HOW DEVELOPMENTS IN SMART GLASSES AND VISUAL TECHNOLOGIES ARE TRANSFORMING SOCIETY

— EXPECTATIONS AND OUTLOOK FOR THE SPATIAL COMPUTING MARKET —

Takahide Aoyagi
Industrial Research Dept., Industrial & Social Studies Div.
Mitsui & Co. Global Strategic Studies Institute

SUMMARY

- The global spatial computing market is projected to grow from USD 165.3 billion in 2024 to USD 620.2 billion by 2032, making it a closely watched sector.
- The evolution of smart glasses is closely tied to technological advancements in the devices themselves. In particular, significant progress is being achieved in the three areas of sight, speech, and touch.
- The industrial structure of spatial computing comprises multiple layers, ranging from hardware to services. Within this structure, business opportunities in spatial computing are expected to include not only movement-path analysis, but also subsequent areas such as field-of-vision and gaze analysis, associated database creation, and IT system development services built around physical objects.

1. RENEWED ATTENTION ON SMART GLASSES AND THE STATE OF EXISTING INDUSTRIES

In recent years, smart glasses have once again come under the spotlight, and expectations for spatial computing have been rising. More than a decade has passed since the debut of Google Glass in 2012, which gained a lot of attention, and the market environment for smart glasses has undergone rapid change driven by technological innovations, including the emergence of generative AI.

1-1. HISTORY AND CURRENT STATUS OF HEADSET TECHNOLOGY

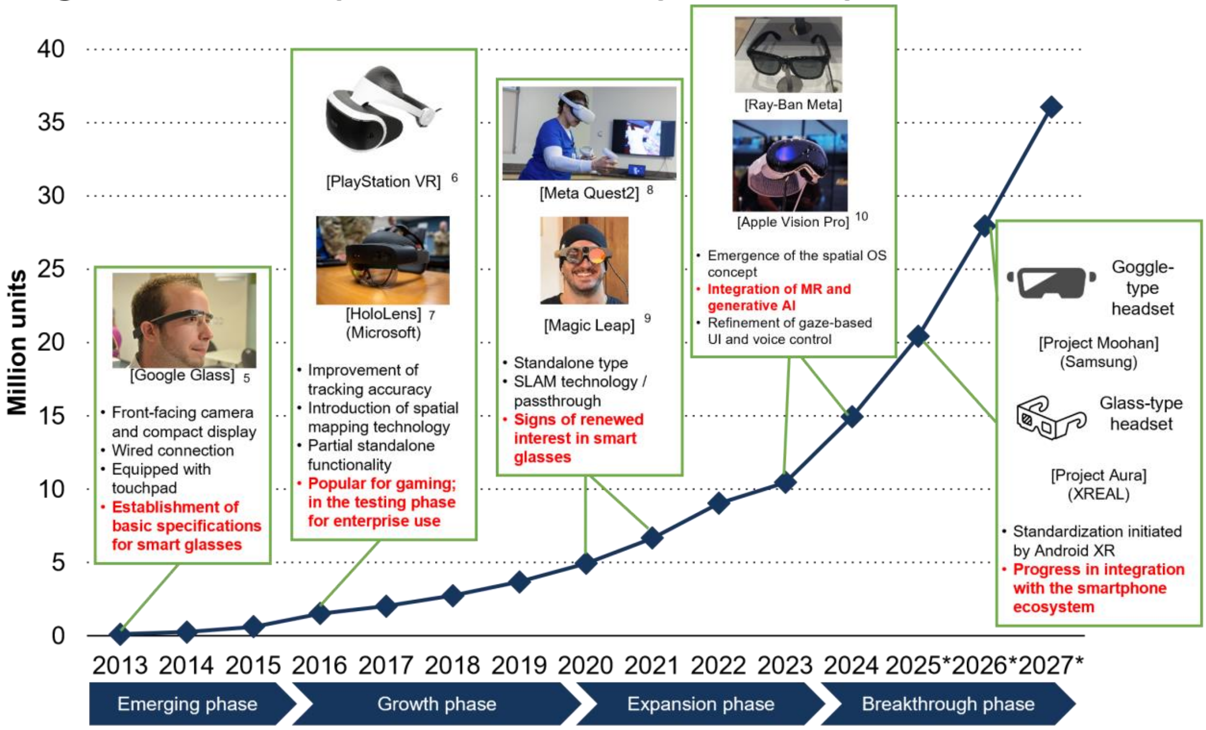
Spatial computing refers to a group of technologies that integrate digital information into physical space, allowing users to view and interact with digital content in physical space. It centers on 3D data processing that goes beyond traditional screens. The core device of this technology is the headset. A headset is a general term for head-mounted displays, which include smart glasses and goggle-style displays. In recent years, these have evolved into distinctive devices that transform the user's field of vision and experience through AR[1], VR[2], and

[1] Augmented Reality: A technology that overlays computer-generated visuals or images onto the real world in front of the user, thereby enhancing the real-world environment (Source: Ministry of Internal Affairs and Communications, Information and Communications in Japan WHITE PAPER 2021)
[2] Virtual Reality: A technology that uses computer graphics to create virtual spaces representing worlds that do not exist in reality or situations that are difficult to experience

MR[3]. Smart glasses also include wearable glasses that do not have AR, VR, or MR functions, but are classified as ER[4] headsets.

In recent years, headsets in the form of smart glasses have gained popularity, and from 2024 onward, the market is expected to enter a phase of accelerated expansion (Figure 1).

Figure 1: Headset shipment volumes and representative products



(Note: * indicates forecast figures)
Source: Compiled by MGSSI based on IDC (Statista), Raysonho / CC0[5], Evan-Amos / Public Domain[6], U.S. Air Force photo / Public Domain[7], Wake Technical Community College / CC0[8], Magic Leap One ©, Horacio Torrendell, 18 Jun 2025 / Licensed under CC BY-SA 4.0[9], author's photos, Apple Vision Pro © LR.127, 31 Aug 2024 / Licensed under CC BY 4.0[10]

1-2. THE HISTORY OF COMPUTING SYSTEMS AND THE IMPACT OF SPATIAL COMPUTING

Devices such as mainframes[11], PCs, and smartphones have defined their respective eras and brought major transformations to society and consumer lifestyles as new computing systems. Now, smart glasses are attracting attention as the next major device in succession to the smartphone (Figure 2).

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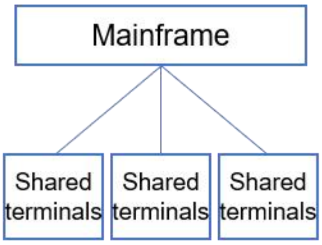
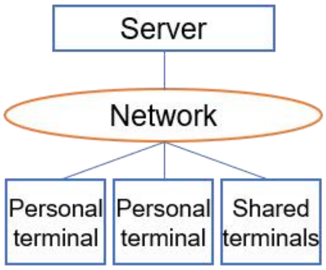
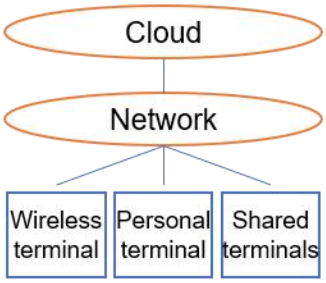
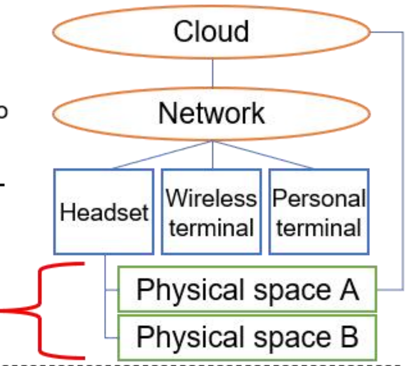
3 Mixed Reality: A technology that combines AR and VR to enable advanced virtual experiences within the physical environment
4 Extended Reality: Transparent or semi-transparent display devices that provide access to external digital content
5 https://commons.wikimedia.org/wiki/File:GoogleGlassMeetup2014.JPG
6 https://commons.wikimedia.org/wiki/File:Sony-PlayStation-4-PSVR-Headset-Mk1-FL.jpg
7 https://commons.wikimedia.org/wiki/File:Through_the_Lens-_NextGen_tech_allows_Airmen_to_be_in_two_places_at_once_(8079273).jpg
8 https://commons.wikimedia.org/wiki/File:Nursing_Lab_VR_Faculty_Spotlight_Kathy_Spade-09.jpg
9 https://commons.wikimedia.org/wiki/File:Magic_Leap_One.jpg
10 https://commons.wikimedia.org/wiki/File:Apple_Vision_Pro_on_display_in_Toronto,_Canada_-_Aug_2024.jpg
11 Large-scale, high-performance computers that support the core systems of major corporations and government agencies

Figure 2: History of computing systems

Era	Representative products	Key features	Computing system diagram
1950–70	Fujitsu FACOM230 (1965) [12] 	• **Centralized architecture** • Shared terminals • Used by a limited number of specialists • Mainly batch processing	
1980–90	IBM IBM-PC (1981) [13] 	• **Personal computing (PC)** • Spread of GUI* • One device per user • Desktop	
2000–	Apple iPhone 3G (2008) 	• **Mobile computing** • Always-on, location-independent connectivity • App economy • Social media integration	
2020–	XREAL Project Aura (2026) [14] 	• Integration with the body and field of view • Information projected onto physical space • Gesture, gaze, and voice-based operation • **Information processing extends to physical space through spatial computing**	

* Graphical User Interface: A user interface that allows operation using visual elements such as icons and buttons on a computer screen

Source: Compiled by MGSSI based on materials from Fujitsu (1965) /Public Domain-Japan [12], User:FA2010/Public Domain[13], SBH/stock.adobe.com, PR TIMES (XREAL, Inc.) [14]

A notable aspect in the evolution of computing systems is that smart glasses redefine the relationship between users and devices. In previous systems, the user was positioned simply as the operator. However, in spatial computing, users input surrounding environmental information based on their movements and field of vision, allowing the smart glasses to acquire, utilize, and process spatial data. As a result, while still being users, individuals also take on a role similar to that of IoT sensors. For this reason, rather than simply being AR glasses

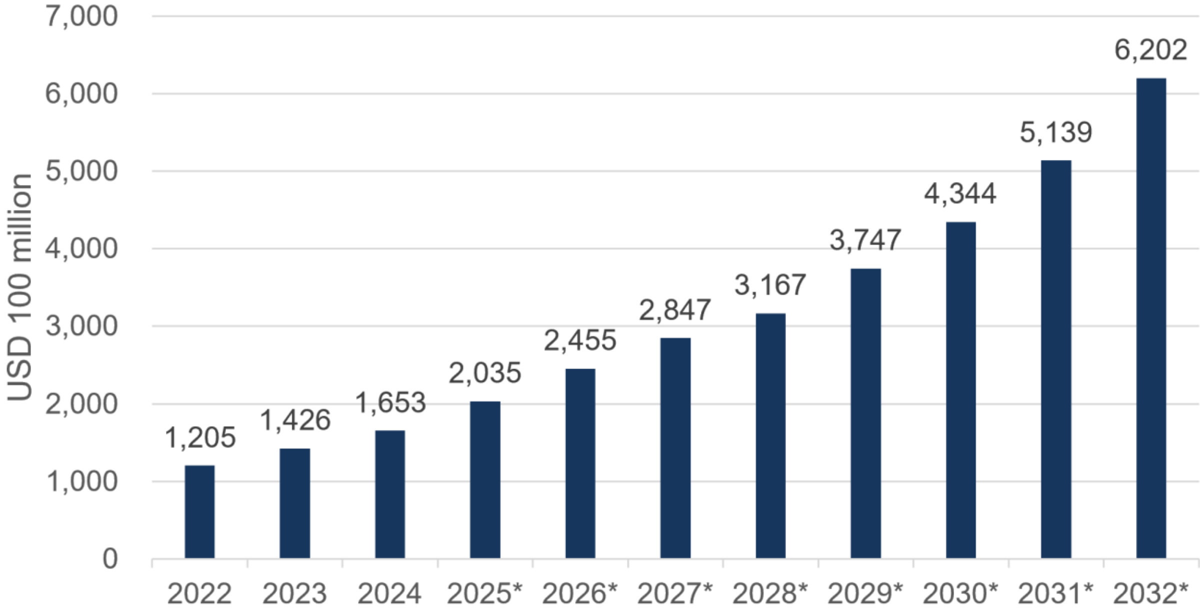
12 https://commons.wikimedia.org/wiki/File:FACOM_230_at_Labor_Market_Center.jpg
13 https://commons.wikimedia.org/wiki/File:IBM_PC_1981_makffm.jpg
14 https://prtimes.jp/main/html/rd/p/000000183.000070978.html

or information display devices, smart glasses can be defined as devices that simultaneously advance the extension of new vision-based human cognitive functions and the transformation of users into IoT-like sensors.

1-3. MARKET SIZE OF SPATIAL COMPUTING AND TRENDS AMONG SMART GLASSES MANUFACTURERS

The global spatial computing market is projected to grow from USD 165.3 billion in 2024 to USD 620.2 billion by 2032, making it a closely watched sector (Figure 3).

Figure 3: Global spatial computing market size (2022–2032)



Note: * indicates forecast figures)
Source: Compiled by MGSSI based on Statista data

Companies driving this market can generally be divided into two categories. The first consists of integrated providers involved in everything from hardware and operating systems to software and solutions. This includes the 'Big Tech' and global electronics manufacturers, which are leading the development of platforms (Figure 4).

Figure 4: Trends among Big Tech and major electronics manufacturers

Manufacturer	Main products and trends	Spatial computing strategy	Overview
Apple	• Offers Apple Vision Pro • Developing smart glasses	• Provides advanced spatial UI/UX through proprietary spatial OS, visionOS • Integrates with iOS devices	• High-end strategy targeting both entertainment and productivity
Google	• Developing Android XR as an OS	• Shifting focus to XR built on Android • Strengthening partnerships with Samsung and LG	• Designing XR OS for re-entry into the market
Microsoft	• HoloLens 2（from 2019） • Ongoing use in military and industrial sectors	• Focusing on MR for business use. Industrial support solutions based on integration with Azure	• Development of HoloLens 3 temporarily stalled and under review
Meta	• Meta Quest 3 popular as a goggle-type device • Ray-Ban Meta performing well in Western markets	• Expanding MR/VR across lifestyle, education, and social media through propriety OS (Horizon OS)	• Integration with generative AI (Llama 3)
LG Electronics	• Announced re-entry into device market (from 2024)	• Leveraging its strengths in display and video tech to target both B2C and B2B	• Partnerships with Google and Qualcomm
Samsung	• Developing Android XR-compatible device (planned for 2025)	• Co-developing XR platform with Google • Leveraging the Galaxy brand	• Utilizing own displays and semiconductors as a key strength
Sony	• Offers PlayStation VR2 for gaming • Provides “XYN” goggle-type device and solutions supporting spatial content and 3D CG production	• Targeting both users and creators in gaming and B2B	• Expanding with strong content capabilities

Note: Includes trends related to goggle-type devices
Source: Compiled by MGSSI based on various materials

The second group consists of companies that specialize in smart glasses or possess strengths in enterprise-oriented solutions (Figure 5).

Figure 5: Trends among notable smart glasses manufacturers

Manufacturer	Example products	Features and direction
Rokid (China)	• Rokid Max	• Specializes in AR glasses • Emphasizes spatial audio and visual experience
TCL (China)	• RayNeo	• Strengthening features from entertainment to AI assistant functionality
XREAL (China)	• XREAL Air、XREAL Air 2 • XREAL One	• Lightweight and portable AR glasses • Shifting from display-focused to spatial UX-compatible models
VITURE (US)	• VITURE One • VITURE Pro	• Lightweight smart glasses focused on video and gaming
Vuzix (US)	• Vuzix Blade • Vuzix Shield	• Enterprise-oriented smart glasses with a track record in manufacturing and logistics
Dynabook (Japan)	• dynaEdge XR1	• Solution first developed for DX at business sites
NTT QONOQ (Japan)	• MiRZA	• Uses smart glasses for video content and event experiences

Source: Compiled by MGSSI based on various media reports

In both groups, companies are planning to implement the key functions required for spatial computing, as discussed in the following section, and are expected to strengthen their presence as providers of the core next-generation devices.

2. EVOLUTION AS DEVICES

Smart glasses are undergoing significant product evolution driven by technological innovation. This section outlines the background of this evolution and analyzes its impact on computing systems.

2-1. CHARACTERISTICS OF SMART GLASSES

The evolution of smart glasses is closely tied to technological advancements in the devices themselves. Smart glasses have made significant progress in enabling more intuitive operations and experiences across three key areas: sight, speech, and touch.

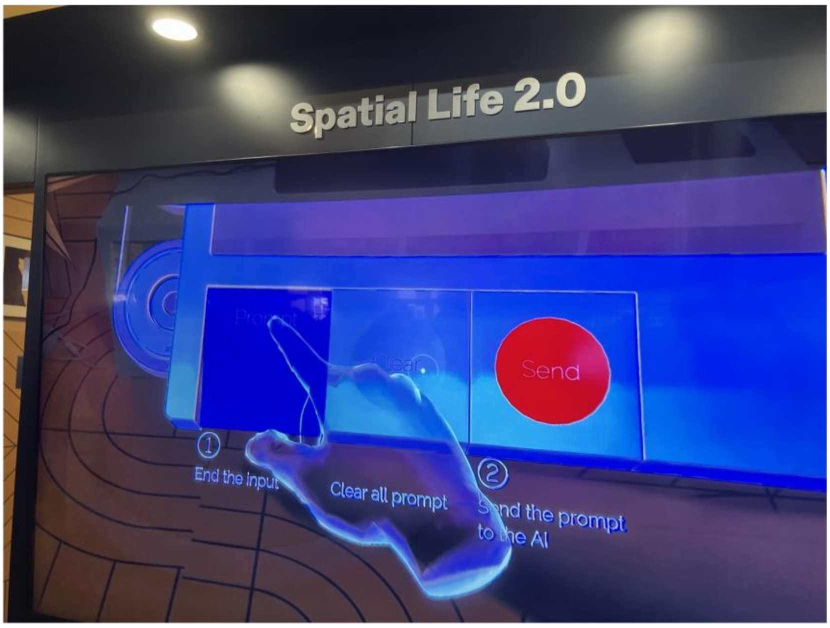
In terms of sight, although smart glasses do not offer the same level of resolution or functionality as smartphones, their compact cameras are sufficiently advanced to capture and share real-world footage. Developments in ultra-compact, high-resolution lenses including micro OLEDs have also contributed to improved responsiveness, allowing for visual experiences that closely match real-world perception.

Concerning speech, enhancements in audio input and output quality are notable. In addition to more advanced microphones and speakers, assistant functions powered by generative AI have enabled real-time integration with visual information.

An example for touch is the use of gestures to press virtual buttons (Figure 6).

Taking all of these into account, the main characteristic of smart glasses is their ability to enhance human perceptual capabilities.

Figure 6: Image of touch operation in spatial computing（XREAL）



Source: Photographed by the author

2-2. A LEADING EXAMPLE OF HARDWARE INTEGRATED WITH GENERATIVE AI

The emergence of generative AI is also having a significant impact on spatial computing. While competition had focused on achieving higher performance, recent developments have centered on lightweight models that can be installed directly onto hardware as on-device AI[15]. In terms of social implementation, on-device AI is attracting attention for its low power consumption and reduced processing load, and its integration with hardware is accelerating.

Smart glasses are one of the devices set to benefit from this trend. Interactive user interfaces powered by generative AI allow users to access apps and services without the need for keyboard input. Smart glasses are uniquely positioned to take full advantage of information from the user's field of view by utilizing the characteristics of glass. This capability is expected to advance significantly.

2-3. CHALLENGES IN THE USE OF SMART GLASSES AND CORRESPONDING RESPONSES

Smart glasses have raised concerns over potential privacy violations, as their video and audio recording functions can be difficult for others to detect. Strong privacy protections are necessary for the widespread use of the technology. This was an issue that existed in the early smart glasses market and has resurfaced as the market grows. At present, responses are largely limited to guidelines, and the development of international standards and regulatory frameworks have not kept pace with development.

One potential solution is the previously mentioned on-device AI, which can deliver significant results. Since an on-device AI enables information processing to be completed within the smart glasses themselves without transmitting data to the cloud, it is also advantageous from the standpoint of privacy protection.

Measures against covert recording are also essential. Currently, systems that provide visual cues such as LED indicators or audible beeps during recording are becoming standard. In business settings, it will also be necessary to implement measures such as signage and privacy notices within facilities.

3. TRANSFORMATIONS FOR BUSINESSES AND CONSUMERS

Spatial computing has a wide range of applications and many potential use cases. This section outlines key considerations for both business and consumer use cases.

3-1. BUSINESS APPLICATIONS

Support for work tasks using smartphones and tablets has long been pursued. However, smart glasses offer the advantage of hands-free operation, which is expected to further improve work efficiency. In particular, their use in task support is gaining attention in industries such as manufacturing and distribution. For example, VIRNECT (South Korea) has developed smart glasses equipped with an AI agent that displays real-time answers and advice in chat format during tasks, enhancing both safety and efficiency in on-site operations (Figure 7).

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15 AI that can execute processing directly on devices such as smartphones or computers without relying on a network

Figure 7: Industrial smart glasses equipped with AI agent (VIRNECT, South Korea)

Source: Photographed by the author

3-2. IMPACT ON CONSUMERS

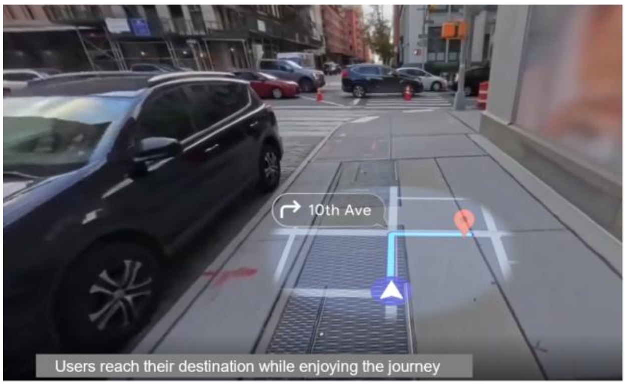
Since its emergence, the capabilities of generative AI have significantly influenced consumer behavior. One notable shift has been in online search behavior. In the US, internet traffic is declining across all categories, with traffic to travel and tourism sites dropping by 20%, and that to news and media sites by 17%. This indicates that traditional functions of search engines and websites are gradually being replaced.

This change in consumer behavior may become even more pronounced with smart glasses. Unlike smartphones, smart glasses enable more intuitive searching by eliminating the need for manual input of commands and clicking. As a result, they allow information to be exchanged with a level of responsiveness unattainable with other devices. In other words, wearing smart glasses creates an environment that makes it easier for consumers to use generative AI for search.

As information-gathering activity through smart glasses increases, companies will likely face a growing need to redefine the value of physical objects. Use of physical items such as signage advertisements in outdoor spaces will play a key role in consumer-oriented services within the spatial computing industry. Objects that have not traditionally been viewed as IT assets may also become essential service infrastructure if installed and treated in ways similar to sensors (Figure 8).

Figure 8: Consumer-oriented spatial computing service deployment

[Route guidance via map app]



[Display of simultaneous translation of Korean text]

Source: Android XR official website[16]

4. BUSINESS OPPORTUNITIES IN THE SMART GLASSES INDUSTRY

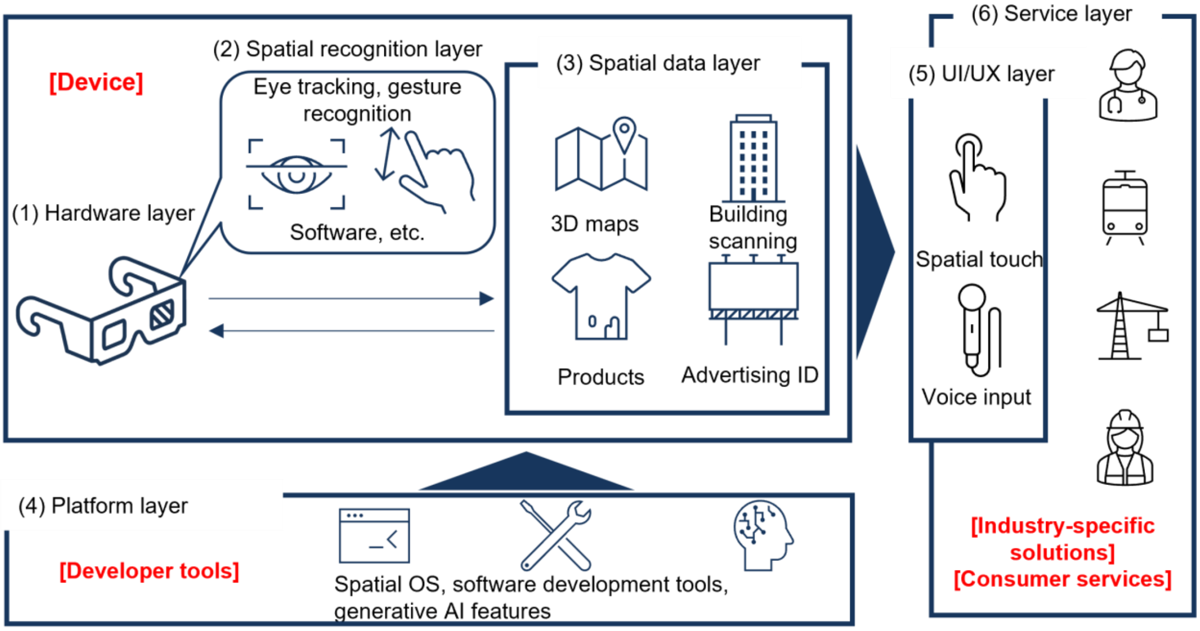
The industrial structure of spatial computing comprises multiple layers, ranging from hardware to services (Figure 9). Based on this, two types of business opportunities can be identified in terms of current understanding and practical application.

The first is related to the spatial data layer. Human vision and smart glasses are expected to become key components of next-generation solution platforms and service interfaces that take over the role of smartphones. As such, movement-path analysis and subsequent areas such as field-of-vision, gaze analysis, and associated database creation will be positioned as important business areas. One business model for utilizing these data can be seen in the smartphone ecosystem centered on payment services[17]. In line with this, smart glasses compatible with payment services are advancing in the market, creating new business opportunities for data utilization.

The second opportunity lies in the UI[18]/UX[19] layer and service layer. As spatial computing expands into outdoor environments, the number of digital advertisements linked to physical objects is expected to increase, along with a rise in data traffic related to real-world object information. In this context, content demonstrating new value through connection and integration with smart glasses will not be purely digital, but rather, content anchored in physical space. Consequently, spatial computing will require IT system development services built on real physical assets in addition to the development of solutions and services.

16 https://www.android.com/intl/ja_jp/xr/
17 Consumers use various services and products centered around smartphones to earn point rewards or benefits, while telecommunications carriers and online service providers link these offerings with their other services to capture user consumption patterns.
18 User Interface (UI): The point of interaction between the user and the service, or the screen layout and control interface responsible for input and output between the user and the system
19 User Experience (UX): The value or satisfaction a user gains from a service through all points of interaction, including UI, as well as elements such as performance, navigation flow, support, and usage context

Figure 9: Envisaged spatial computing ecosystem



Layer	Overview	Key players	Focus of business opportunities
(1) Hardware layer	Displays, sensors, SoC, etc.	Manufacturers, component suppliers	• Niche enterprise-use glasses, development of lightweight models, B2B sales channels
(2) Spatial recognition layer	SLAM, eye tracking, gesture recognition	Big Tech, tech startups	• Differences in precision directly impact UX. Companies with proprietary SLAM technology have an edge
(3) Spatial data layer	3D mapping, building scans, advertising IDs	Data platform providers	• Use of gaze data, spatial tags, and ad-linked data
(4) Platform layer	Spatial OS, SDKs, generative AI integration	Big Tech	• Intensifying competition through proprietary UIs and operating systems
(5) UI/UX layer	Spatial layout, gaze/voice UI design	System integrators	• Specialized UX design and immersive UX technologies that enhance operational efficiency
(6) Service layer	Construction, healthcare, advertising, manufacturing support, etc.	SaaS vendors, solution providers, content creators	• Deployment of task assistance, on-site AI, gaze-based advertising, and other solutions

Note: Explanations of SoC, SLAM, and SDK are provided below.

Abbreviation	full expression	Overview
SoC	System on a Chip	• An integrated circuit that combines CPU, GPU, memory, and communication functions in a single package. Contributes to miniaturization and power efficiency in smartphones and IoT devices.
SLAM	Simultaneous Localization and Mapping	• A technology that allows robots or AR devices to estimate their position and generate maps in real time using sensor data in unknown environments.
SDK	Software Development Kit	• A set of tools for developing apps and services for a specific platform, including libraries, sample code, and documentation.

Source: Created by MGSSI