
Numerous pain points persist for users' pool cleaning and yard irrigation. According to recent IDC research, over 86% of buyers cite ease-of-use as a core purchasing criterion for pool robots. Smart yard-irrigation products have attracted substantial user attention. Mid-to-high-end users place higher requirements on convenience and intelligence for yard management. More than 40% of early-adopter customers are already seeking ecosystem-based smart yard solutions with multi-device interoperability. They hope technical innovation can eliminate tedious manual yard upkeep and deliver carefree, labor-saving and high-efficiency outdoor living.

2.1 Core Pain Points: Users Aspire for Zero-Intervention Operation

Pool-Cleaning Pain Points

Pool maintenance ranks among the most time-consuming, labor-intensive yard chores. Conventional approaches such as manual skimming and manual pool vacuums demand considerable time and physical effort yet yield inconsistent cleaning results. More than 70% of users clean their pools at least once per week. Meanwhile, 66% of respondents report floating debris such as fallen leaves and insect carcasses rapidly spoil pool water quality, forcing them to clean more frequently. 46% describe pool upkeep as overly time-intensive, and over one-third lack consistent regular-cleaning routines. Water-quality management represents another major user headache. IDC research indicates most users struggle to accurately assess pool-water conditions. They must manually test parameters including pH and free-chlorine levels, while dosing chemicals is difficult to calibrate, frequently leading to over-dosing or incomplete sanitization.

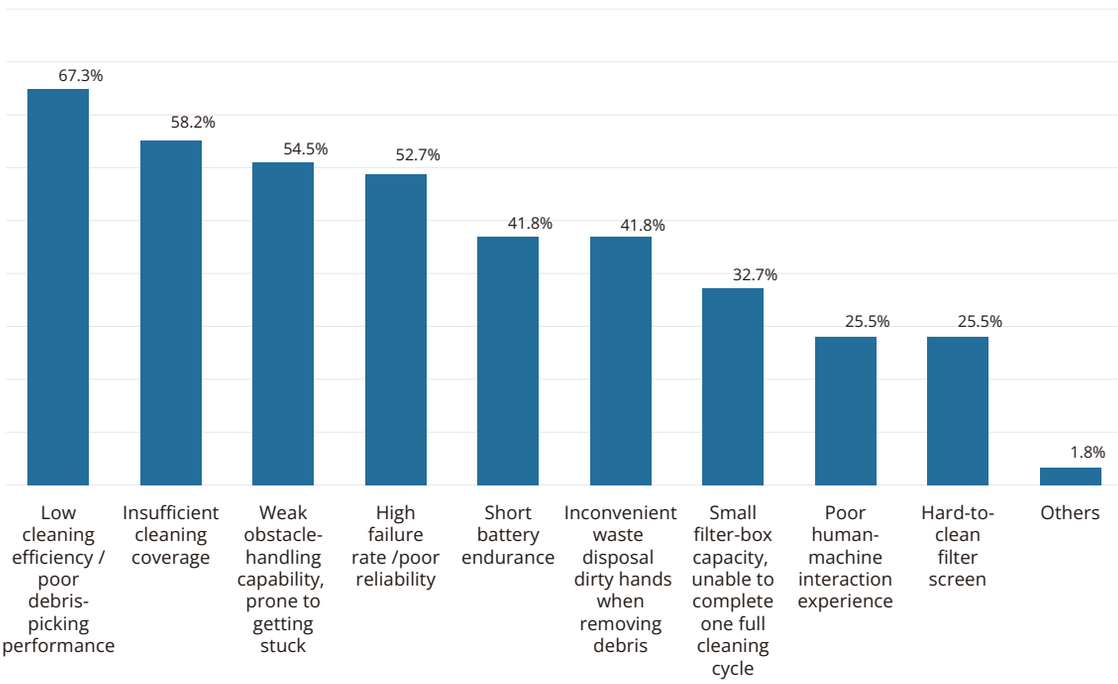
Figure 1: Core User Pain Points for Pool Cleaning



Source: IDC, 2026

When using robotic pool cleaners, insufficient cleaning performance tops user frustrations: 67% report poor cleaning efficiency and 58% complain about incomplete coverage. Corners, steps and drain openings are commonly missed zones. Battery runtime is another critical pain point: 51% of users state many existing robots cannot finish cleaning large-sized pools in one cycle and require frequent recharging, hurting user experience. Furthermore, 82% of users identify automatic return-to-dock for recharging as a high-priority feature to minimize manual intervention.

Figure 2: Core User Pain Points for Robotic Pool Cleaners



Source: IDC, 2026

"I currently monitor water quality manually. I use cameras to observe water conditions remotely plus a small device to test pool chemistry. It would be really awesome if a pool-cleaning robot integrated water-quality monitoring. That would truly free me from manual work."

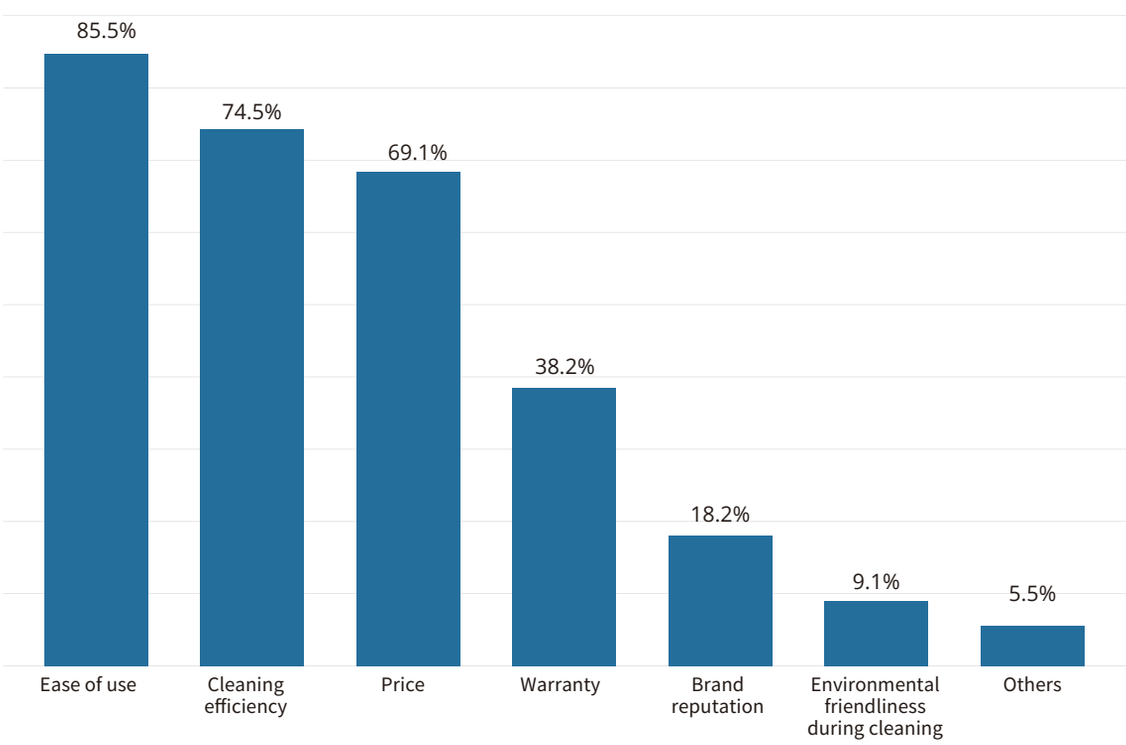
— A private pool owner, Germany

2.2 Meeting Core Requirements: Optimization for Intelligent Experiences and App-Based Control

Purchasing drivers for pool-robot buyers follow a clear priority ranking: ease-of-use (86%), cleaning efficiency (75%), price (69%). Ease-of-use extends far beyond simple operation and inherently includes intelligence-related expectations. Users want hardware to minimize on-site supervision and hands-on adjustments to deliver effortless, effective cleaning. Concrete demands include autonomous path-planning, one-touch activation, remote control and intelligent obstacle avoidance.

User expectations for intelligence also cover multi-function integration across cleaning scenarios. Over 87% of respondents want a single device capable of full-scope cleaning: pool surface, floor, walls and waterline without needing multiple separate units. 75% hope robotic pool cleaners incorporate water-quality monitoring for combined “cleaning plus water-quality management”, advancing toward the zero-intervention ideal.

Figure 3: Core Purchase Decision-Making Factors for Robotic Pool Cleaners



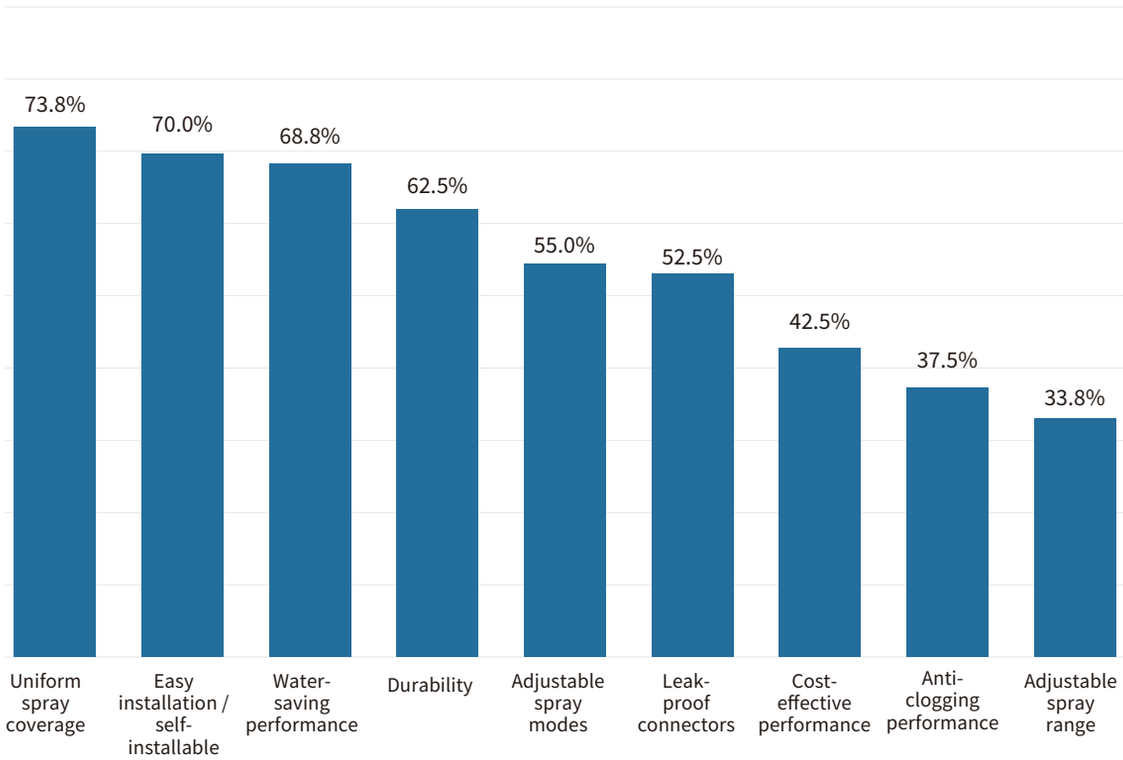
Source: IDC, 2026

Mobile applications constitute a critical carrier of smart-device experiences; app quality heavily shapes user perceptions of usability and exposes gaps between user expectations and real-world performance. IDC survey data shows 36% of deployed pool robots lack app connectivity. Even among users with app-compatible robots, only 28% regularly use the app. Common complaints include unstable connections, clunky workflows and missing intelligent cleaning scheduling capabilities. In terms of desired app features, 82% want anytime-anywhere remote control; 68% expect customizable cleaning schedules; 64% wish to view real-time cleaning status. These demands correspond directly to current app-experience shortcomings and define key improvement directions for smarter robotic pool-cleaner experiences.

2.3 Expanded-Scenario Expectations: Ecosystem-Driven Collaboration from Swimming Pool to Smart Yard

As users pursue more sophisticated yard care, demand for smart-irrigation systems keeps rising. Traditional irrigation wastes water, delivers uneven watering and involves cumbersome workflows, yet over 68% of households still rely on conventional irrigation methods. IDC research identifies the top buying considerations for irrigation-product purchasers: uniform water distribution (74%), easy deployment (70%), water-use efficiency (69%), durability (63%) and adjustable watering modes (55%). Nearly 95% of users hold positive attitudes toward smart-irrigation systems. Core value lies in automatic adjustment of watering duration and volume responding to plant-growth requirements and weather changes — perfectly matching the owner's needs. Specifically, 84% want irrigation systems that dynamically optimize schedules based on weather forecasts; 71% expect rain-sensor functionality; 68% look for remote app-based operation. Zone-specific control and water-consumption monitoring are also highly desired smart-irrigation capabilities.

Figure 4: Key Concerned Functions for Smart Irrigation Users



Source: IDC, 2026

Early-adopter smart yard consumers are no longer satisfied with isolated smart-hardware performance. They desire holistic yard solutions covering pool cleaning, lawn maintenance, smart irrigation and water-quality management. Survey results show 63% of high-end yard owners prefer brands delivering all-in-one smart-yard offerings. Their primary goal is coordinated multi-device operation under unified management, eliminating the hassle of juggling multiple apps and maintaining separate pieces of

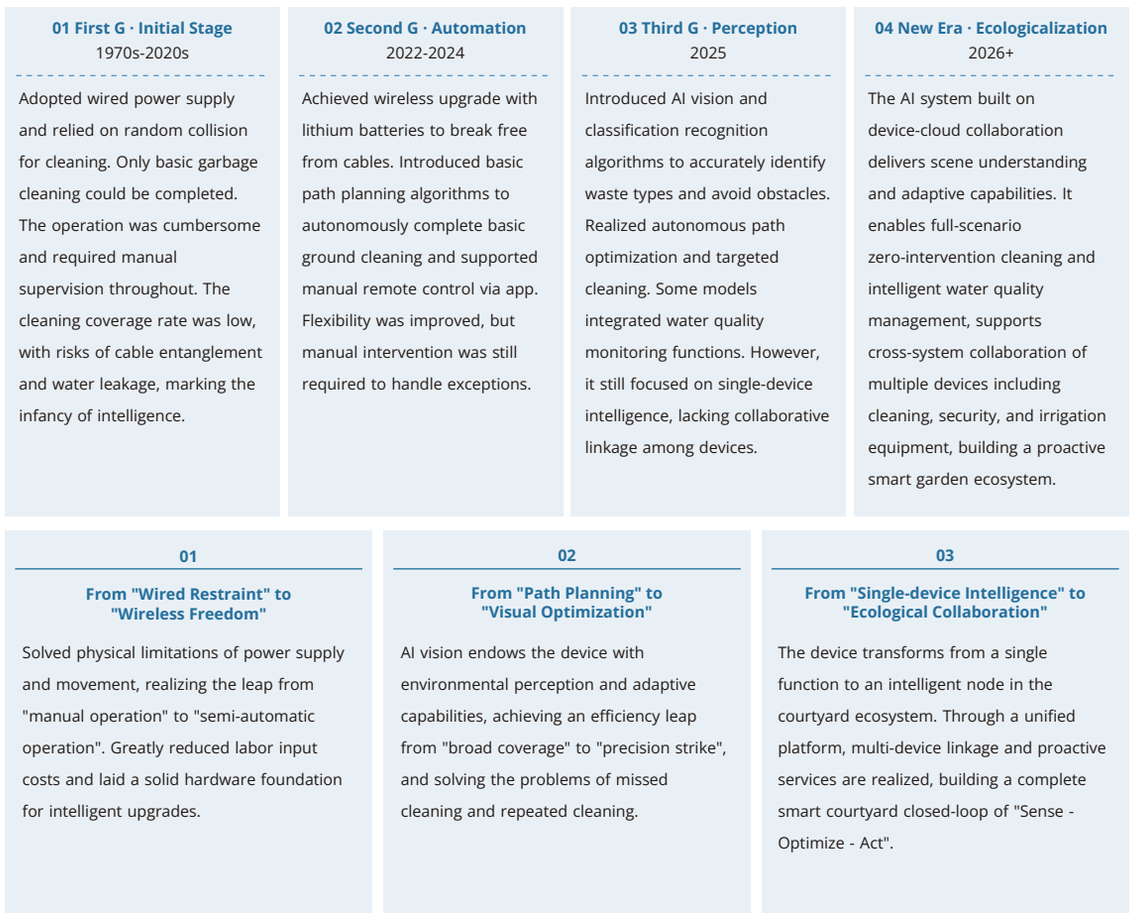
> "A holistic ecosystem solution would be fantastic. Integrating pool cleaning, lawn mowing and irrigation would be like moving from smart homes to smart courtyards. I'm really excited about that scenario."
>
> — Mike Lewis
> Manager of pool cleaning business, United Sates

CHAPTER 3

Evolution of Smart Yard Technology: From Standalone-Device to Ecosystem Intelligence

3.1 Evolution of Smart Yard Technology — A Case Study of Pool Robots

Figure 5: Roadmap of Smart Yard Technologies Evolution



Source: IDC, 2026

1G to 2G: Wireless Technology Delivers Initial User Liberation

Around 2022, companies led by Aiper launched commercially available lithium-battery-powered robotic pool cleaners. These fundamentally resolved classic pain points of wired equipment: cable tangling, limited operating range and electric-safety hazards. Users no longer needed to physically manage cables, greatly improving usability. However, limitations persisted. Most units adopted gyroscope-odometer inertial navigation with low path-planning accuracy; roughly 30% retained random-pattern cleaning logic, yielding

average cleaning coverage below 80%. Lacking fault-handling capabilities, robots trapped or overturned could not self-recover and demanded human oversight. User priorities shifted from “getting rid of cables” toward “can the hardware complete full cleaning cycles independently”.

2G to 3G: AI Vision Powers Perception-Driven Standalone Intelligence

Equipped with monocular or binocular vision sensors and classification algorithms, third-generation pool robots accurately identify typical pool debris (fallen leaves, pebbles, hair clumps etc.) and obstacles (ladders, drain outlets). SLAM technology builds three-dimensional pool maps and computes optimal cleaning routes, lifting industry average cleaning coverage above 95%. Premium models from leading manufacturers incorporate combined pH-turbidity sensors for real-time basic water- quality readouts.

Nevertheless, intelligence remained confined to “perception and execution on individual hardware”, constrained by instruction-driven-AI paradigms:

- **At device level**: Robots execute pre-programmed workflows or user commands. They cannot dynamically adjust cleaning intensity or frequency based on actual debris volume, nor extend cleaning cycles responding to deteriorating water quality.
- **At ecosystem level**: Siloed standalone-device architectures create incompatibility across hardware. Pool cleaners, lawn-care robots and irrigation systems require separate mobile applications, resulting in heavily fragmented user experiences.

Insufficient intelligence at the individual-device level plus disjointed ecosystem-level performance created strong end-user demand: “Can the system decide when and how to clean, so I do not need to manage my yard?” This market pull drives the industry toward fourth-generation ecosystem intelligence.

3G to 4G: "Adaptive AI + Device Collaboration" Build Ecosystem Intelligence

Breakthroughs in adaptive AI technology together with unified ecosystem-platform architecture enable transformative advances for smart yards. On one hand, adaptive AI systems equip hardware with environmental awareness and optimization capabilities. Leveraging debris distribution, water-quality changes, weather conditions and user habits, systems autonomously create and adapt operating strategies in real time. On the other hand, standardized device communication protocols and unified management platforms deliver interoperability across categories and hardware vendors. Users control all smart yard hardware within one single application to access complete all-in-one smart yard solutions and achieve genuine zero-intervention yard management.

Limitations of each technology generation define innovation opportunities for the next. First-generation cable dependencies, second-generation path-planning shortcomings and third-generation standalone-intelligence bottlenecks all propel industry progress. Most notably, third-generation "isolated smart devices" fragment user workflows and fail to satisfy demand for holistic multi-scene management. This opens key market opportunities for fourth-generation ecosystem intelligence, where adaptive AI and ecosystem integration provide the technical solution.

3.2 Adaptive AI: The Core Tech Engine for 3G-to-4G Transition

From Instruction-Executing Technology to Adaptive AI: Fundamental Paradigm Shift

Legacy technology deployed within 3rd-Gen products operates fundamentally as instruction-executing technology, built around "passive response plus fixed rules". Hardware completes predefined tasks triggered by user inputs or preset threshold values. It cannot interpret underlying scene-level requirements or learn optimizations from historical datasets. For instance, third-generation pool robots clean along fixed grid trajectories regardless of actual debris load, applying identical speed and cycle counts. When encountering unlisted obstacles, they simply detour without attempting alternative strategies.

By contrast, adaptive AI delivers active-decision-making paradigms, built on a complete "Sense - Analyze - Optimize - Act" closed-loop workflow. Multi-sensor fusion collects comprehensive scene data. With historical records and user-behavior models, systems autonomously interpret situational requirements, to refine movement logic, generate and dynamically tune optimal operating strategies. This shift transforms generic uniform cleaning into personalized on-demand services, marking the most essential distinction between third- and fourth-generation technologies.

Key Application Scenarios for AI in Smart Yard Technology

- **Pool-cleaning scenarios:** Multi-modal sensing (vision+pressure+water-flow sensors) identifies debris categories and contamination severity to dynamically adjust cleaning parameters. Heavily soiled areas with persistent algae trigger high-pressure scrubbing and extra cleaning cycles; light floating leaves activate fast sweep-and-suction modes; sediment-heavy zones trigger reduced travel speed with increased suction power.
- **Water quality management scenarios:** Using data from multi-parameter sensors and historical water quality trends, AI autonomously identifies causes for water quality degradation and generates targeted treatment plans. For example, detecting low free-chlorine together with elevated pH enables computed dosing requirements for sodium hypochlorite and hydrochloric acid, which can trigger connected automatic chemical-dosing hardware. Early warning signals for cyanobacteria blooms activate pre-emptive sanitization and send user alerts.
- **Smart irrigation scenarios:** Real-time weather feeds, soil-moisture-sensor readings and plant-growth models inform adaptive irrigation strategies. Irrigation schedules are automatically cancelled ahead of forecast rainfall; watering frequency rises under hot drought conditions; zones with different vegetation receive customized water volumes to maximize water savings.

- **User habit learning:** Analysis of historical-operation logs identifies usage patterns and adapts system behavior accordingly. For example, after detecting pool-usage every Saturday afternoon, the system automatically reschedules cleaning for Saturday mornings. If users exhibit noise sensitivity, high-power operations are scheduled for times when residents are away from home.

Technological Value of Adaptive AI

Adpative AI delivers three core layers of value:

- **Environmental awareness capability:** Overcoming "execute-without-comprehending" limitations of conventional technology. Hardware interprets situational context and user intent, evolving from pure tools into intelligent assistants.
- **Continuous optimization capability:** Algorithms improve over time using scene-data collection plus user feedback. Devices grow smarter and better aligned with user preferences through operation.
- **Foundation for ecosystem collaboration:** Provides a unified ecosystem for coordinated multi-device optimization, synthesizing data and capabilities across disparate hardware to deliver globally optimized outcomes — the core technical underpinning of fourth-generation ecosystem intelligence.

3.3 Key Technical Breakthroughs

Underwater Acoustic-Communication Technology

Underwater acoustic-communication constitutes a cornerstone technology enabling stable underwater connectivity and cross-device collaboration for pool robots. It mitigates severe radio-frequency-signal attenuation underwater, insuring reliable wireless transmission. This technology combines FSK (Frequency-Shift Keying) and OFDM (Orthogonal Frequency-Division Multiplexing) modulation schemes, transferring data through acoustic-wave propagation within water. Algorithms are tuned specifically for acoustic properties of pool environments; adaptive noise-reduction filters out

interference generated by water pumps and water currents. In standard-pool conditions: bit-error rate $<10^6$ within six meters at 300 bps (with forward-error correction coding); bit-error rate $<10^5$ within three meters at 1000 bps. The hardware features low-power consumption: standby draw <1mW, active operating draw <50mW, supporting pools of varying sizes and turbidity levels.

User value: Underwater acoustic-communication enables precise remote robot control even when units rest on the pool floor. Operators no longer need to retrieve robots manually to adjust settings. It also supports real-time data exchange and command- level coordination between pool-cleaning robots, underwater water quality sensors and automatic chemical-dosing devices. For example, once water quality sensors detect localized water quality anomalies, acoustic-communication commands direct the pool robot to perform focused cleaning and on-site water quality sampling in the target zone.

Low-Carbon Energy Management Solutions

Low-carbon energy management technology optimizes energy efficiency and battery runtime, aligning with global low-carbon trends and addressing well-documented pain points of insufficient pool-robot runtime and frequent recharging. High-efficiency brushless DC motors plus hydrodynamically optimized impeller designs cut operational power draw by more than 25%. High-density lithium-iron-phosphate batteries paired with intelligent BMS (Battery-Management System) further boost capacity and safety. Intelligent energy-management algorithms dynamically allocate power budgets based on operating modes (cleaning / standby / sensing) and task priority. For instance, robots enter low-power standby between cleaning passes and boost power output in high-debris zones for optimized energy utilization.

User value: Typical runtime increases from two hours (second-generation hardware) to over four hours, enabling complete single-cycle cleaning for pools up to $150m^2$. Solar-assisted charging reduces grid-power draw, cutting annual electricity costs by approximately USD7-12 while improving environmental sustainability. Smart power management prevents cleaning interruptions caused by depleted batteries and enhances user experience.

Intelligent Water Quality Management Technology

Intelligent water quality management technology forms a core supporting capability of smart-pool systems, resolving burdens and inaccuracies of manual water quality testing and experience-based chemical dosing. High-precision multi-parameter sensors simultaneously measure detect five key water quality indicators: pH (±0.02 accuracy), ORP (oxidation-reduction potential), EC (electrical conductivity), TDS (total dissolved solids) and water temperature (±0.5℃ accuracy). Residual chlorine concentration can be accurately derived from ORP readings via algorithms, replacing conventional manual detection methods. Combined with AI algorithms and water quality-prediction models, systems evaluate water quality conditions from real-time measurements plus historical trends, compute precise chemical-dosing volumes and generate remediation recommendations. Modules can interface with automatic chemical-dosing hardware for automated, accurately calibrated chemical dispensing. Long-term data logging and analysis produce monthly or quarterly water quality reports and deliver actionable maintenance guidance.

User value: Users avoid manual testing and manual chemical-dose calculation.

Hardware autonomously monitors and optimizes water quality, eliminating skin irritation and poor water quality stemming from incorrect chemical dosing. Water quality metrics sync in real-time to mobile-app interfaces for remote visibility without on-site inspection. Stable long-term water quality reduces pool-water replacement frequency and manual-maintenance workloads while improving swimming safety.

3.4 Ecosystem Integration: The Inevitable Outcome of Technical Progress

Limitations of Standalone-Device Intelligence

Rising user expectations for smart yard-system intelligence expose growing drawbacks of isolated-hardware deployments, which fail to satisfy demands for holistic end-to-end yard care:

- **Functional fragmentation:** Each device fulfills only dedicated tasks. For example, pool-cleaning robots only execute cleaning and cannot handle water quality monitoring or safety surveillance. Households must purchase multiple separate units, raising procurement and maintenance burdens.
- **Operational fragmentation:** Hardware from different brands and product categories employ proprietary communication protocols and separate mobile applications. Users juggle multiple apps, creating complex workflows and steep learning curves.
- **Scenario fragmentation:** Devices operate independently without scenario- based linkage or global optimization. Illustrative pain points: pool-cover systems cannot activate automatically upon cleaning completion; irrigation systems are not shut down during rainfall; pool-circulation runtime is not adjusted responding to water quality anomalies.

These three layers of fragmentation demand fundamental architecting at system level. Ecosystem integration is not mere hardware aggregation. It requires end-to-end alignment spanning technical protocols, management platforms and AI-driven coordination. This builds up unified ecosystems to support data sharing and coordinated command execution. This transition moves smart yard technology from “device-level intelligence” into “system-level intelligence”, delivering minimal-intervention.

Core Technical Implementation Pathways

The Smart Yard Ecosystem runs on its own loop: Sense – Analyze – Coordinate – Unify. Three layers underpin smart yard ecosystem realization:

- **Unified technical protocols:** Standardized device-communication specifications enable data exchange and coordinated command execution across diverse smart-yard hardware, dismantling information silos between devices.

- **Centralized management platform:** A single mobile-app interface delivers consolidated control, data visualization and parameter configuration for pool-cleaning, smart-irrigation and water quality-monitoring hardware to streamline user workflows.
- **AI-powered ecosystem:** Systems autonomously orchestrate multi-device collaborative workflows responding to changing conditions and user priorities. For instance, weather forecasts trigger pre-emptive pool cleaning to avoid debris accumulation ahead of rain while concurrently adjusting irrigation schedules for optimal resource allocation. Cloud-platform infrastructure supports cloud-side data storage and analytics to generate personalized yard care recommendations.

User-Facing Value Created through Ecosystem Integration

Ecosystem-integration technology creates measurable improvements across time-saving, cost-reduction and experience dimensions.

- **Time savings:** Users are freed from multi-app operations, manual water quality testing and parameter tuning. Weekly time spent on yard upkeep drops by 4-6 hours to realize zero-intervention management.
- **Cost savings:** Multi-device collaboration improves energy efficiency, lowering annual yard maintenance expenditure (electricity, pool chemicals, servicing) by 20-30%.
- **Enhanced user experience:** Holistic consolidated workflows simplify operation, raise overall intelligence and convenience for yard care, boosting quality-of-life by reducing tedious chores and enabling residents to enjoy outdoor spaces.

Iterations for smart yard products are driven not purely by technology advances but by evolving user demands for convenience and intelligence. Every upgrade from first-generation wired cleaning hardware through to fourth-generation ecosystem intelligence originates from solving real-world user pain points. Breakthroughs in adaptive AI together with ecosystem-integration progress lift performance of individual devices while reshaping yard care paradigms. Effortless smart yard living becomes achievable, ushering the industry into a brand-new development phase.

CHAPTER 4

Aiper, a Pioneer of the Smart Yard Ecosystem

As the leader in smart robotic pool cleaners, Aiper is advancing intelligent outdoor living through continuous innovation centered on real-world user needs. With more than four million users worldwide, Aiper has built extensive expertise in cordless robotics, AI-powered cleaning, underwater communication, and smart automation. As smart yard technology evolves from standalone-device intelligence toward ecosystem-level intelligence, Aiper is pioneering two complementary approaches: **Adaptive AI**, enabling devices to understand their environment and make adaptive decisions, and **Aiper Intelligence of Things (AIoT)**, enabling connected devices to share information and coordinate operations. Together, these innovations form the foundation of the **Aiper Smart Yard Ecosystem**, designed to simplify outdoor maintenance and create a more reliable, efficient, and carefree living experience.

4.1 Adaptive AI Technology

Aiper is applying adaptive AI to robotic pool cleaning, advancing the industry beyond predefined cleaning patterns toward intelligent, adaptive maintenance. Unlike conventional robotic cleaners that primarily follow fixed routes, Aiper's adaptive AI operates through a continuous **Sense–Analyze–Optimize–Act** process. Through substantial R&D investment, Aiper continuously optimizes AI algorithms using large volumes of real-scenario data, 3D-modelling resources, and large-model training data. Algorithms accurately analyze scene shifts and users' operational history to compute optimal autonomous operating strategies.

Aiper has launched a complete adaptive AI-enabled product portfolio for pool maintenance: the Aiper AI Series robotic pool cleaners, including the Scuba V Series and its **Scuba V3 and Scuba V3 Ultra** models, making intelligent cleaning accessible to consumers with different needs and budgets. The Scuba V3 Ultra, an AI-powered 6-in-1 robotic pool cleaner, demonstrates the practical application of this technology. Equipped with dual-camera AI vision, VisionPath™ 2.0 navigation, and AI Navium™ Mode, it recognizes more than 20 types of debris and obstacles, intelligently targets debris, and adapts cleaning routes in real time. Its AI-powered targeted cleaning is up to 10 times

faster than conventional route-based cleaning, improving efficiency while reducing unnecessary movements.targeted cleaning is up to 10 times faster than conventional route-based cleaning, improving efficiency while reducing unnecessary movements.

Beyond cleaning efficiency, its adaptive AI capabilities also analyze pool size, weather conditions, and cleaning history to optimize cleaning frequency and intensity, supporting up to seven days of hands-free maintenance. This represents an important shift from individual cleaning cycles toward more proactive, personalized pool care.

Aiper further extends AI-powered pool maintenance through **EcoSurfer Senti**, an intelligent robotic pool skimmer that combines AI surface patrol cleaning with water quality monitoring and management capabilities. By integrating debris detection, intelligent cleaning, and water quality insights, Aiper is expanding the role of robotics beyond cleaning alone toward more comprehensive pool care.

Through continued innovation in AI vision, intelligent navigation, and automated maintenance, Aiper is demonstrating how adaptive AI can address practical consumer challenges. Its expanding AI-powered portfolio provides a technological foundation for more connected and intelligent pool and yard care.

4.2 Leader of Smart Yard Ecosystem Solutions

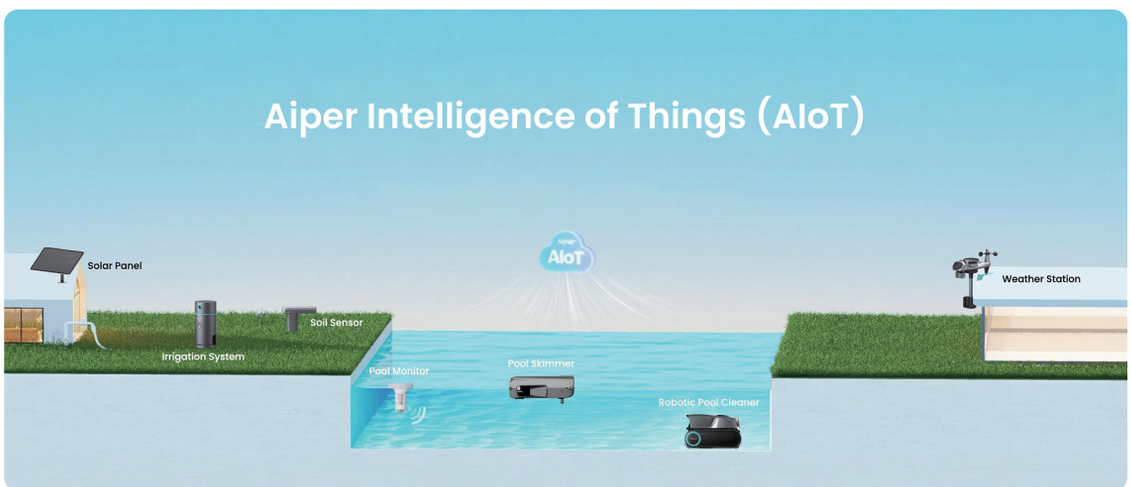
Building on its expertise in intelligent pool cleaning, Aiper is expanding beyond individual devices to develop the **Aiper Smart Yard Ecosystem**, an integrated approach to outdoor maintenance spanning pool cleaning, water quality management, smart irrigation, and connected outdoor equipment.

Powered by Aiper Intelligence of Things (AIoT), the ecosystem connects devices through shared data, centralized management, and AI-driven coordination. A unified app experience simplifies outdoor care, enabling smarter, more seamless operations across compatible devices.

At the architectural level, Aiper's ecosystem follows a **Sense–Analyze–Coordinate–Unify** framework. Connected devices and environmental sensors collect information about weather, soil conditions, and pool status, while the system also incorporates user

preferences. AI-powered analysis interprets these inputs to identify maintenance needs and optimize operating strategies. Device-cloud collaboration enables operational data exchange and coordinated actions across connected devices, while the Aiper app provides a centralized interface for monitoring, control, and personalized management. This architecture supports the transition from device-level automation toward system-level intelligence.

Figure 6 Aiper AIoT Intelligent Ecosystem



Source: IDC & Aiper, 2026

Aiper's expanding product portfolio provides the hardware foundation for this ecosystem. In pool maintenance, its Scuba robotic cleaners and EcoSurfer skimmers deliver intelligent cleaning across underwater and surface environments. In garden care, Aiper introduced **IrriSense 2**, the world's first 4-in-1 multi-zone smart irrigation system, integrating an irrigation controller, sprinkler, valve, and nutrient feeder. Its EvenRain™ technology simulates natural rainfall for uniform water distribution, while customizable irrigation zones and weather-responsive scheduling help reduce water consumption by up to 40%. **The IrriSense 2 SE** further extends these capabilities through a more accessible 3-in-1 solution, combining a controller, sprinkler, and valve.

Beyond these core products, Aiper is developing connected infrastructure including weather stations and soil sensors. These technologies enable greater environmental awareness and information sharing, supporting more responsive maintenance strategies across the yard.

The ecosystem's value lies not simply in connecting devices, but in enabling them to work together to manage day-to-day yard care autonomously. For example, weather forecasts and soil moisture readings can inform irrigation adjustments, reducing unnecessary watering before rainfall. Pool conditions and cleaning history can support more adaptive maintenance schedules, while centralized monitoring allows users to manage multiple outdoor systems through a single interface. As device interoperability and AI capabilities continue to evolve, these interactions provide a pathway toward more automated, resource-efficient outdoor management.

Through the integration of adaptive AI and AIoT, Aiper is advancing a broader transformation in smart yard technology: **from isolated devices to connected systems, and from passive maintenance to proactive, intelligent care.** By combining intelligent hardware, shared data, and coordinated automation, the Aiper Smart Yard Ecosystem aims to reduce maintenance complexity, improve resource efficiency, and give households more time to enjoy their outdoor spaces.

This approach reflects Aiper's long-term commitment to making intelligent technology practical, reliable, and accessible—bringing its brand promise, **"Bring Vacation Home,"** into the next era of smart outdoor living.

IDC Custom Solutions

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