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Promoting Elderly Care Sustainability by Smart Village Facilities Integration—Construction of a Public Service Field with Introduction of Fall Posture Monitoring

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Abstract: In recent years, rural communities in China have been actively exploring a novel approach to elderly care that integrates treatment with health preservation. This study aims to contribute to the sustainable development of rural elderly care by introducing smart technology, specifically fall posture monitoring, into public services and facilities within rural communities. The focus of this study is on addressing a critical issue in elderly medical care: the timely feedback and treatment of falls. To begin, we conduct a comprehensive review of the current status and challenges associated with the application of fall posture monitoring technology. Additionally, we examine the environmental factors that contribute to the risk of falls in public spaces for the elderly. These assessments serve as the technical and environmental foundation for developing the proposed service framework. Our research is conducted from two primary perspectives: the supply of service resources that combine treatment with health preservation and the identification of risk factors associated with outdoor public spaces in the community where falls are likely to occur. Data for this study are collected through behavior mapping and field interviews. In conclusion, we present a constructive logic for the development of a public service field that effectively combines treatment with health preservation. This logic encompasses the integration of technology applications, resource coordination, and improvements to the physical environment. The findings from this study provide a scientific basis for the construction of public service fields in "smart villages" and serve as practical references for similar villages striving to adopt this innovative model. By leveraging the insights gained from this research, it is expected that rural communities will be better equipped to address the challenges of elderly care and facilitate the widespread adoption of this integrated care model.

Keywords: smart village; sustainable planning and design; elderly care community; public service field; fall posture estimation

Citation: Meng, J.; Yang, L.; Lei, H. Promoting Elderly Care Sustainability by Smart Village Facilities Integration—Construction of a Public Service Field with Introduction of Fall Posture Monitoring. *Buildings* **2023**, *13*, 2144. https://doi.org/10.3390/buildings13092144

Academic Editor: Adrian Pitts

Received: 27 May 2023
Revised: 8 August 2023
Accepted: 21 August 2023
Published: 23 August 2023

1. Introduction

In recent years, rural communities in China have been actively exploring an innovative model of elderly care that integrates treatment with health preservation. This model, which combines various elements such as community restructuring, resource integration, and the establishment of healthcare facilities, draws inspiration from successful experiences in urban communities.

However, the promotion of this model in rural areas has encountered several challenges and obstacles. The main factors limiting its implementation are the relative scarcity of resources and the disconnection between medical treatment and care. For instance, in 2018,

the number of licensed physicians and registered nurses per 1000 people in rural areas was significantly lower than in urban areas, indicating a shortage of medical professionals [1]. In some villages, there is a lack of dedicated nursing staff, with only middle-aged and elderly women providing limited nursing services. These deficiencies in community healthcare professionals greatly hinder the development of the integrated model.

Scholars both domestically and internationally have conducted extensive research on how to integrate medical treatment and care. For example, Yang et al. [2] proposed the development of old-age support facilities, a professional home-based community model, the refinement of old-age security laws, and the establishment of long-term nursing insurance as necessary steps for promoting the combination of treatment and health preservation in China. Tang et al. [3] suggested addressing fragmented service supply through a "multi-synergy and all-win" model, which aims to achieve a balance of interests among various stakeholders.

Despite the existing research and policy recommendations, two key issues have been overlooked. Firstly, most of the existing day care centers for the elderly in rural communities have been converted from existing spaces within the past five years. Implementing the combination of treatment and health preservation by merging these centers with village health stations would result in resource wastage. Secondly, even if integrated service facilities are created at great cost, the overall shortage of medical and care personnel in rural areas would inhibit their effective operation, leading to fragmented service provision. This inadequacy is a common problem in numerous rural villages' public service facilities.

To address these challenges, our study proposes utilizing intelligent technology to drive resource integration and improve facility space construction. We present a constructive logic for the public service field that combines treatment with health preservation consisting of technology application, resource integration, and space improvement. To demonstrate the practicality of this approach, we focus on addressing the issue of timely feedback and the treatment of falls among the elderly. By reviewing the current status and bottlenecks of fall posture monitoring technology and examining the environmental factors contributing to fall risks in public spaces, we establish a technical and environmental foundation for constructing the service field. Based on behavior mapping and field interviews, we analyze the availability of service resources that integrate treatment and health preservation and identify areas within the community's outdoor public spaces where fall risks are prevalent. Ultimately, we propose the idea of constructing a public service field in smart villages by combining technology with service resources and public spaces.

2. Literature Review

2.1. Present Applications of Fall Posture Estimation Technology and Bottlenecks

2.1.1. Fall Posture Estimation and Monitoring Technology

There are two main types of intelligent technologies used for monitoring the health of elderly individuals in their living environments: vision-based human activity recognition (HAR) and sensor-based HAR [4,5]. Vision-based HAR analyzes images or videos captured by optical sensors, while sensor-based HAR focuses on raw data collected from wearable and environmental sensors [6,7]. Sensor-based solutions can be further categorized into three major deployment types: wearable, object-tagged (device-bound), and dense sensing (environment-tagged/device-free) [8].

In the wearable approach, users need to carry the sensors while performing daily activities. However, this approach can be inconvenient, especially for the elderly. Object-tagged and environment-tagged approaches involve attaching sensors to objects or the environment. Users are then required to interact with specific objects or environments [9], such as smartphones and external sensors for smart homes [7].

A recent development in this field is "Motion Units: Generalized Sequence Modeling of Human Activities", which achieved impressive results in fall estimation and daily activity recognition using smartphones as wearable sensors [10,11]. The development and popularity of sensor-based HAR undoubtedly play a significant role in the design

of interactive public environments. However, this research highlights some obstacles to the application and adoption of unconventional smartphone functions among the elderly population in rural areas of China. According to data from the China Population and Development Research Center, only about 50% of individuals aged 65–69 employ smartphones, with approximately 30% of the elderly in rural areas being "afraid" to use smartphones. Furthermore, nearly 40% of the elderly in rural areas are only familiar with three mobile phone functions, and only 22.77% can use more than ten functions [12]. The main reason for this is the relatively low level of education among the rural elderly population. Statistics show that 85.32% of rural elderly individuals have only completed primary school education or below [13]. Consequently, the coverage of individuals who can actively utilize unconventional smartphone functions remains limited. Therefore, sensor-based techniques are not employed in this study.

On the other hand, vision-based HAR solutions do not interfere with user behavior and have wide coverage when applied in public spaces. They can be easily implemented by configuring routine monitoring devices. Therefore, vision-based technology is currently applied for research in the field of public services. It involves transmitting and importing data into a centralized surveillance system through posture estimation in surveillance videos. Information fusion analysis and activity judgment are then performed in the system. Yan's study (2018) utilized pose estimation on videos and constructed spatial–temporal graphs on skeleton sequences. Multiple layers of spatial–temporal graph convolution (ST-GCN) were applied to generate higher-level feature maps and classify actions using a SoftMax classifier (Figure 1) [14].

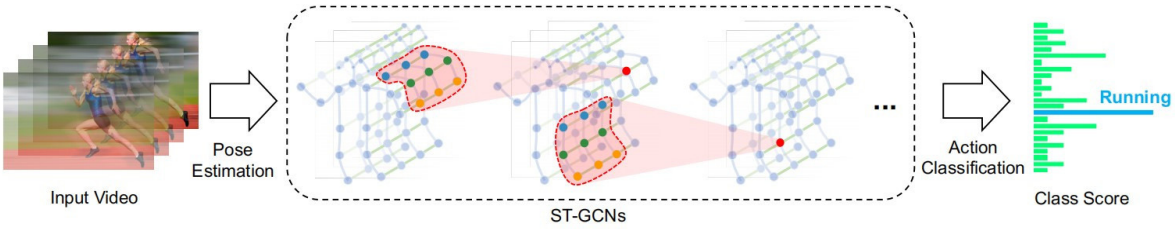

Figure 1. Structure of ST-GCNs in pose estimation [14].

In recent years, the development and application fields of vision-based HAR technology have become increasingly mature. Li et al. (2014) reviewed the existing digital technologies for detecting abnormal behaviors from three perspectives: action detection, feature extraction, and behavior understanding [15]. Various techniques have been explored, including two-dimensional profiles for identifying physical weakness, toppling, vomiting, chest pain, and headache [16,17]. Sequential analysis of behaviors has been used to recognize abnormal behaviors by modeling the spatial–temporal relationship of the human body and constructing spatial–temporal video volumes (STVs) [18,19]. Long-term identification of abnormal behaviors has been achieved through frameworks such as LOTAR, which combines expert systems, data mining, and machine learning for sustainable aging in place for the elderly [20–22]. Hidden Markov models (HMM) and statistical models are also important machine learning algorithms for fall detection and posture estimation, providing simplicity, speed, and interpretability [23–25].

In China, there has been research and development of integrated identification and analysis systems, including patents, software, and equipment available on the market. These technologies are accessible not only to the government but also to enterprises and individuals. However, at its current stage of development, this technique has some limitations. One main limitation is the misjudgment of falling movements, resulting in false positives. Complex movements and environmental factors such as camera angle, lighting, sheltering, road conditions, and noise can also impact monitoring accuracy [26]. These technical limitations should be addressed using other professional means in practical applications.

2.1.2. Video Surveillance Management Platform

So far, the domestic intelligent video surveillance management platforms in China have not yet formed a unified product definition and standard. They can be roughly divided into three categories: telecom operation, industrial customization, and general applications [27,28]. Application management platforms based on intelligent fall monitoring technology of posture estimation belong to the category of industrial customization and generally comprise three modules: analysis function, management function and linkage function. It is necessary to unfold the technical operation of the modules by revolving around scenario-specific requirements. The building of this kind of management platform needs to be forward-looking and specific so that it can better fit into the needs of users [29]. At present, no relevant achievements of video surveillance platforms precisely targeting the old-age support model of the combination of treatment and health preservation are available (Figure 2).

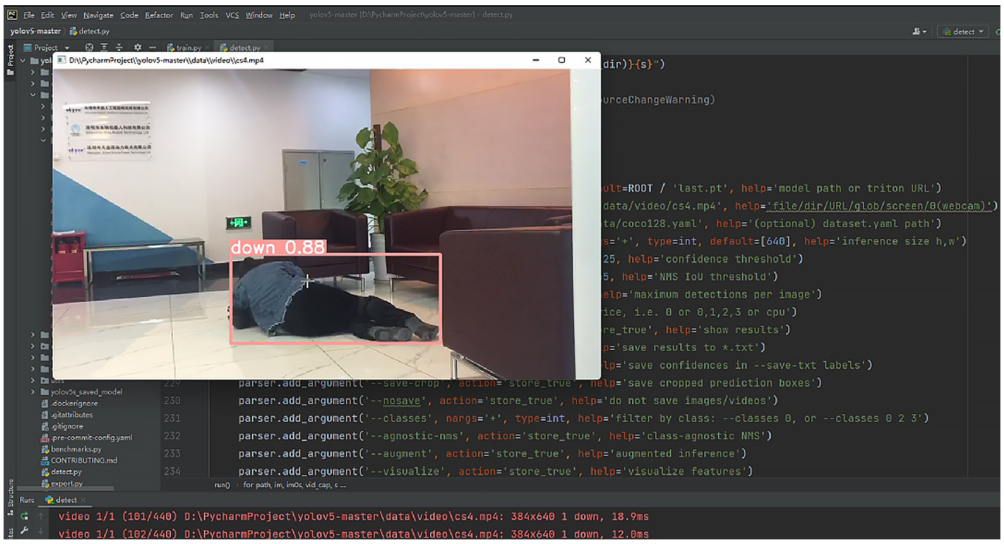

Figure 2. Intelligent integrated video management platform [30].

2.2. Environmental Factors of the Risk of Falling of the Elderly in Public Spaces

The risk factors of falling of the elderly in public spaces mainly encompass two aspects: internal factors and external factors. Among them, external factors involve a considerable number of environmental factors (as listed in Table 1):

Table 1. Environmental factors of falls of the elderly.

Research Perspective	Main Findings	Representative References
Internal factors	Environment-independent: gender, race, drugs, nutritional deficiency, cognitive impairment	Gibson et al., 1987; Lord et al., 2000; Masud and Morris, 2001; Skelton ,D A, 2004; Wang and Wollin, 2004 [31–35].
	Environment-related: impaired mobility and gait, sedentary behavior, fear of falling, visual impairment, foot problems	
External factors	Indoors: improper interior settings in private dwellings, nursing homes, and hospitals, such as slippery floors, narrow staircases, or no handrails, etc.	Chu et al., 2005; Gill et al., 1999; Huang, 2005; Lord et al., 2006; Rubenstein et al., 1990; Tideiksaar, 1998 [36–41].
	Outdoors: Most outdoor falls occur on sidewalks, roadsides, and streets, among which walking is the most common fall-related activity. Slippery road surfaces, smooth ground, many sundries, dazzling sunlight, or low brightness are common inducing factors. Abrupt changes in height (rise or fall), such as curbsides or bumps; insufficient lighting on the street; freezing rain or snowy days; contact between the feet and the ground is particularly important; when it is crowded; at turnings in the road.	Rubenstein and Josephson, 2003; Xie Na, Yang Yue, Wei Quan, 2016; Sun Yuhua, Zhang Mei, et al., 2018; Chen Yichen, Li Xiaopan, 2018; Zhao Ming, 2017; Yang Haifeng, Huang Danni, 2022; Wang Xiadong, 2021; Cao Wenzhu et al., 2018; Ayres and Kelkar, 2006; Gu Ruying, Jiang Haiyan, et al., 2022; Jiang Yijun, Zheng Qiaomu, et al., 2021; Ding Zhihong, Du Shuran, Wang Mingxin, 2018 [42–53].

3. Methodology

The initial survey conducted in this study included the sampling and analysis of three administrative villages (rural communities). Its purpose was to assess the availability of local service resources that integrate treatment with health preservation as well as to evaluate the cognitive perception of the risk of falls among elderly individuals in public spaces within rural areas. To illustrate, our study focused on Zhejiang Province, a prominent province in the Yangtze River Delta region, and selected three administrative villages as the research sites: D Village in Deqing, situated in northern Zhejiang; L Village in Fenghua, located in eastern Zhejiang; and S Village in Shengzhou, positioned in central Zhejiang.

According to the 7th National Population Census, Zhejiang Province has experienced significant economic development, particularly along its coastal areas. However, this rapid development has resulted in a substantial influx of working populations from rural areas to cities. This demographic shift has led to a considerable disparity in population density, with the highest and lowest densities differing by a factor of 50.96. Consequently, the rural population in the province exhibits an exceptionally high aging rate of 28.27% among individuals over 60 years old. Therefore, our selection of sample villages adhered to three criteria: firstly, due to their population structure, these villages urgently require models that combine treatment with health preservation to address the challenges posed by the high aging rate and the limited availability of service resources; secondly, from an economic development perspective, both collective and individual economies in these villages possess the necessary conditions for implementing supporting services and facilities that integrate treatment with health preservation; and thirdly, local governments demonstrate a high level of openness and inclusivity towards "innovation pilots", which greatly facilitated the smooth progress of our sampling procedures.

The survey was initiated in autumn 2021, employing behavior mapping as its primary methodology to conduct on-site interviews and analysis. Two distinct groups of respondents were targeted. The first group comprised current operational management and maintenance personnel in the villages, including representatives from governmental and non-governmental organizations such as village committees, healthcare station doctors, senior citizen association members, and women's organization members. This group was required to provide information regarding the present state of public services and their spatial–temporal aspects concerning the combination of treatment and health preservation for elderly individuals. However, during the actual survey, we encountered difficulties in promoting the concept of combining treatment with health preservation in rural areas, as many respondents struggled to comprehend this notion. To address this challenge, our team expanded the scope of the survey and opted to inquire about the contents and spatial–temporal information relating to "medical services" and "daily public services" instead. Additionally, service behavior mapping was employed to analyze the respondents. Behavior mapping, as initially defined by Ittelson and other scholars, serves as a means to explore the relationship between behaviors and the physical spaces in which they occur. It utilizes structured observation techniques to record and monitor behaviors and the corresponding built environment during field investigations [54]. In this study, the focus lay in capturing the spatial–temporal characteristics of public services targeting the elderly at the village level, utilizing a simplified form of behavior mapping to track and analyze the distribution of services during specific timeframes. Initially, the recording times were set at two-hour intervals from 7:00 to 21:00. After filtering out time points with minimal activity, the service behavior mapping was centralized around four specific time points: 9:00, 13:00, 15:00, and 19:00.

The second group of respondents consisted of elderly individuals aged 60 and above residing in the villages. They were asked to identify geographic or environmental characteristics associated with locations prone to falling or at risk of falls within their community. Furthermore, the survey encompassed the demographic characteristics (age, gender, and history of falling) as well as the personal characteristics (such as gait, balance, and visual acuity) of the respondents. This phase of the survey continued until summer 2022 and

relied primarily on standardized questionnaire interviews. The selection of the elderly interviewees was facilitated by administrative staff from the village committee and senior citizens association. In total, 78 individuals were interviewed, with 24 participants in D Village, Deqing, 15 participants in L Village, Fenghua, and 39 participants in S Village, Shengzhou. One major challenge encountered during the survey process was the low level of education and vision impairments prevalent among the rural elderly population. Consequently, most respondents were unable to complete the questionnaire independently. To address this issue, investigators resorted to dictation and transcription while respondents marked and indicated falling-prone public spaces on maps provided to them.

4. Results

4.1. The Supply of Service Resources That Combined Treatment with Health Preservation

Due to the difficulty in promoting the combination of treatment and health preservation in rural areas at present, as a matter of fact, there were no service resources exclusive to the combination of treatment and health preservation in the villages. Village committees, village doctors, and staff in non-governmental organizations delivered public services covering the whole village around the clock, so in this study, the scope of this service resource was expanded for description.

4.1.1. Service Field

Since the service resources covered tangible places and intangible social spaces, they complied with Bourdieu's concept of a "field". In terms of tangible places, the service behavior maps of the four temporal sections of the three sample villages were drawn (as shown in Figure 3):

In the section studied at 9:00, the service behaviors were mainly concentrated in the health stations, retail sections, and food market of main residential areas (MRAs) and the entrance and retail sections of residential areas (RAs). Among them, the service behaviors of the food market were the most active. In the section studied at 13:00, the service maps of MRAs and RAs mainly occurred in retail sections and day care centers, while the service behaviors of other activity areas for the elderly in this period, such as sports grounds, squares, green landscapes, and other service care behaviors arrived unconditionally. In the section studied at 15:00, at this point, the retail sections of MRAs and RAs in each village had highly active service behaviors. In the section studied at 19:00, the number of sports grounds and village entrance sites used by the elderly in MRAs and RAs in each village reached the peak, but relevant care services arrived unconditionally.

Based on the service behavior maps in combination with the characteristics of the social resources, "functional service field" and "emotional service field" were generalized (as shown in Table 2).

The functional service fields mainly included the aggregation of relationships in a certain time frame as well as the use of public space under the medical treatment, shopping, and leisure activities of the elderly. They had obvious characteristics of time of use. The emotional service fields mainly referred to the spontaneous gathering, staying, and stopping of the elderly in a specific public place and were driven by a particular relationship or feeling and the acquisition of some level of nursing services. From the morphology of material space, they could be further divided into staying-type, intersection-type, and landscape-type fields, as well as integrated fields that mingled all three. In the functional service fields, for health stations, the small number of doctors with professional medical qualifications was a prevalent problem confronting the existing rural communities. Hence, in some rural communities, there were still some informal medical service workers who offered economical medical aids to empty-nest, five guarantees, and underprivileged elderly people. Apparently, this kind of aid without medical qualification is risky, and how to effectively integrate and utilize these limited resources has become a problem that needs to be addressed. There was also a general shortage of caregivers in the day care centers. Generally speaking, non-governmental organizations under the jurisdiction of

village committees (e.g., women's associations and senior citizen associations) appointed one to two middle-aged and elderly women as informal caregivers, and a small number of subsidies were given. In cultural auditoriums and other festive venues, due to a high proportion of short-term staff, the degree of care for elderly people in specific activity periods was nevertheless high. Most of the temples/churches in the rural communities were small in size and held faith activities in certain seasons. Monks advocated the idea of valuing both agriculture and Zen, that is, elderly monks were also a part of the rural elderly people. Food markets and retail sections were very particular daily life service fields, which were not only the smallest retail enterprises but also the sites for exchanging and disseminating information. The commodity counters or shelves of retail sections usually only took up a small part of the overall space, and they could bring productive income to shopkeepers. However, there was also space for visitor reception, leisure, and entertainment, composed of stools or chairs, to fulfil information exchange services outside business. In this case, the shopkeepers were the providers of this service, but there also existed liability risks. Sports grounds undertook one of the most typical fitness sports of the elderly in China, that is, square dancing. It was also a communicative activity that belonged to typical public activity fields for elderly people in rural areas with sound abilities. So far, this kind of activity could only provide material space service resources, and it was difficult to manage and nurse.

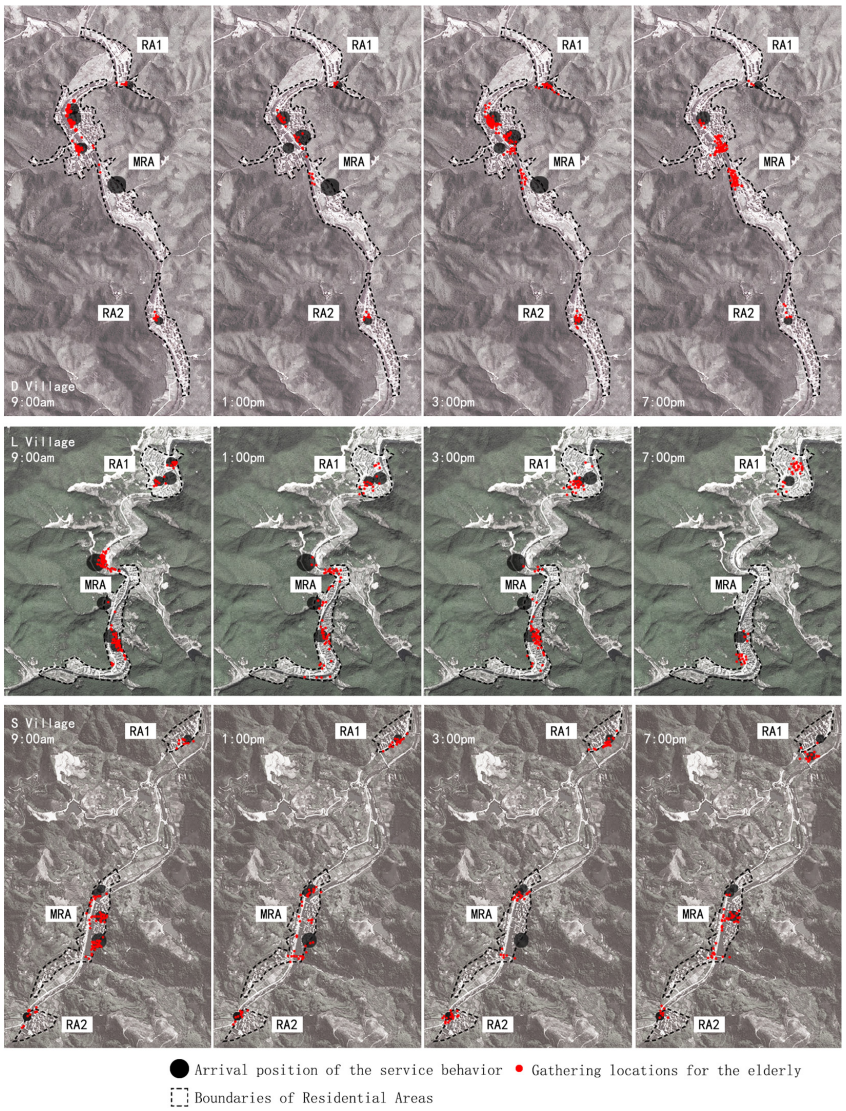

Figure 3. The service behavior maps of four temporal sections of three sample villages.

Table 2. The current state of service resource fields in rural communities.

	Tangible Place	Aggregation Time	Services and Activities	Participant	Characteristics of Social Resources
Functional Service Fields	Health station	8:30–9:30 am	Seeking medical advice and treatment	Elderly people Doctors	The number of professional doctors was small. The professional doctors were mostly local residents. The doctors had a lot of external medical contacts. There were informal medical workers.
	Day care center	Morning and afternoon	Playing cards and chess and carrying out other leisure activities	Elderly people Informal caregivers	The number of caregivers was small. The caregivers came from women's organizations in the community. The caregivers were weak in terms of professionalism.
	Cultural auditorium	Specific activity time	Festive activities	Elderly people Civil servants at the grass-roots level Members of non-governmental organizations	The degree of care for the elderly in specific activity periods was high.
	Temple church	Specific activity time	Religious activities	Elderly people Religious personnel	The exchange relationship between seeking spiritual ballast, donation, and begging for alms. Valuing both agriculture and Zen: elderly monks were also elderly people in rural areas.
	Food market	Morning	Shopping	Elderly people Shopkeepers	The smallest retail enterprise in size. Sites for exchanging and disseminating information. Places where productive spaces and restorative spaces were merged.
	Retail section	Daytime		Other customers	
	Sports ground	Nightfall	Square dance	Elderly people with sound abilities	Types of relatively intense exercise. Making friends through dance was the second function
Emotional Service Fields	Day care center	Morning and afternoon	Chatting and staying in a trance	Mildly disabled + moderately disabled elderly people	Staying-type field with a sense of security and enclosure in the place. With a large number of people and large information content. Insufficient caregivers.
	Retail section		Chatting and gathering		
	Sports ground	Nightfall	Watching the square dance	Mildly disabled elderly people	Landscape-type field with good sight spots or viewing content. It was difficult to manage and nurse within a large coverage.
	Featured landscape	Daytime	Wandering around the village		
	Village entrance sites	Nightfall and evening	Wandering around the village		Intersection-type field with the characteristics of high accessibility and it being easy to come across each other. It was difficult to manage and nurse within a large coverage.
	Intersection of village roads	Daytime			

In emotional service fields, day care centers and retail sections were the most popular among the moderately disabled elderly because they belonged to the staying type of service fields, and they had a sense of place security and enclosure with a large number of people as well as large quantities of information exchanges and informal caregivers. Landscape-type fields and intersection-type fields were typical public activity places for healthy and mildly disabled elderly people because of their good sight spots or viewing content, high accessibility, and the fact that it was easy to come across other people. However, it was hard to manage and nurse within a large coverage.

4.1.2. Human Resources of Care Services

Through a typical survey of sample villages, three types of identities were summarized: the first type was village doctors, nurses, and other professionals with professional knowledge of health and medical care who were qualified for the position. Due to a lack of professionals and the sub-optimal scale of rural public services, at present, the number of professionals in each village was mostly one to two. The second type was informal medical service workers as well as members of senior citizen associations and women's organizations. This group was usually a group with a developed social network in the village who were the most active in dealing with public affairs. This group was the backbone of the service organizations in the transmission and sharing of information and the seeking

of external resources. The third type was the extended kinship of elderly people in the village. At present, although the awareness of family and clan has gradually faded away in rural China, there was also an expanded level of kinship. For example, villagers with the same surname beyond five generations still addressed each other as "cousin brother" or "cousin sister".

4.2. Extraction of Risk Factors of Falling of Elderly People in Public Spaces of Rural Communities

The incidence of falling was not constant in terms of space, as the factors related to falls were multivariate and combined randomly. Nevertheless, to summarize the characteristics of the falling sites and the immediate service fields was conducive to the narrowing down of the research scope (as shown in Figure 4).

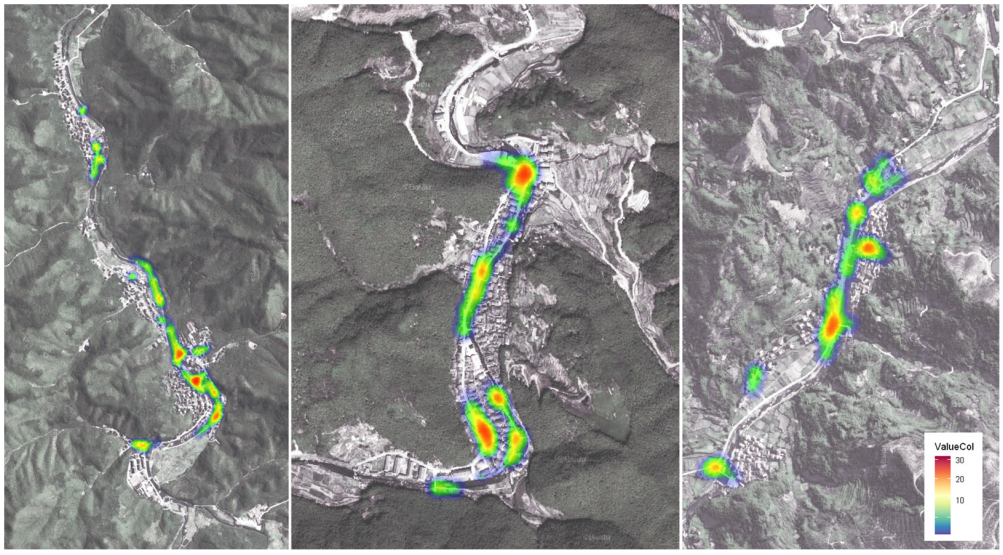

Figure 4. Cognitive heat map of areas at high risk for falls.

Falling accidents in open-air food markets were mentioned the most frequently, which was induced by randomly discarded waste, crowding, noise, and obstruction to vision caused by the placement of many sundries. Furthermore, squatting and bending to pick up items while shopping could frequently also easily lead to falling accidents of the elderly. Therefore, the same types of fields, such as retail sections and garbage stations, should be monitored emphatically.

Intersections and turnings also received a lot of attention. The layout of the rural settlement environments studied was different from the characteristic of cities, that is, "planning in advance". In most of the villages, the spatial pattern grew out of the process of historical evolution and had great randomness and irregularity. For this reason, visual blind spots were apt to occur at intersections and turnings. Furthermore, elderly people tended to have a fear of falling when they crossed an intersection where motor vehicles could pass, which further raised the possibility of falling among the elderly.

Slippery environments and stepped environments were also frequently referred to. Some interviewees tended to avoid walking in slippery areas. For example, D Village had a scenic and long riverbank walkway adjacent to water. However, since it also had ecological functions, after the river ebbed, silt and moss were easily left in the river, which could easily induce falling. Thus, the elderly would take the initiative of avoiding going to such non-functional slippery environments. The villagers in L Village would go to the elderly activity room less frequently because the room was on the second floor, which made it gradually obsolete. However, there were also some functional areas that could hardly avoid this situation.

Health stations, cultural auditoriums, and other places manned with professionals mentioned the risk of falling least frequently. Unexpectedly, sports grounds were also

referred to less frequently. When asked about the reasons, a host of people believed that sports grounds had been optimized during the environmental transformation of previous rural communities. At present, the ground was flat, and the roughness was moderate. There were more young elderly people who could join in the square dance and other activities, and they were confident in their personal health issues.

5. Discussion

Based on the aforementioned findings, our study offers valuable and practical insights into the sample villages and other similar communities in terms of combining technology with service resources and enhancing public spaces. It explores the concept of constructing smart villages by integrating technology, resource utilization, and spatial improvement within the realm of public services.

5.1. Combination of Technology and Service Resources

5.1.1. Technical Management

Analysis function modules were mainly used to detect user behaviors and analyze abnormal bending, falling, and other behaviors in the scenarios through video surveillance areas that need to be set, such as community elderly activity centers, canteens for elderly people, parks, fitness running tracks, and other public spaces predisposed to falling, so as to achieve the real-time estimation of falling of the elderly.

Management function modules: For the specific application scenario of the old age support model of the combination of treatment and health preservation, how to associate the sudden medical needs of the elderly in daily life and medical aid resources in a timely and effective way has become a critical point, because for left-behind elderly people in poor health in rural China, the real-time care services from caregivers were wild wishes. Therefore, management function modules were mainly employed in three aspects: (1) Emergency warnings and queries. With this, medical administrative staff can receive and query information about falls during or after the event (time, position, direction of fall, approximate site of injury, etc.). (2) Video analysis management. With this, the management side (medical administrative staff) can draw specific warning lines and warning areas (one to ten lines and one to ten areas) on surveillance pictures as required. The enabling or disabling of one or multiple video analysis and estimation can be set on the management end. (3) User permission management. This is mainly adopted to protect the activity privacy of elderly people in communities and allocate the right to operate systems, the right to view fall periods, the right of disposal, and so on.

Linkage function modules: At present, one of the dilemmas in the implementation of the model of the combination of treatment and health preservation in rural China lies in the fact that in the studied rural communities, "village health service stations" with a few formal medical service resources and "day care centers for the aged" with a few informal care resources belonged to two different national service systems, that is, "health" and "civil affairs"; they could not interact and share resources because they were founded in different years, and their facilities were often too far away from each other. For this reason, linkage function modules were mainly used to generate alarms on the medical side and the care side after a fall occurred and was intelligently recognized to create a platform for nursing and medical staff to remotely monitor crisis alerts and deal with emergencies.

5.1.2. Service Management

The core of service management lies in establishing a coordinated operation mechanism between a technology platform and service resources. This means creating service organizations under technical support and making rational use of the three types of caregiving human resources available in villages. The first type includes village doctors, nurses, and other professional medical workers. Their main responsibilities in treatment and health preservation service organizations are to screen information from intelligent fall alerts, handle emergencies, and interface with higher-level social medical systems. The second

type comprises informal medical service workers, senior citizen association members, and women's organization members. With minimal training, this group can contribute to the normal operation and information contact of treatment and health preservation service organizations. The third type refers to the extended kinship networks of the elderly in a village. These networks represent not only genetic relationships but also mutual help, sustenance, and support. They play a crucial role in providing medical assistance to the elderly when they experience sudden falls and their children are not present.

Based on this foundation, a closed-loop structure combining treatment and health preservation services is established under the monitoring and platform of fall posture estimation. This structure, known as "monitoring-feedback-action", forms a dynamically balanced control system, with the monitoring platform serving as the "control valve". The intelligent estimation system of the monitoring platform coordinates with professional medical care workers and informal caregivers, functioning both as a recipient for identifying falling information among the elderly and as an output for sending alarms to professionals and caregivers. In cases where serious injury or illness is identified, the monitoring platform also serves as a liaison, contacting and seeking help from the extended kinship network recorded in the database.

5.2. Combination of Technology and Public Space

5.2.1. Building a Fall Monitoring Range Based on Service Resources

The second crux in the construction of service fields lay in the rational layout of monitoring areas, so that the areas involved in monitoring could accurately cover functional environments under the model of the combination of treatment and health preservation. The risk factors of falling in the public spaces of the communities were covered on the basis of functional fields and emotional fields, and the degree of importance of the monitoring areas could be divided, among which day care centers, retail sections, food markets, village entrance sites, village road intersections, and other intersections and turnings were key monitoring areas, while sports grounds and featured landscapes were important monitoring areas (as shown in Table 3).

Table 3. Degree of importance of monitoring areas of falling of the elderly in rural communities.

	Monitoring Site	Monitoring Time	Services and Activities	Intelligent Monitoring
Functional Service Field	Health station	8: 30–9: 30 am	Seeking medical advice and treatment	Not important
	Day care center	Morning and afternoon	Playing cards and chess and other leisure activities	Extremely important
	Cultural auditorium	Specific activity time	Festive activities	Not important
	Temple/church	Specific activity time	Religious activities	Not important
	Food market	Morning	Shopping	Extremely important
	Retail section	Daytime		
	Sports ground	Nightfall	Square dance	Important
Emotional Service Field	Day care center	Morning and afternoon	Chatting and staying in a trance	Extremely important
	Retail section		Chatting and gathering	
	Sports ground	Nightfall	Watching the square dance	Important
	Featured landscape	Daytime	Wandering around the village	
	Village entrance site	Nightfall and evening	Wandering around the village	Extremely important
	Village road intersection	Daytime		

5.2.2. Collocation between Technical Restrictions and Space

Given the limitations of this technology, in practical application, it is requisite to adapt the equipment to the environment through the design of public spaces. For example, it is not advisable to use glass, marbles, and other reflective materials in monitoring areas to minimize interference to the camera, and the equipment should be placed in a less-shielded public spaces. A corresponding number of devices are configured based

on the service radius of monitoring according to the measurement parameters such as the resolution, pixels, lens angle, shooting distance, shooting range, etc., of the cameras configured according to actual economic conditions or existing video surveillance cameras.

6. Conclusions

In conclusion, previous studies have focused on addressing the disconnection and fragmentation between "medical treatment" and "care" in the model of combining treatment and health preservation in communities. The scholars Tang Jian and He Tao (2022) proposed a "multi-synergy and all-win" model to tackle the issue of fragmented service supply in community settings. However, these research ideas overlook existing supporting facilities in rural areas and the labor shortage present in those areas.

To address these gaps, our study identified the specific pain points of timely feedback and the treatment of falls in elderly care. Through a comprehensive analysis of the limited service resources available for the integration of treatment and health preservation in rural areas, as well as identifying high-risk fall areas within community public spaces, we provided a scientific basis for the construction of public service fields in smart villages. Although our study established the overall logical framework for the service field, further work is needed to fine-tune the specific equipment parameters and monitoring spaces. Particularly, in highly inclusive sample villages that are receptive to new technologies, the implementation details should be determined and carried out through practical model practice. By combining technology with service resources and leveraging public spaces, we believe that intelligent solutions can effectively promote the combination of treatment and health preservation in rural communities, ultimately enhancing the quality of elderly care and addressing the challenges faced by the existing model.

Author Contributions: Conceptualization, J.M.; Methodology, H.L.; Writing—original draft, J.M.; Writing—review & editing, L.Y. and H.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by Major Humanities and Social Sciences Research Projects in Zhejiang higher education institutions, Grant Number: 2023QN119.

Data Availability Statement: The data used in this study are available by requesting correspondence.

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

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