

Article

Data-Driven Futuristic Scenarios: Smart Home Service Experience Foresight Based on Social Media Data

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Abstract: Exploring future scenarios can consider future generations and society from a long-term perspective. A Futures Triangle is an approach used for mapping future scenarios. In general, the Futures Triangle collects weak signals using qualitative research methods. However, collecting weak signals qualitatively is limited by its small data size and manual data analysis errors. To overcome those limitations, this study proposes the data-driven futuristic scenario approach. This approach analyzes a large number of social perceptions existing in social networks as weak signals via semantic network analysis. Using our proposed data-driven approach, researchers can quantitatively collect weak signals for a Futures Triangle. To verify the applicability of the proposed method, we conducted a case study on the Chinese smart home service experience. The dataset consists of 2421 posts containing the keyword “smart home experience” on the Chinese social media platform Weibo. Three future scenarios were constructed using the proposed method. The results demonstrate the feasibility of the proposed methodology. The data-driven futuristic scenario approach has the advantage of quantitatively analyzing a large amount of stakeholder data to provide weak signals for the Futures Triangle. We suggest that the data-driven futuristic scenario approach serves as a supplementary method, combined with the traditional Futures Triangle approach, to comprehensively explore future scenarios.

Keywords: future scenarios; data-driven; Futures Triangle; service experience; smart home; future thinking



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1. Introduction

With the development and market expansion of smart homes, service experience has become a critical factor affecting their development [1]. Smart homes are emerging as common homes and are becoming a part of people’s lives [2]. Notably, changing lifestyles affect society’s future to a certain degree. Simultaneously, human activities increasingly affect the planet at all levels more than natural processes. The Earth is now in the Anthropocene, where human activities have become a major geological force [3]. So, the great challenge during the Anthropocene is how to move toward a sustainable future [4]. The United Nations’ new sustainable development agenda for 2030 initiates 17 development goals. These sustainable development goals provide a blueprint for a better future [5]. In a rapidly evolving technological environment, visions for future change have become new opportunities. Understanding and applying the theories and methods of future studies can allow people and groups to effectively predict an alternative future [6,7]. Therefore, considering the smart home service experience from the perspective of future thinking has important implications for future generations and society.

Exploring the future scenario of the smart home service experience can help develop the smart home industry from a long-term perspective. Specifically, a scenario refers to a hypothetical future [8]; as such, future scenarios are designed using methods related to future research and strategic planning methods [9,10]. Imagining possible future scenarios can help organizations take a long-term view of future decision-making, thus improving their ability to deal with uncertainty [11,12].

The Futures Triangle is a model proposed by Inayatullah to map future scenarios [13]. The Futures Triangle includes three dimensions; these dimensions are the pull of the future, the push of the present, and the weight of history. The interaction of these three dimensions allows for a more comprehensive view of the impact of different factors on the future. The data for the three dimensions of the Futures Triangle comprise corresponding weak signals. Weak signals refer to symptoms that may impact the target and serve as warning signs or indications of new possibilities [14]. Organizations can recognize future trends or even social phenomena by detecting weak signals [15]. Therefore, weak signals are closely related to future research, and play an irreplaceable role in the analysis of future scenarios [16]. The Futures Triangle data sources are typically based on qualitative methods such as in-depth interviews [17], workshops [18–20], and reviews of the literature [21–23]. Collecting data through qualitative methods facilitates an in-depth discussion of topics and offers insights into the Futures Triangle. Fan and Khng [17] used the Futures Triangle to analyze social worker organizations' plausible futures by interviewing 27 social workers in Singapore [17]. Fergnani [18] explored the future scenarios of medical operations through a future research workshop project. Eastwood et al. [21] analyzed the future of livestock systems under the influence of technology through qualitative reviews of the literature. The Futures Triangle analysis is a reliable approach for mapping future scenarios. Given this, by using the Futures Triangle model, we can design future service experience scenarios for smart homes.

Although the application of qualitative methods for the Futures Triangle is well established, it also has limitations. First, qualitative methods collect data from small samples. The number of participants in in-depth interviews and workshops is generally limited to a small number [17,18]. Second, the workshop results are seriously influenced by participants' insights. At the same time, the emergence of information and communication technology and the increased number of social network users have enabled methodological innovation in foresight exercises including future scenario planning [24]. Previous studies have applied network analysis techniques to obtain weak signals associated with future developments in society. Kayser and Bierwisch [25] applied Twitter data to scenario development research using network analysis. Kayser and Blind [26] demonstrated that more actors and views could be considered using web text mining in foresight research. Pang [27] explains how weak signals in Twitter can be grasped to improve futures. Through quantitative methods, such as network analysis and text mining, we can explore future weak signals from social media platforms and provide insights into the Futures Triangle model. This approach has the advantage of considering more actors and perspectives.

In this context, we propose the data-driven futuristic scenario approach. We collected social opinions from smart home stakeholders on social media platforms and extracted weak signals regarding the future through semantic network analysis. The weak signals were then analyzed using the Futures Triangle tool to plan future scenarios. Social media platforms store the social opinions of a large number of stakeholders. Accordingly, by using the proposed methodology, we can provide more stakeholder data for Futures Triangle analyses and plan future scenarios more rigorously using a quantitative approach. This approach can serve as a supplementary or alternative source of knowledge for future scenario development.

This paper is an extension of our work in data-driven scenarios [28]. The primary objective of this paper is to propose a data-driven approach for applying social media data to Futures Triangle analyses, therefore generating data-driven futuristic scenarios. To verify the proposed method, we applied it to the case study of exploring future scenarios for the Chinese smart home experience. The dataset of this study was collected from the Chinese social media platform Weibo. Subsequently, the following three research questions were formulated:

RQ1: Does the social media platform Weibo have multiple stakeholders related to the smart home service experience in China?

RQ2: Do semantic network analysis results provide valuable weak signals for Futures Triangles? Can the proposed data-driven futuristic scenario approach successfully explore future scenarios?

RQ3: What are the advantages and limitations of the data-driven futuristic scenario approach?

The rest of this paper is organized as follows. Section 2 presents a review of the background of the Futures Triangle analysis, a foresight exploration via network analysis, and reviews of the literature about the smart home service experience. Section 3 proposes the “data-driven futuristic scenario approach”, and Section 4 illustrates the utility of the proposed approach through a case study of the future Chinese smart home experience. Finally, Section 5 is a discussion of the results and the study’s conclusion.

2. Related Works

2.1. Futures Triangle for Scenario Planning

Futures research should apply scientific theories and methods to explore and predict trends, movements, and prospects; moreover, it should respond to developmental changes, planning, management, strategies, and various decision-making services [29]. In futures studies, researchers applied weak signals to predict an alternative future [30]. While the exact future cannot be predicted, alternative futures can and should be predicted [31]. A fundamental task of futures research is to identify and examine alternative futures by parsing various weak signals, thereby assisting individuals or groups in developing, implementing, and reimagining preferred organizational futures [6]. Future thinking can help create highly effective strategies, enhance organizational information, and create a preferred future [13].

The Futures Triangle is one of the methods used for mapping alternative future scenarios. In a previous study, Inayatullah proposed future six pillars. The first pillar maps where the past, present, and future are depicted. By describing time, we can obtain a clear picture of the event’s causes and trends [13]. The Futures Triangle is a tool in the first pillar; it reflects the current view of the future in three dimensions. The three dimensions are the pull of the future, the push of the present, and the weight of history. The pull of the future refers to people’s imaginations of the future. The push of the present refers to influence factors that have a driving force for the future. Finally, the weight of history refers to obstacles when people carry out reforms. [32]. By combining these three dimensions, the Futures Triangle model provides various scenarios. The following five archetypes can summarize future scenarios generated from the Futures Triangle: evolution and progress, collapse, Gaia, globalism, and back to the future [13]. Evolution and progress refer to technology and the belief in rationality, respectively; collapse refers to the deterioration of the world in terms of inequity, climate disasters, and humans reaching their limits; Gaia refers to the development of technology and culture, which have reached a balance; and globalism focuses on the collaboration between economies and cultures which can move closer together. “Back to the future” is the possibility of returning to a past in which hierarchies are more apparent, and technology is less destructive. As such, future scenarios may be similar to these five archetypes.

The name of the Futures Triangle results are referred to differently in studies [13]. Some studies indicate the results of the Futures Triangle as imaginations or visions [17]. In [18], the results of the Futures Triangle 2.0 are referred to as future scenarios. Although the description of the Futures Triangle results may have different expressions, they all refer to imagining future scenarios. In this study, we uniformly refer to the results of the Futures Triangles as futuristic scenarios.

2.2. Apply Social Media Data for Foresight

The application of social media data is one of the methods used to predict future trends. Some organizations and government departments are aware of the benefits of social media as an information source for acquiring social feedback and identifying future trends [33].

Some studies indicate that analyses or foresight programs using social media data allow foresight practitioners to obtain valuable insights with a small investment in resources [34]. Moreover, certain scholars explored weak signals using social media data [28,35]. Scholars have employed social media data to identify the weak signals of emergency events, detect dissemination event sources, and report strategy foresight [36]. Studies have explored the strategic foresight of health policies using social media [34]; accordingly, social media data are reliable for future weak signal predictions.

A semantic network analysis can identify trends in the social perceptions of an event on social media [37]. A semantic network analysis allows us to analyze the relationship between the content posted on social media platforms such as Twitter, Facebook, and Weibo. When social media data are analyzed using semantic network analysis, nodes represent the words posted by the user, links represent the relationship between two nodes, and centrality is used to describe the importance of a node in the semantic network [38]. Degree centrality is a common approach used for measuring the centrality in a semantic network as it represents the sum of the links between a node and the other nodes [39]. The greater the degree of centrality, the more connections the word represented by the node has with other words in the network. Checking the degree of centrality can confirm the most critical words in the collected data [40]. The advantage of collecting data from social media is that they include various stakeholders [41]. Through semantic network analysis, researchers can examine the most critical words in social networks from various event stakeholders to obtain their social views and trends.

2.3. Smart Home Service Experience

Smart homes provide customized services to users via smart integrated technologies [1]; in fact, technology is the foundation of smart homes, and services are their purpose. Smart homes collect information from the surrounding environment using sensors and smart devices and provide their residents with services such as management, monitoring, support, and response using various devices [42]. Smart homes are advantageous for supporting their residents with improving their quality of life, assisting them in health management, and helping special populations live independently. Additionally, smart homes promote environmental sustainability [43]. Scholars have stated that smart homes are equipped with multiple devices which cooperate in homogeneous systems to monitor electronic equipment and promote efficient energy management and sustainability. In particular, smart homes offer numerous economic, social, health-related, emotional, sustainable, and security benefits which critically affect both humans and society.

The service experience constitutes an essential user satisfaction indicator in smart homes. In previous studies, researchers classified service experiences into phenomenological, process-based, and outcome-based service experiences [44]. Some studies indicate that the technical performance of services, the tangible materials associated with services, and the behavior of service providers influence customers' rational and emotional perceptions of the services [45]. Most studies report that service experiences can be interpreted as a combination of sensible, functional, affective, and emotional customer responses or assessments [46,47]. Moreover, some studies emphasize the impact of the interactions between the service providers, customers, smart technologies, services, and delivery channels on the experience of smart services [48]. In comparison, some studies distinguish the service experience from physical and social aspects; specifically, the physical element includes equipment, space, ambiance, and design, and the social part has nurturing and non-commercial relationships [49]. In addition, some studies classify the experience into the following three aspects: usability, emotional experience, and user value [50].

Based on the literature review, this study defines the smart home service experience as a functional and emotional experience. The functional experience refers to the experience of using a smart home and includes device usage, system connectivity, and spatial experience. The emotional experience refers to the experience related to the emotions of stakeholders

in the process of using and producing smart homes, which comprises privacy, ambiance, and value perception.

3. Data-Driven Futuristic Scenario Approach

This study proposes a data-driven futuristic scenario approach to design the 2050 smart home service experience scenarios in China. The proposed scenarios are intended for China's long-term future. The dataset was collected from Weibo, a Chinese social media platform. We applied semantic network analysis to explore the future weak signals of the smart home experience. Subsequently, weak future signals were generated to map future scenarios using the Futures Triangle. The research process of the data-driven futuristic scenario approach was divided into the following four phases: dataset collection, dataset preprocessing, data analysis, and results (Figure 1). In the data collection phase, text data from Weibo users were collected using a crawler program. In the dataset preprocessing phase, the collected paragraphs were divided into words using the word segmentation technique, and a semantic network was then constructed. In the data analysis phase, we conducted stakeholder, network, and Futures Triangle analyses. Finally, the results show future scenarios for China's 2050 smart home experience.

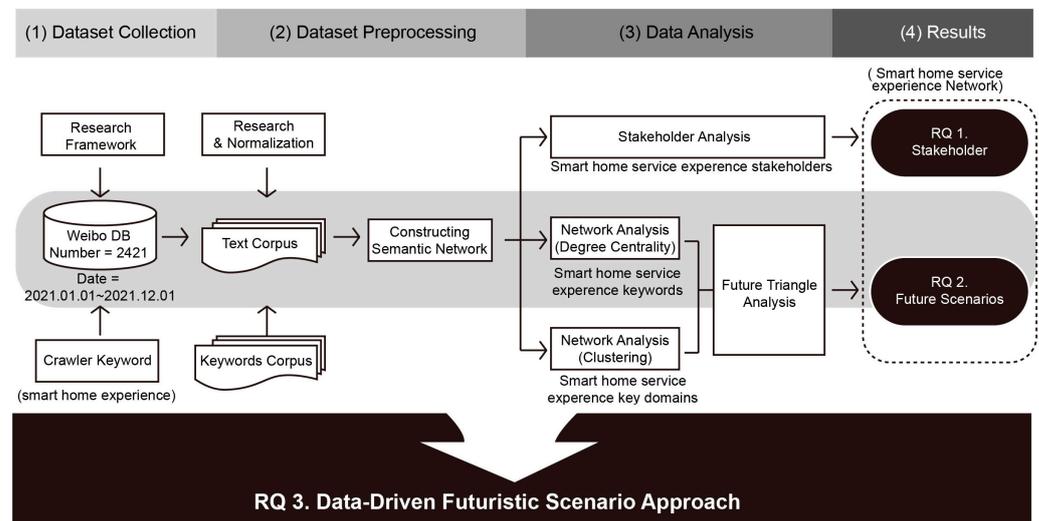


Figure 1. Research process of data-driven futuristic scenario design.

3.1. Dataset Collection

Social media platforms store many social views of users and stakeholders. These views are rich data sources for studying the social sectors of smart home service experiences. Weibo is one of the most dominant social media platforms in China, and its users can share texts, images, and videos to express their opinions. First, we executed a Python crawler program to crawl Weibo text and collect data from 1 January 2021 to 1 December 2021. The crawling keywords were “smart home experience”, and the critical parameters of the collected dataset are shown in Table 1. We collected 2421 posts. The data types in this dataset include user IDs, user nicknames, Weibo texts, Weibo URLs, topics, number of comments, number of likes, post times, and style. Table 2 lists the specific meanings of the collected data. When analyzing social media, the most common analysis approach is to conduct a text analysis on the tweets posted by users, so the main parameter used is tweet posting. In this study, we mainly analyze the “Weibo posts” parameter. More specifically, we performed the following three analyses using this dataset: stakeholder, degree centrality, and clustering. In the stakeholder analysis, we used user IDs, Weibo URLs, and Weibo posts as parameters. For degree centrality and clustering analyses, we used the parameters of Weibo posts.

Table 1. Key parameters of the dataset.

No.	Contents	Parameters
1	Search for	#Smart home experience
2	Period	From 1 January 2021 to 1 December 2021
3	Number of Weibo posts	2421
4	Number of deleted Weibo posts (data cleansing)	350
5	Number of analyzed Weibo posts	2071

Table 2. Overview of collected data types.

No.	Data Types	Description
1	User ID	ID set by Weibo for registered users
2	User Nickname	Nickname set by Weibo user
3	Weibo Post	Texts and paragraphs posted by Weibo users representing their thoughts
4	Weibo URL	Weibo post's web address
5	Topics	User-tagged topics
6	Number of comments	Number of messages for this Weibo post
7	Number of likes	Number of views that agree with this Weibo post
8	Number of reposts	The number of reposts of this Weibo post
9	Post time	The time the user posted this Weibo post
10	Style of the obtained data	Text, picture, or video

3.2. Dataset Preprocessing

We performed data cleansing at the beginning of the preprocessing data phase. The obtained dataset comprised invalid Weibo posts promoting products that were unnecessary for the analysis. We manually separated the data from repeated advertising. The total number of Weibo posts after data cleansing was 2071.

3.2.1. Word Segmentation and Refinement

Second, word segmentation and refinement were conducted using Python. In Weibo, posts are presented as paragraphs, and words must be extracted using a word segmentation technique. We used the “Jieba” Chinese text corpus to extract words and count word frequencies; a total of 19,129 words were extracted.

In contrast to verbs and adverbs, nouns are better at reflecting the critical meanings of paragraphs. Therefore, we identified nouns with a high word frequency as “pick words” to ensure the network results are more refined. We extracted nouns with a frequency higher than 27 and a character length greater than 1. A total of 446 words were selected and named the “pick words” document. If words existed in the “pick words” document, we calculated their semantic situation. On the contrary, if the words did not exist in the “pick words” document, they did not reflect the critical meaning of the Weibo posts, and we did not need to calculate the semantic situation of these words.

3.2.2. Construction of Semantic Network

Semantic networks, sometimes referred to as co-occurrence networks [51], are used to analyze texts [52]. Co-occurrence networks are based on the graphical visualization of the potential relationships between words within a given text unit. We considered two words to have a co-occurrence relationship if they were simultaneously present in a Weibo post. The number of times the two words appear in the Weibo posts represents the weight of the co-occurrence relationships. Suppose A_i is a post containing keyword i , and A_j is a post containing keyword j . Subsequently, the weight W_{ij} between ij is calculated as follows:

$$W_{ij} = \text{Card} (A_i \cap A_j), \quad (1)$$

where Card denotes the number of elements of set A .

Therefore, the co-occurrence method is implemented by the following (**Algorithm 1**):

Algorithm 1 The words co-occurrence method

Input: a set of sentences, a set of keywords
Output: word pairs with their presented times
 Translate sentences in English
for $s = 1, \dots, n$
 Select keywords k_s from s
 Generate pairs from k_s
 Count the number of pairs
end

The co-occurrence analysis yielded 511 group relationships. Excerpts from the co-occurrence results are presented in Table 3. In Table 3, the words “Smart home” and “experience” are a set of co-occurrence relations, which shown together in 1891 posts. We consider one of the columns as the source and the other as the target for the network visualization. When we create a network in Gephi (version 0.10.1), we need to input the sources and targets, and then the network will generate by the Gephi software.

Table 3. Co-occurrence results of Weibo smart home experience dataset (excerpts).

No.	Source	Target	Weight
1	Smart home	Experience	1891
2	Smart home	Smart	1024
3	Experience	smart	993
4	Smart home	Life	731
5	Experience	Life	616
6	Smart home	Weibo	558
7	Smart home	Video	533
8	Smart home	Product	519
9	Experience	Product	509
10	Experience	Weibo	504
11	Science and technology	Smart home	491
12	experience	Video	485
13	Video	Weibo	480

Finally, the semantic network was visualized using the Gephi software (version 0.10.1) [53]. Gephi is a specialized software for visualizing networks and is implemented based on force-directed layout algorithms. In Gephi, the visualization results of the network can be derived by inputting the source and target. In this study, weights are added to refine the network. By importing the data from Table 3, we obtained a co-occurrence visualization graph of the semantic network, as shown in Figure 2. Section 3.3.2 describes the semantic network’s degree analysis and cluster analysis.

3.3. Data Analysis

3.3.1. Stakeholder Analysis

The dataset collected from Weibo contained user IDs, usernames, and Weibo posts. This information allowed us to check users’ Weibo pages and browse their profiles. Using the content of Weibo smart home users, we can determine the types of stakeholders in a smart home. For instance, suppose a user posts the following:

“First time I experienced the renting service of Mijia Smart Home, it is still not very convenient, no automatic control of curtains and lights.”

As such, we categorize this user as a smart home user. Suppose a user posts the following:

“Designers should consider the operative feeling when designing smart products and meet the user’s emotional expression.”

In this case, we categorize the user as a smart home industry practitioner. Suppose a user posts the following:

Given this, we implemented a cluster analysis through the community detection function in the Gephi software (version 0.10.1). The Gephi community detection was based on the algorithms proposed by Lambiotte et al. and Blondel et al. [56,57]. The cluster analysis results represent the main domains of a smart home experience network. These domains served as weak signals for the Futures Triangle analysis, together with the weak signals obtained from the degree centrality analysis.

3.3.3. Futures Triangle Analysis

In this phase, we applied a Futures Triangle analysis to summarize and classify the weak signals investigated in the previous step to determine future scenarios. We conducted a triangle analysis based on the methodologies presented by Inayatullah [13] and Fernani [18]. First, we considered 2050 Chinese smart home experience scenarios as design objects. Second, the weak signals were classified into the three dimensions of Futures Triangles. In this study, the pull of the future refers to a vision related to the future smart home service experience. The push for the present is a trend that influences the development of future smart home experiences. The weight of history is the service-experience pain point that has already appeared in smart homes. The interactions among the three dimensions were fully considered through brainstorming. Finally, scenario narratives were applied to describe the Futures Triangle results. In the Futures Triangle analysis processes, two aspects must be considered. First, each future scenario should be fully considered in three dimensions, and second, the future scenarios should not include duplicates. If there are two similar scenarios, only one is retained. The semantic network and Futures Triangle analyses aim to answer RQ2: Do semantic network analysis results provide valuable weak signals for Futures Triangles? Can the proposed data-driven futuristic scenario approach successfully explore future scenarios? In addition, the analysis results form the basis for answering RQ3: What are the advantages and limitations of the data-driven futuristic scenario approach?

4. Results

4.1. Stakeholders of Smart Home Service Experience Weibo Network

Table 3 presents the results of the stakeholder analysis. The stakeholders in smart home experience networks include smart home industry practitioners, users, news media, and technical experts. A description of the stakeholders is provided in Table 4. The results of the stakeholder analysis indicate that Weibo has multiple types of stakeholders related to the smart home industry. The data collected from social media can be used to express the social perceptions of diverse stakeholders. As an answer to RQ1, the social media Weibo has multiple stakeholders related to the smart home service experience in China.

Table 4. Stakeholders of smart home service experience in the Weibo network.

No.	Stakeholders	Description
1	Smart home industry practitioner	Including smart home companies, brands, manufacturers, and designers
2	Smart home users	Users who use smart homes
3	News media	Media reporting industry news and government policies
4	Technique expert	Individuals or self-media who post smart home consultations and technical discussions on social media

4.2. Future Scenarios of Smart Home Service Experience

4.2.1. Future Weak Signals

Results of Degree Centrality Analysis

The semantic network analysis results provide weak signals for the Futures Triangle. First, the degree centrality analysis determined 135 nodes, which represents 135 keywords in the semantic network. In Figure 2, the circle refers to the value of the degrees; the larger the circle, the more critical the keyword in the network. For instance, the largest three

circles are “experience”, “smart home”, and “smart”. Therefore, we can clearly understand the critical level of each keyword from the network visualization.

The 11 nodes with the highest degrees are listed in Table 5. These nodes represent the top 11 critical keywords in the network; the higher the degree, the higher the importance of each keyword. The dataset was collected from Weibo using the keyword “smart home experience”. This means that every post we collected contains the words “smart home”, “experience”, and “smart”. Therefore, we started the analysis with “product”, which was ranked fourth in Table 5. We collected Weibo posts containing the word “product” and then performed qualitative coding on these posts. Using the same process, we analyzed the nodes listed in Table 5.

Table 5. Results of semantic network degree centrality analysis and cluster analysis.

No.	Node (Keywords)	Degree	Modularity Class	Clustering
1	Smart home	133	4	0.0415
2	Experience	122	4	0.0456
3	Smart	76	1	0.0992
4	Product	38	3	0.2588
5	Life	36	4	0.3126
6	Science and technology	22	4	0.5671
7	Scenario	20	2	0.5631
8	Wisdom	18	2	0.6339
9	Build	17	4	0.7205
10	System	16	1	0.6583
11	Brand	14	4	0.8461

The parts of the qualitative coding results are presented in Table 6. The full results are presented in Appendix A—Table A1. The results represent the most critical opinions on the smart home experience network. We consider the qualitative coding results to be the weak signals of future smart home service experiences.

As shown in Appendix A—Table A1, a total of 59 weak signals were observed. The keyword “scenario” contained the highest number of weak signals; in comparison, the keyword “brand” contained the lowest number of weak signals. In the overall 59 weak signals, 17 weak signals are classified as the pull of the future, 32 weak signals are classified as the push of the present, and 11 weak signals are classified as the weight of history. Moreover, the future weak signals derived from the degree centrality analysis incorporate insights from all the stakeholders across the network. Among them, the smart home industry practitioners accounted for the highest proportion (49 participants), and the number of smart home users was ranked second with 15 participants.

Table 6. Future weak signals generated from network degree centrality (excerpts)¹.

Keywords	No.	Weak Signals	Dimensions of Futures Triangle	Stakeholders
Product	1	Smart homes' demand for design aesthetics pulls the industry forward.	Pull of the Future	Smart Home Industry Practitioner
	2	The real demand of users for products to promote the development of the smart home industry.	Push of the Present	Smart Home Users
	3	Products of different systems cannot be used at the same time and affect the user experience.	Weight of History	Smart Home Users
Life	1	Users resonate with the vision of a better life created by smart homes.	Pull of the Future	Smart Home Users
	2	Users realize that a smart home makes life more convenient.	Push of the Present	Smart Home Users
Science and Technology	1	People's aspiration for technology promotes the development of the smart home industry.	Push of the Present	Smart Home Users
	2	The development of technology promotes the smart home industry.	Push of the Present	Smart Home Industry Practitioner
Scenario	1	The government carries out holographic projection technology exhibitions to show the public scenes of electric power development, smart communities, and smart homes to promote society's desire for the smart industry.	Pull of the Future	News Media
	2	VR (virtual reality), virtual experience telemedicine, smart home, smart city, and other scenes help create an immersive experience of the power of technology to change society.	Push of the Present	Smart Home Users
	3	Individual brands advocate user-centered scenarios and ignore other aspects of social responsibility.	Weight of History	Smart Home Industry Practitioner
Wisdom	1	The smart home industry has started to popularize artificial intelligence in more industries.	Pull of the Future	Smart Home Industry Practitioner
	2	Users' complaints about smart home products affect society's view of the smart home.	Weight of History	Smart Home Users
Build	1	Smart home enterprises' consideration of building public service promotes social progress.	Pull of the Future	Smart Home Industry Practitioner
	2	Social media tutorials on building smart homes enhance users' experience.	Push of the Present	Technical Experts
System	1	Smart home enterprises focus on smart home security.	Pull of the Future	Smart Home Industry Practitioner
	2	Smart home brands strive to improve system fluency to promote smart home service.	Push of the Present	Smart Home Industry Practitioner
	3	The current smart home-building materials industry lags and cannot meet the needs of the local building materials market.	Weight of History	Smart Home Industry Practitioner
Brand	1	High-level technology companies provide a technical guarantee for smart home technology.	Push of the Present	Smart Home Industry Practitioner
	2	The users accumulated by traditional home appliance brands provide the user base for future smart home development.	Push of the Present	Smart Home Industry Practitioner

¹ The full results of Table 6 are shown in Appendix A—Table A1.

Results of Clustering Analysis

The results of the clustering analysis are presented in Table 7. The keywords of the smart home experience network are divided into five clusters, and represent five domains. Specifically, the visualization of each domain is shown in Figures 3–6. In Figure 3, the first domain contains 32 keywords related to system interconnection techniques and solutions, such as “smart”, “connected to the Internet”, “control”, “automatic”, “linkage”, and “the solution”. Domain 1 also includes the keywords “China”, “the company”, and “market”. By combining the above two aspects, we extracted a weak signal from Domain 1 as “China’s solutions for smart home system compatibility”. Moreover, we classify the weak signal of Domain 1 as the dimension of the push of the present in a Futures Triangle. Using the same approach, we analyzed the other four domains. Therefore, we summarize the weak signal of Domain 2 as “Future intelligent scenario system (Figure 4)”; Domain 3 as “Consumers’ design demand (Figure 5)”; and Domain 4 as “Smart home creates quality life experiences (Figure 6)”. Domain 5 includes fewer than four keywords, and we did not analyze them for any weak signals. In the clustering analysis, we analyzed the weak signals holistically by considering all the keywords in the network.

Table 7. Future weak signals generated from network clustering.

Domain	Keywords	Weak Signals	Dimensions of Futures Triangle
1	smart, control, family, upgrade, support, home appliance, formal, China, the company, center, cooperation, robot, interconnection, choose, era, app, market, model, field, AI, innovation, the environment, connected to the Internet, plan, possess, automatic, solution, security, voice, linkage, ORVIBO	Chinese brand’s solutions for smart home system compatibility	Push of the Present
2	scenario, wisdom, system, Huawei, equipment, the user, future, service, ecological, HarmonyOS	Future intelligent scenario system	Pull of the Future
3	undergo, product, technology, development, industry, mobile phone, release, feeling, function, design, consumers, Xiaomi, ascension, digital, home, platform, intelligent, demand, Aqara Home, business, decorate, the article, space, focus on, enterprise, really, health, MIJIA, work, 5G, city, time, cover, core, research and development, customization, lighting, scene, connection, launch, new product, show, Apple, light, concept, TV, to participate in, better, the air conditioning, friend, activity, using, like, strategic, simple, related, depth, data, HarmonyOS	Consumers’ design demand on experience and product	Push of the Present
4	smart home, life, science and technology, build, brand, the global, new, enjoy, quality, new experience, spokesman, the housework, household, convenient, comfortable, way, web page, the first, happy, operation, link, information, a series of, network, power, pro, group, share, headlines, high-end, layout	Smart home creates quality life experiences	Pull of the Future
5	Weibo, video, whole house	-	-

4.2.2. Three Dimensions of the Futures Triangle

The futures weak signal results obtained by summarizing the network analyses are presented in Appendix A—Table A2, with parts of the results shown in Table 8. We reorganized or deleted the repeated sections. Finally, 33 future weak signals were proposed for the Futures Triangle analysis. Accordingly, 11 weak signals were classified as the pull of the future, 14 were classified as the push of the present, and 8 were classified as the weight of history. We describe the meanings of three dimensions in Figure 7.

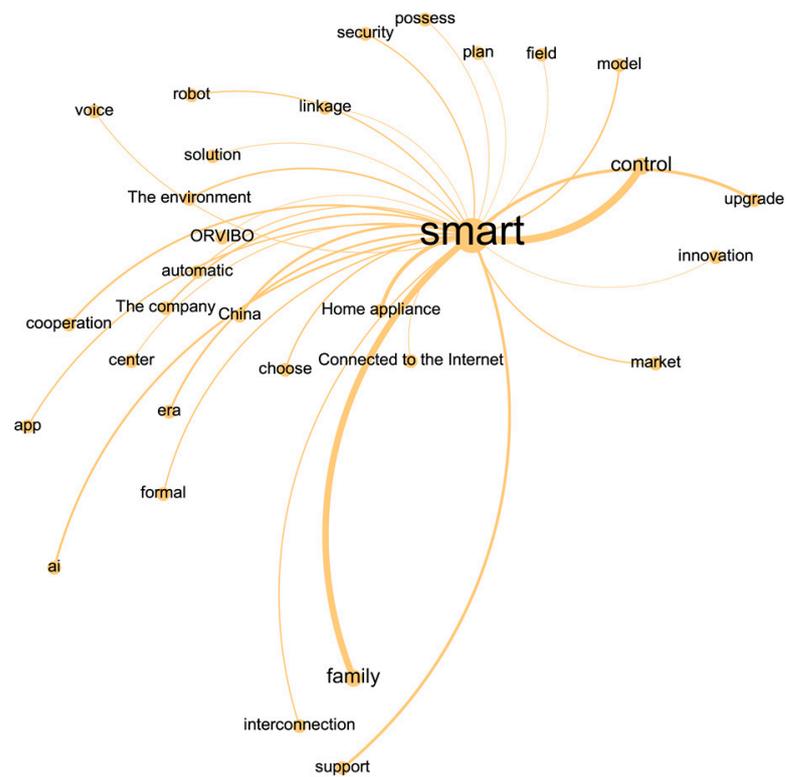


Figure 3. Visualization result of Domain 1.

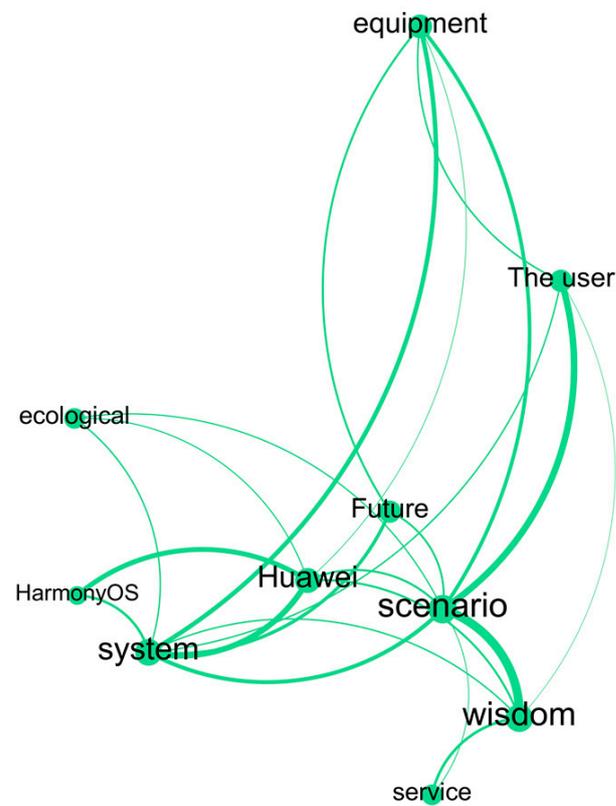


Figure 4. Visualization result of Domain 2.

Table 8. Three dimensions of the Futures Triangle (excerpts) ¹.

Dimensions of Futures Triangle	No.	Weak Signals	Stakeholders
Pull of the Future	1	The government carries out holographic projection technology exhibitions to show the public the scenes of electric power development, smart communities, and smart homes to promote society’s desire for the smart industry.	News Media
	2	Smart home enterprises focus on smart home security and thus promote the sustainable development of the smart home industry.	Smart Home Industry Practitioner
	3	Users’ expectations of a quality life pull the development of the smart home industry.	Smart Home Users
	4	Technology fans publish social media posts to look forward to future smart home scenarios and express their aspirations for future smart home life.	Technical Experts
Push of the Present	1	Smart home manufacturers have launched various solutions to enhance user experiences according to application scenarios and needs.	News Media
	2	The smart home market is rich in products, promoting healthy brand competition and development.	Smart Home Industry Practitioner
	3	Smart home technique products bring convenience to life.	Smart Home Users
	4	Users feel comfortable using smart home techniques and believe a smart home improves their quality of life.	Smart Home Users
	5	VR (virtual reality), virtual experience telemedicine, smart home, smart city, and other scenes help create an immersive experience of the power of technology to change society.	Smart Home Users
Weight of History	1	Individual brands advocate user-centered scenarios and ignore other aspects of social responsibility.	Smart Home Industry Practitioner
	2	Users are skeptical of the intervention of artificial intelligence and worry about privacy issues affecting users’ smart home experience.	Smart Home Users
	3	The connected smart home terminals should strengthen the consideration of security defense systems. Otherwise, it is equivalent to being completely exposed to the control of hackers.	Technical Experts

¹ The full results of Table 8 are shown in Appendix A—Table A2.

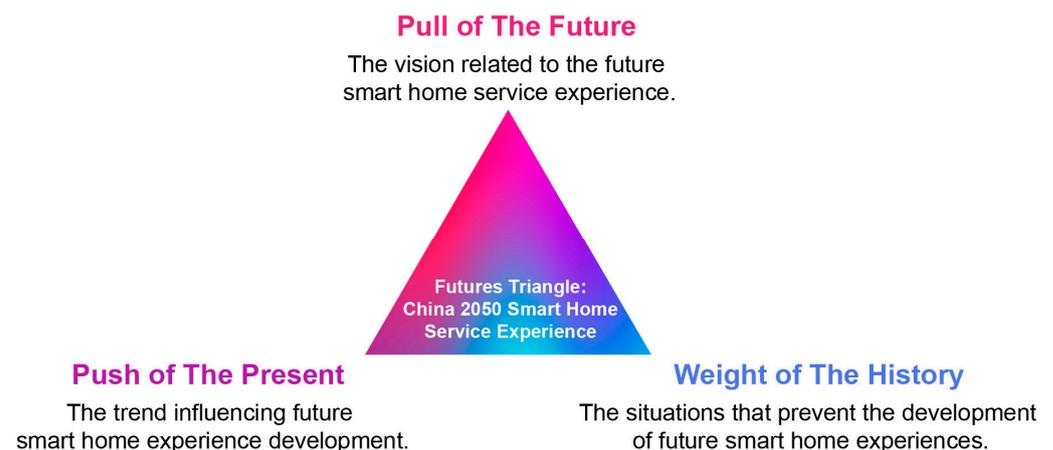


Figure 7. Three dimensions of Futures Triangle in Chinese future smart home experience.

The pull of the future represents the vision or conditions that will pull smart homes toward the future. First, the government proposes policies stating that the smart home industry should pay attention to security monitoring and guide it to standardize its vision. In addition, the government actively publishes and constructs intelligent cities, leading to the development of social and urban intelligence. Second, the smart home industry focuses on product safety and solves technical barriers to improve the service experience.

Smart home industry practitioners also improve the design aesthetics and focus on users' quality of life. These aspects provide a better vision for the future of smart homes. Third, smart home users' expectations of a high-quality life drive the development of the smart home industry. Finally, technical experts release future smart home scenario images, giving society a beautiful vision of future smart homes.

The push of the present refers to the factors or trends that determine the future direction of smart homes. First, the news media reports that smart home manufacturers launched various solutions to improve the user experience according to different needs and to promote the development of smart home experiences. Second, the richness of smart home brands and products promotes healthy competition and industrial development. Third, the smart home industry focuses on developing products and experiences for older people and those living alone, thus reflecting the company's sense of social responsibility. Finally, attention to home security and user privacy protection drives smart homes toward a sustainable future.

Regarding the weight of history, weak signals include situations that prevent the development of future smart home experiences. First, some smart home brands advocate user-centered commercial value, thereby ignoring higher-level social responsibilities such as materials and environmental protection. Simultaneously, the building materials industry is unable to meet the needs of the local smart home building materials market. This situation creates obstacles for the future of the smart home industry. Second, smart home users indicate that the inability to interconnect the products of different systems is the most significant limitation of the smart home experience. Third, technical experts explain that weaknesses in the security system may cause severe privacy and security risks. Functional limitations and privacy concerns hinder the future development of smart homes.

4.2.3. Future Scenarios

Through brainstorming, we comprehensively analyzed the three dimensions of the Futures Triangle and devised the following three scenarios: evolution and progress, collapse, and Gaia.

The evolution and progress scenario aims to improve future smart home experiences through technological progress, design concepts, and cooperation between industries. Currently, the primary limitation is the inability of different brands and systems to achieve technical and protocol compatibility. As such, we should focus on solving the integration system construction through technology and industrial agreements. In the future, we will achieve compatibility with different brands of products in a smart home and realize the vision of a rich, scene-based experience. In addition, the sustainable concept of ensuring user privacy and security through technological updates can achieve high efficiency and energy savings. Moreover, smart homes may not be limited to homes, and future scenarios may include smart communities and cities. Overall, through technological advancements and industrial cooperation, future smart homes can overcome the current limitations of service experience and meet people's expectations regarding functional and emotional experiences. The smart home industry balances business and social responsibility and improves people's quality of life by improving their service experiences. So, the evolution and progress scenario is the most likely scenario for the future service experience of a smart home.

The following future scenario for smart homes is "collapse". People believe that smart homes cannot live because of significant privacy, technological, and environmental crises. In the collapse scenario, smart homes cannot guarantee privacy leaks, and people must abandon their smart products and smart homes and use basic household appliances without an Internet connection. In another collapse scenario, the excessive use of non-environmentally friendly building materials without planning has pushed Earth's environmental problems to a more destructive state. Collapse is the worst-case scenario in a smart home service experience.

Finally, the smart home scenario moves toward the “Gaia” future. Future smart home experiences may present a perfect combination of culture and technology because people experience a sense of belonging and happiness in their homes. In the future, smart homes will overcome technical barriers and privacy leaks. Home-building materials can be used through advanced policy control and planning. Smart homes enable energy saving and environmentally sustainable development, so technology and nature can be balanced. Gaia is an idealized future scenario that is generally difficult to achieve.

The results of the smart home future scenarios answer RQ2, and the semantic network analysis results can provide weak signals for Futures Triangles. The three future scenarios are successfully explored using our proposed data-driven futuristic scenario approach.

4.3. Future Smart Home Service Experience Strategies

By analyzing future scenarios, we can determine which futures we do not want to face and what we look forward to when developing strategic plans to move closer to the preferable futures we want to realize. In the future smart home service experience, the user must be considered along with the service experience that is beneficial to future generations, society, and the future environment. To get closer to a preferable future smart home, we summarize future service experience strategies from the following two aspects: functional and emotional experiences.

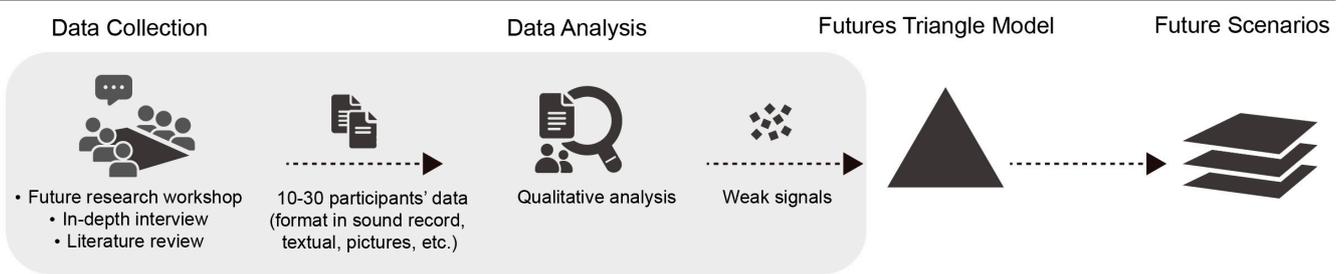
In terms of functional experience, we provide two suggestions. First, for the scenario-based vision of smart homes moving toward whole-house interconnection, the products of different brands and platforms must overcome the problem of connection incompatibility through technologies or communication protocols. To prevent situations where users purchasing different brands must download different settings and operations, different products cannot be interconnected, and smart scenes cannot be formed, we must solve the compatibility problem. Second, current products in smart homes present disadvantages such as a lack of complete automation. In the future, smart home products can strengthen algorithms to predict user requirements and improve the user equipment experience.

In terms of emotional experience, we suggest fulfilling people’s sense of belonging at home and their vision of a better life, as well as strengthening the privacy protection experience and sustainable value perception experience of smart home users. First, the sense of belonging to a smart home is an emotional experience based on a safe and private home environment. In the future, smart homes must ensure user data security in terms of technology, regulations, and policies, and enhance user privacy and security experience. Second, an energy-saving and sustainable smart home ecological environment must be created. Stakeholders have a strong sense of identity with sustainable brands and the smart home concept. These ideas that promote social equity and sustainability are obligations for the planet’s future ecology.

4.4. Data-Driven Futuristic Scenario Approach

The results of the China 2050 future smart home service experience scenarios demonstrate the feasibility of the data-driven futuristic scenario approach. As shown in Figure 8, there are two methods of data collection for exploring future scenarios using the Futures Triangle model. The original Futures Triangle model collects data through a qualitative analysis such as interviews, workshops, and reviews of the literature. The data-driven futuristic scenario approach proposed in this study uses textual data from social media to obtain weak signals for Futures Triangles. Regarding RQ3, the advantages and limitations of the data-driven futuristic scenario approach can be described as follows:

Mapping Future Scenarios Based on Original Futures Triangle



Data-Driven Futuristic Scenario Approach

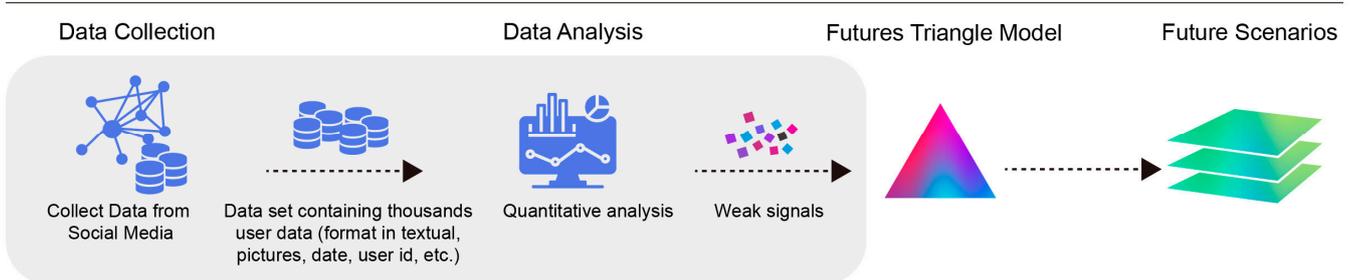


Figure 8. Comparison of original Futures Triangle [13,18] and the Data-Driven Futuristic Scenario Approach.

The data-driven futuristic scenario approach has several advantages. First, a data-driven approach can collect enormous amounts of data from a social media platform; notably, by using crawling programs, researchers can obtain large amounts of social data. Second, a data-driven approach has the advantage of rapid collection as the required data can be downloaded from a social media platform within a few hours. Third, the dataset collected from social media represents the social perceptions of multiple stakeholders. These opinions are generally spontaneously published by users and existed on the social media platform before the research was conducted, thus avoiding the error of research data being revised in advance. Fourth, quantitative analysis is a relatively reliable way to avoid research bias to a certain extent compared to qualitative analysis.

However, the data-driven futuristic scenario approach has several limitations that must be dialectically considered. First, the scope of the data collection was limited to a population using the social media platform. For example, the data of older adults on social media platforms comprise a relatively small proportion, and the proportion of each stakeholder is uncontrollable. Missing stakeholder data must be supplemented using other approaches. Second, advertisements issued by brands may have been included in the dataset. Therefore, data cleansing is required prior to data analysis. Third, researchers must protect the privacy of social media users and abide by research ethics when collecting the data. Finally, compared with qualitative analysis, quantitative analysis has the limitation of being unable to gain a deep understanding of the research samples.

Therefore, this method is more suitable for research topics that require the analysis of a large amount of data, in particular, research topics involving a large population on social media. The data-driven futuristic scenario approach may be a supplementary method—combined with the traditional Futures Triangle approach—to comprehensively explore future scenarios. Before researching topics using the original Futures Triangle process, researchers can explore social perceptions using a data-driven futuristic scenario approach. In addition, the results of the data-driven futuristic scenario approach can be used as a supplement to the results of the qualitative approach. The data-driven futuristic scenario approach can identify future weak signals that the qualitative research may ignore. Therefore, combining quantitative and qualitative methods can help to explore future scenarios more comprehensively for different topics.

5. Conclusions

Exploring future smart home service experience scenarios can help develop the industry from a long-term perspective. In this regard, the Futures Triangle is a standard method for mapping future scenarios in futures studies. The traditional method of collecting data in a Futures Triangle is limited by small sample sizes. In this study, we propose a data-driven futuristic scenario approach. This approach can collect a large amount of stakeholder data from social networks, thus complementing the limitations of traditional Futures Triangle data sources. At the same time, applying the data-driven futuristic scenario approach to the Futures Triangle does not replace the original method, but serves as a supplementary method. The data-driven approach is particularly applicable at the beginning of future scenario research, where big data are used to explore society's views on topics. Our proposed data-driven futuristic scenario approach successfully explored the future scenarios of the Chinese smart home experience using the Weibo data, thereby confirming the feasibility of the method.

In the future, we will continue to improve the data-driven futuristic scenario approach. The dataset used in this study was obtained from only one social media platform. It is necessary to apply datasets from other social media platforms, such as Twitter, in subsequent studies to explore the extension of our proposed approach to other scenarios or regions. Moreover, we will continue to explore how the data-driven futuristic scenario approach can be combined with future research workshops to provide suggestions for future scenario planning. From the perspective of method improvement, apart from semantic network analysis, we can explore the application of other natural language processing methods in future studies.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Future weak signals generated from network degree centrality.

Keywords	No.	Weak Signals	Dimensions of Futures Triangle	Stakeholders
Product	1	Smart homes' demand for design aesthetics pulls the industry forward.	Pull of the Future	Smart Home Industry Practitioner
	2	The real demand of users for products to promote the development of the smart home industry.	Push of the Present	Smart Home Users
	3	The brand has a large number of access products and a full range of experience scenarios.	Push of the Present	Smart Home Industry Practitioner
	4	Brand launches intelligent caravan products to improve users' quality of life.	Push of the Present	Smart Home Industry Practitioner
	5	The smart home market is rich in products, promoting healthy brand competition and development.	Push of the Present	Smart Home Industry Practitioner

Table A1. Cont.

Keywords	No.	Weak Signals	Dimensions of Futures Triangle	Stakeholders
	6	Smart home practitioners propose designers consider the user experience when designing products to promote industry development.	Push of the Present	Smart Home Industry Practitioner
	7	The offline experience exhibition provides a convenient way for users to experience smart home products while providing opportunities for smart home brands to promote themselves.	Push of the Present	News Media
	8	Products of different systems cannot be used at the same time and affect the user experience.	Weight of History	Smart Home Users
	9	Different systems' smart home products cannot be interconnected.	Weight of History	Smart Home Industry Practitioner
	10	Companies control different brands of products through a smart home hub, but technical flaws still exist.	Weight of History	Smart Home Industry Practitioner
	11	The disadvantage of the product is that the sweeper often has to be cleaned, and often collides with tables or gets stuck. In addition to providing the basic needs of the product, the appliance industry hopes to enhance the user experience beyond the functional value of the subsistence type.	Weight of History	Smart Home Users
	12		Weight of History	Smart Home Industry Practitioner
Life	1	Users resonate with the vision of a better life created by smart homes.	Pull of the Future	Smart Home Users
	2	Users' expectation of a quality life pulls the development of the smart home industry.	Pull of the Future	Smart Home Users
	3	Users realize that a smart home makes life more convenient.	Push of the Present	Smart Home Users
	4	The brand's sense of social responsibility to provide a better social life.	Push of the Present	Smart Home Industry Practitioner
	5	Smart home experience exhibitions enhance users' aspirations for a better life.	Push of the Present	Smart Home Users
Science and Technology	1	Smart home technique products bring convenience to life.	Push of the Present	Smart Home Users
	2	People's aspiration for technology promotes the development of the smart home industry.	Push of the Present	Smart Home Users
	3	Users feel comfortable using smart home techniques and feel smart homes improve their quality of life.	Push of the Present	Smart Home Users
	4	The development of technology promotes the smart home industry.	Push of the Present	Smart Home Industry Practitioner
	5	Smart home brands propose to promote the industry's sustainable development with a sense of social responsibility and are committed to improving users' quality of life through smart home technologies.	Push of the Present	Smart Home Industry Practitioner
Scenario	1	Companies offer smart home future experiences through virtual scenario games.	Pull of the Future	Smart Home Industry Practitioner
	2	VR (virtual reality), virtual experience telemedicine, smart home, smart city, and other scenes help create an immersive experience of the power of technology to change society.	Push of the Present	Smart Home Users
	3	A brand's efforts on the whole house smart scene promote the development of the smart home industry.	Push of the Present	Smart Home Industry Practitioner

Table A1. Cont.

Keywords	No.	Weak Signals	Dimensions of Futures Triangle	Stakeholders
	4	The industry focuses on the scenarios of using smart products for older adults to promote the sustainable development of the smart home industry.	Push of the Present	Smart Home Industry Practitioner
	5	Individual brands advocate user-centered scenarios and ignore other aspects of social responsibility.	Weight of History	Smart Home Industry Practitioner
	6	The vision of future family and community linkage scenarios pulls the future development of the smart home.	Pull of the Future	Smart Home Industry Practitioner
	7	The government carries out holographic projection technology exhibitions to show the public scenes of electric power development, smart communities, and smart homes to promote society's desire for the smart industry.	Pull of the Future	News Media
	8	Smart home brands create "meta-universe" experience venues to build smart home future scenarios.	Pull of the Future	Smart Home Industry Practitioner
	9	The VR experience hall provides immersive smart home scenarios to promote people's bright imagination of a smart home future.	Pull of the Future	Smart Home Industry Practitioner
	10	The smart home industry puts forward the vision of a home–community–city scene of intelligent life.	Pull of the Future	Smart Home Industry Practitioner
	11	The government puts forward the policy direction that the smart home industry should pay attention to security monitoring, application scenes, market scale, and industry chain co-development to guide the standardization of the smart home industry.	Pull of the Future	News Media
	12	Smart home brands focus on developing the user experience of older adults, young children, and people living alone by using smart product scenarios.	Push of the Present	Smart Home Industry Practitioner
	13	Smart home brands create security system scenarios to ensure residential safety.	Push of the Present	Smart Home Industry Practitioner
	14	Technology fans publish social media posts to look forward to future smart home scenarios and express their aspirations for future smart home life.	Pull of the Future	Technical Experts
	15	Smart home manufacturers launched various solutions to enhance user experiences according to application scenarios and needs.	Push of the Present	News Media
	16	Smart home brands put forward the vision of whole house smart scenarios to guide the progress of smart home technology.	Pull of the Future	Smart Home Industry Practitioner
	17	The smart home industry promotes using energy-saving equipment and environmental protection materials to promote the industry's sustainable development.	Push of the Present	Smart Home Industry Practitioner
	18	Users are skeptical of the intervention of artificial intelligence and worry about privacy issues affecting users' smart home experience.	Weight of History	Smart Home Users

Table A1. Cont.

Keywords	No.	Weak Signals	Dimensions of Futures Triangle	Stakeholders
Wisdom	1	The smart home industry has started to popularize artificial intelligence in more industries.	Pull of the Future	Smart Home Industry Practitioner
	2	Smart home brands are committed to solving the technical limitations of existing smart homes and promoting the development of the smart home industry.	Push of the Present	Smart Home Industry Practitioner
	3	The vision of the smart home brand is to popularize a new intelligent life with more technology, convenience, and comfort, and to enhance the social responsibility of the smart home brand.	Push of the Present	Smart Home Industry Practitioner
	4	The smart home industry covers a wide variety of life scenarios such as lighting, cleaning, and cooking to improve the users' quality of life.	Push of the Present	Smart Home Industry Practitioner
	5	Users' complaints about smart home products affect society's view of the smart home.	Weight of History	Smart Home Users
Build	1	Smart home enterprises' consideration of building public service promotes social progress.	Pull of the Future	Smart Home Industry Practitioner
	2	People's expectation for the smart home to build a better life pulls the development of the smart home industry.	Pull of the Future	Smart Home Users
	3	People's expectation for the smart home to build a more intelligent and convenient lifestyle pulls the development of the smart home industry.	Pull of the Future	Smart Home Users
	4	The smart home industry is committed to creating multi-person, multi-scene smart experiences to promote industry development.	Push of the Present	Smart Home Industry Practitioner
	5	Smart home brands carry out exhibitions to facilitate users' experience of the smart home.	Push of the Present	Smart Home Industry Practitioner
	6	Social media tutorials on building smart homes enhance users' experience.	Push of the Present	Technical Experts
System	1	Smart home enterprises focus on smart home security.	Pull of the Future	Smart Home Industry Practitioner
	2	Smart home brands strive to improve system fluency to promote smart home service.	Push of the Present	Smart Home Industry Practitioner
	3	Smart home companies consider security systems with an awareness of privacy protection.	Push of the Present	Smart Home Industry Practitioner
	4	The current smart home-building materials industry lags and cannot meet the needs of the local building materials market.	Weight of History	Smart Home Industry Practitioner
	5	The current smart home has systematic limitations and needs robust competitive solutions.	Weight of History	Technical Experts
	6	The connected smart home terminals should strengthen the consideration of security defense systems. Otherwise, it is equivalent to being completely exposed to the control of hackers.	Weight of History, Push of the Present	Technical Experts
Brand	1	High-level technology companies provide a technical guarantee for smart home technology.	Push of the Present	Smart Home Industry Practitioner
	2	The users accumulated by traditional home appliance brands provide the user base for future smart home development.	Push of the Present	Smart Home Industry Practitioner

Table A2. Three dimensions of the Futures Triangle.

Dimensions of Futures Triangle	No.	Weak Signals	Stakeholders
Pull of the Future	1	The government carries out holographic projection technology exhibitions to show the public the scenes of electric power development, smart communities, and smart homes to promote society’s desire for the smart industry.	News Media
	2	The government puts forward the policy direction that the smart home industry should pay attention to security monitoring, application scenes, market scale, and industry chain co-development to guide the standardization of the smart home industry.	News Media
	3	Smart home brands create “meta-universe” experience venues to build smart home future scenarios.	Smart Home Industry Practitioner
	4	The VR experience hall provides immersive smart home scenarios to promote people’s bright imagination of a smart home future.	Smart Home Industry Practitioner
	5	The smart home industry puts forward the vision of a home–community–city scene of intelligent life.	Smart Home Industry Practitioner
	6	Companies offer smart home future experiences through virtual scenario games.	Smart Home Industry Practitioner
	7	Smart homes’ pursuit of design aesthetics pulls the industry forward.	Smart Home Industry Practitioner
	8	Smart home brands put forward the vision of whole house smart scenarios to guide the progress of smart home technology.	Smart Home Industry Practitioner
	9	Smart home enterprises focus on smart home security and thus promote the sustainable development of the smart home industry.	Smart Home Industry Practitioner
	10	Users’ expectations of a quality life pull the development of the smart home industry.	Smart Home Users
	11	Technology fans publish social media posts to look forward to future smart home scenarios and express their aspirations for future smart home life.	Technical Experts
Push of the Present	1	Smart home manufacturers have launched various solutions to enhance user experiences according to application scenarios and needs.	News Media
	2	The smart home market is rich in products, promoting healthy brand competition and development.	Smart Home Industry Practitioner
	3	The brand’s sense of social responsibility to provide a better social life.	Smart Home Industry Practitioner
	4	The development of technology promotes the smart home industry.	Smart Home Industry Practitioner

Table A2. Cont.

Dimensions of Futures Triangle	No.	Weak Signals	Stakeholders	
	5	Smart home brands propose to promote the industry's sustainable development with a sense of social responsibility and are committed to improving users' quality of life through smart technologies.	Smart Home Industry Practitioner	
	6	Smart home brands focus on developing the user experience of various scenarios for older adults, children, and people living alone, thereby promoting the sustainable development of the smart home industry.	Smart Home Industry Practitioner	
	7	Smart home brands create security system scenarios to ensure residential safety.	Smart Home Industry Practitioner	
	8	The smart home industry promotes using energy-saving equipment and environmental protection materials to promote the industry's sustainable development.	Smart Home Industry Practitioner	
	9	Smart home brands are committed to solving the technical limitations of existing smart homes and promoting the development of the smart home industry.	Smart Home Industry Practitioner	
	10	Smart home brands strive to improve the interconnection of different systems to promote smart home service.	Smart Home Industry Practitioner	
	11	Smart home companies consider security systems with an awareness of privacy protection.	Smart Home Industry Practitioner	
	12	Smart home technique products bring convenience to life.	Smart Home Users	
	13	Users feel comfortable using smart home techniques and believe a smart home improves their quality of life.	Smart Home Users	
	14	VR (virtual reality), virtual experience telemedicine, smart home, smart city, and other scenes help create an immersive experience of the power of technology to change society.	Smart Home Users	
	Weight of History	1	Individual brands advocate user-centered scenarios and ignore other aspects of social responsibility.	Smart Home Industry Practitioner
		2	In addition to the basic needs of the product, the appliance industry plans to enhance the user experience beyond the functional value of the subsistence type.	Smart Home Industry Practitioner
		3	The current smart home-building materials industry lags and cannot meet the needs of the local building materials market.	Smart Home Industry Practitioner
		4	Products of different systems cannot be used at the same time and affect the user experience.	Smart Home Users
5		The disadvantage of the smart sweeper is that it often has to be cleaned, and often collides with tables or gets stuck (user pain points).	Smart Home Users	

Table A2. Cont.

Dimensions of Futures Triangle	No.	Weak Signals	Stakeholders
	6	Users' complaints about smart home products affect society's view of the smart home.	Smart Home Users
	7	Users are skeptical of the intervention of artificial intelligence and worry about privacy issues affecting users' smart home experience.	Smart Home Users
	8	The connected smart home terminals should strengthen the consideration of security defense systems. Otherwise, it is equivalent to being completely exposed to the control of hackers.	Technical Experts

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