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"Visibility" of "Transparent" Algorithmic Technologies in Senior Living: Materiality-Based Perspective

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***Abstract*—** *The understanding of algorithmic technology should not be limited to the dimension of technical risk, but also to the technical practice of algorithmic technology and its intertwining and interaction with the social context. This paper examines the "visibility" of algorithmic technology in the life of the elderly based on the perspective of materiality. This paper argues that algorithms as hardware are material in terms of arithmetic power, data, and the design, production, and transformation of multiple subjects. Algorithms act as mediators to reshape the perception of older people and construct new social relationships. In the spatio-temporal dimension, algorithms have made a full-scale invasion of senior life. The discourse construction around algorithmic technology reflects the game and interaction between political and capital forces. It is necessary to help older people get rid of the "algorithmic unconsciousness" and enhance the "visibility" of algorithms*.

***Keywords*—** *Algorithm; Materiality; Elderly population*.

I. INTRODUCTION

In the era of artificial intelligence, algorithms have penetrated into all aspects of human life, deeply embedded in the fields of finance, justice, employment, education and medical care. Algorithms and their social impact have become a core issue of common concern in academia and industry. In the academic world, social science research has thus taken an "algorithmic turn", and issues such as "information cocoon", "algorithmic bias" and "algorithmic tyranny" have received widespread attention. Scholars have pointed out that algorithms are not only a technical architecture, but also a broader social paradigm of human design, intention, audience, relationship, consumption and use. In the concept of "algorithms as culture" proposed by data sociologist Nick Seaver, algorithms are shaped not only by rational processes but also by institutions, humans, intersecting contexts, and understandings gained in ordinary cultural life, so it is important to understand algorithmic technologies through their users and institutions. The 48th *Statistical Report on the Development of the Internet in China* shows that as of June 2021, the proportion of Internet users aged 50 and above was 28.0%, an increase of 5.2 percentage points from June 2020, and the proportion of middle-aged and elderly Internet users in the overall Internet population has increased significantly. As a "digitally disadvantaged group", the society needs to inject humanistic care for the elderly. At a time when algorithmic technology is increasingly penetrating into daily life, it is of theoretical and practical significance to understand the impact of algorithmic technology on the lives of the elderly.

The previous research on technology reflects the obvious characteristics of emphasizing software over hardware and virtual over material. Concepts such as hyperlinks, virtual reality, and cyberspace continue to emerge, with virtualization, contextualization, and invisibility increasingly becoming signs and symbols of the information society [1]. This emphasis on the virtual and the textual has led Graham Murdock to criticize "materiality as a blind spot in communication research". In 2010, the field of cultural studies spoke more systematically about the "materiality turn" Today, materiality as a theoretical perspective has stimulated the academic imagination of communication and media studies. The current research on algorithmic technology is mostly focused on its technical impact, but lacks a theoretical perspective of materiality. Therefore, it is necessary to examine the "visibility" of algorithmic technology in daily life from the perspective of materiality. Based on this, this paper asks the following research questions: What are the materiality characteristics of algorithms? What is the impact of the materiality of algorithms on the life of the elderly? In what ways are the "virtual" algorithms visible? This paper explores the role of "transparent" algorithmic technology in senior living from the perspective of materiality.

II. MATERIALITY STUDY OF ALGORITHMS

1. Materiality and media materiality

There has been a tendency in the field of communication studies to imagine the Internet as a virtual space that carries data and information. Merovitz, Innes and McLuhan opened the precedent of media studies and enlightened us to see the important role of media. In recent years, the materiality of the media as a research perspective has received wide attention from scholars. Friedrich Kittler, a German media theorist, advocates the recovery of the materiality of the media, mentioning that "it is worth dissecting whether the media determine our present situation, whether we are influenced by it, or whether we want to avoid it." At the same time, Debray argues that "the spirit can act on another only by acquiring an entity in a perceptible materiality, by settling on a vehicle. Without this objectification or publication, no thought can become a practice, nor can it become a capturing or

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counteracting force", which shows that, for Debray, the textuality of communication is inseparable from its materiality.

Scholars have provided different definitions of media materiality. Jussi Parikka suggests that when we discuss media materiality, we should include things that do not have a fixed entity, such as electricity, magnetism, light, energy, and even things that we do not traditionally consider as objects. [2] Zhang Gehao and Zhang Lei's definition covers a broader scope, referring to all media composition, media elements, media processes and media practices that involve "things" and "matter". [3] Some scholars point out that the algorithm is the medium, and the algorithm that constitutes the infrastructure of the intelligent era is a medium in a higher sense, which connects, matches and adapts value relationships through a series of judgmental structures, shapes cognition, constructs relationships and integrates society. Therefore, looking at algorithmic technology from the perspective of materiality can help break away from the dichotomy of "things" and "people" and expand the imagination of communication research.

2. Materiality of the algorithm

In the study of the materiality of algorithms, the most typical study by Sun Ping, scholars understand from the level of "technical availability", the materiality of algorithms usually refers to the concrete display of the technical design logic of algorithms in social practices and social interactions, specifically, the materiality of algorithms refers not only to the meaning of physical, and urban infrastructure, but also to the interweaving and interaction of multiple social factors such as spatial, hierarchical, relational, and discursive factors around algorithms. [4] Cai interrogates the material properties of algorithms, revealing that algorithms are "value intermediaries" in the information economy, that algorithms as technical "commodities" are "multilateral" in value exchange. The labor behind the algorithm is abstracted, and both people and things in the system lose their own specificity and independent meaning. [5] Ding points out four analytical dimensions to explore the issue of communication materiality: technology, body, space, and discourse. Shu examines the Internet infrastructure from the perspective of media materiality, examining the dual direction of technical practice and discourse construction, and reminds us that the examination of materiality needs to highlight its material substrate, but also to see the interaction between the material practice of the Internet infrastructure and the social context, so as to avoid falling into the monism of materiality.

To sum up, our study of algorithmic technology should not be limited to the perspective of mathematical logic, only see the dimension of technical risk cannot be a comprehensive and objective understanding of algorithmic technology. In the algorithmic technology increasingly penetrate people's daily life, we need to explore the relationship between algorithms and culture from a broader perspective, and materiality provides new imagination to the study of algorithmic technology. In this paper, we explore the technical practice of algorithmic technology and its interweaving and interaction with social contexts from two dimensions of the materiality of algorithmic technology, and analyze it from the dimensions of technology, space and discourse in order to discover the "visibility" of the seemingly "transparent" algorithmic technology in the life of the elderly.

III. Technology in Practice: Algorithms as Hardware

Algorithms are deeply embedded in urban infrastructure systems and daily life, becoming an integral part of them, and the technological practices of infrastructure constitute our most basic perception and experience of the materiality of technology. Algorithms as hardware rely on physical hardware technology, and data, as the basis of algorithms, is itself a digital response to the real world and human practice, with materiality. This paper argues that the technical practice of algorithmic technology involves two parts, one is the distribution and popularity of terminal devices in the geographical environment; the other is the design, manufacture and use of Internet infrastructure by multiple subjects such as ordinary users, program engineers, Internet companies, enterprises, media and social organizations, while the failure, maintenance, repair and transformation of algorithms reflect the materiality characteristics of algorithmic technology.

1. Distribution and popularity of terminal devices

An "algorithm" is a formalized process or a set of step-by-step procedures. In essence, an algorithm is an information technology based on "matter" and is necessarily subject to material laws and physical limits. Kittler also pointed out that "software does not exist" and that coding programs are never immaterial. Matthew Kirschenbaum, in *Mechanisms: New Media and the Forensic Imagination*, divides the materiality of electronic media into forensic materiality and formal materiality. [6] Materiality is the rules and patterns that can be recognized by the computer, and algorithms are the instructions issued to the physical hardware of the computer, as a computational method and program more involved in formal materiality.

Algorithms rely on the material properties of material laws and material limits. Among the three elements of artificial intelligence, data and computing power are inseparable from algorithms, and the volume of data and computing power promote the application and innovation of algorithm technology. In January 2015, Yiming Zhang, the founder of Today's Headlines, gave a keynote speech at the Geek Park Innovation Conference, pointing out that Today's Headlines mainly uses the following data about The following data about users are used by Today's Headlines to make information recommendations: action characteristics (including click, stay, swipe, comment, share), environmental characteristics (including GPS location, whether in Wifi or 3G environment, whether it is a holiday, etc.) and social characteristics (e.g. microblogging followers, historical tweets). The material characteristics of users' action, environment and social attributes are integrated into Today's Headlines' information recommendation algorithm. The algorithm of Today's headlines. "For example, the arithmetic power of quantum computers is much higher than that of traditional silicon processors, and Google's "Sycamore" quantum processor takes

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about 3 minutes to accomplish what a traditional supercomputer could do in 10,000 years.

2. Design, production and transformation of multiple subjects

Algorithm design is characterized by materiality. Wenqi Huang, the first director of the Institute of Artificial Intelligence and Optimization at the School of Computer Science of Huazhong University of Science and Technology, was one of the first experts in China to focus on algorithm research, and he proposed the idea of anthropomorphic algorithms, using some of the design and layout wisdom of nature and human society to solve mathematical algorithm problems, and has been continued to this day. For example, in the personalized recommendation algorithm of today's avatar, the algorithm plays a series of functions including classification, filtering, searching, prioritizing, recommending, and judging, all around the core concept of "personalization", while the company's value orientation is different, the algorithm used is also different. for example the current popular Google ranking algorithm, Facebook marginal ranking algorithm.

The study of algorithms is not isolated; the development of knowledge related to algorithms such as probability theory, mathematical statistics, and deep learning is temporal and cumulative. For example, algorithmic journalism is based on previous studies such as data analysis, precision journalism, and data journalism. Researchers of algorithms use citation, quotation and graphs (figures) in the laboratory to reinforce their ideas and defend against the challenges of other algorithm researchers and institutions. Project understanding, data cleaning, model building and training, and continuous learning become the daily routine of algorithm researchers. In other words, behind the algorithm technology is the accumulation of knowledge and specific people.

The algorithm's failure, maintenance, repair and transformation reflect the materiality characteristics of the algorithm technology. Today's headline's information recommendation algorithm is considered the most representative information recommendation algorithm in China, and even in the world, and has undergone four major adjustments and modifications since the first version was developed and run in September 2012. The criteria involve the number and quality of articles distributed, the accurate portrait of users and user subgroups, different categories of news and the weight of the distribution. The algorithmic technology continues to enhance its social adaptability and legitimacy, and is also a vivid manifestation of materiality.

IV. The Demystification of Algorithmic Technology: The Mediation of Algorithmic Technology

To analyze the materiality of communication in a technological dimension is to demystify the nature of technology, to recognize that media create perceptions, and to acknowledge that media practices cannot be separated from the mediating role of technology. The "unmasking" of algorithmic technology requires seeing that the logic of algorithmic technology is increasingly used as a format and strategy for observing the world, constructing its existence, and developing its actions and interactions, and that algorithms, as mediators, reshape people's perceptions of older people and construct their social relations.

1. Cognitive breakthroughs and obscurations

In information recommendation platforms, algorithms determine the distribution of traffic and the visibility of information that affects the way humans perceive the world. Like virtual searchlights, algorithms influence people's understanding and imagination of older people by amplifying or obscuring attention and imagination. On short-video social media platforms, silver-haired netizens show a fashionable, bright and active media image, which subverts the stereotypical impressions of netizens about the elderly group and satisfies netizens' psychological projection of the elderly group itself with idealized elderly images, and also gains more traffic distribution, triggering many netizens' praise and emulation, such as Jitterbug's "Grandma Wang who only wears high heels ", "fashionable grandmother group", "Beihai grandfather", "British butterfly grandmother's diary" , and under the algorithm logic, such accounts are more visible and present a richer and more diversified image, breaking the public's inherent perception of the elderly group. However, under such algorithmic rules, the majority of the general elderly group is obscured, and the "echo chamber" of the perception of the elderly group intensifies the circle segmentation, while the fashionable and bright elderly image is wrapped in the consumerist discourse, obscuring the deeper health, class and social relations. [7]

2. Construction and regulation of social relations

Algorithms as mediators are constructing relationships between things, matching, regulating, and controlling are the main relationship patterns. Algorithms construct social relationships in their own way, and this process is the process of resetting social relationships, and this resetting may be both repetition, reinforcement, and subversion. For older people, repetition and reinforcement are more common. Algorithms become a channel for older groups to build and explore relationships with each other. For example, in the short video social platform, features related to people of interest, video content of interest, and people nearby are intentionally or unintentionally helping older adults to expand their virtual social circles and establish new possible social relationships, although most of these are reinforcement of previous relationships or interests. However, some studies point out that compared to young people who prefer to build virtual relationships based on the Internet, the emotional communication of older people online often becomes a strong impetus to lead to offline gatherings, and the offline-based approach of older people transforms the weak relationships on the Internet into strong relationships in real life, which is also the strengthening of social relationships.

V. The Materiality of Algorithms in the Spatio-Temporal Dimension: The Invasion of Algorithms Into the Life of the Elderly

1. Time thieves: the "digital addiction" of the elderly

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"The medium is like a time thief, little by little, unknowingly stealing people's lives." According to the *2020 Internet Life Report for Seniors*, more than 100,000 seniors are online for more than 10 hours a day, and senior users aged 60 and above spend more than one hour online each day, logging into applications five times a day on average, higher than other age groups. After crossing the "digital divide", some elderly people have fallen into "digital addiction". One is because older people have a lot of free time at their disposal, and the other is because the time perception of aging makes them tend to devote more resources to emotionally meaningful goals or activities, and try to avoid uncomfortable or negative emotions, while platforms with embedded algorithm technology, such as short video platforms and news and information, meet the needs of older people's mind transformation with minimal effort, and also complete the encroachment on the real time of the elderly group.

2. Expansion and construction of space

It has been argued that the focus on materiality can be seen as an extension and deepening of the "spatial turn". [8] Marx's study of capital explores how technology in progress replaces labor time, providing greater space for profit creation and capital reproduction in capitalist society. At the same time, Lefebvre's theory of space points out that the so-called space is not just the work space mentioned in capitalism, but that every space under the rule of capital has the potential to become a productive space. Older people use mobile devices to browse information in their leisure time, and the technology intervened by capital penetrates into private space through big data and algorithms, and uses the information obtained from data for capital production, so the daily life space of older people becomes the production space of platform capital. According to the *Silver Hair Crowd Insight Report* released by Quest Mobile this year, short video applications are particularly prominent in occupying the time of middle-aged and elderly people. In May 2020, the per capita monthly length of the surveyed middle-aged and elderly people using Kwai, Watermelon Video and Tik Tok was about 800 minutes, 1000 minutes and 1500 minutes respectively. Older people are turning into "digital laborers", producing data and content for short video platforms. The labor of producing immaterial goods also relies on highly materialized infrastructure, technology networks and commodities, and is also strongly materialistic. In this process, the elderly group expands their daily living space and completes the construction of a new production space.

Algorithms are closely linked to digital news, news aggregation, smart news and other news-related fields, presenting a reconfiguration of the media communication space. New generation social media tools use collaborative filtering, deep learning and neural network algorithms to recommend personalized digital content for older users in order to avoid segregation of older groups from social groups. Big data-based algorithmic journalism is better at summarising stories based on overall data sources, breaking the limitations of past case-based reporting, with a wider reach and greater spatial dissemination power. The pushing of news information to individual audiences makes older people get more knowledgeable satisfaction from the Internet, expands the dissemination space of news, and makes news more comfortable in the fragmented communication space to achieve the maximum effectiveness of communication.

VI. The Discourse Construction Behind the Algorithm

The French scholar Bruno Latour proposed the actor network theory, which breaks with the previous treatment of infrastructure, media and communication hardware as physical or economic contexts and highlights the ontological and dynamic nature of things, and has been influential in the study of the materiality of media and communication. Latour is "concerned with how 'technology' as a thing enters the so-called 'network' of social fields and how it stabilizes the 'social bond'. He argues that actors are not only human beings, but also extends the category of actors to include non-human objects such as ideas and technologies. [9] The widespread application of algorithmic technology in the field of communication has broken the old communication pattern and extended the subject of communication from human beings to algorithms as "technological objects". As "non-human actors", algorithms and human communication activities are woven together to form a new "actor network". Algorithms are not purely technical artifacts; algorithm engineers, managers, content producers and operators, users, platform business strategies, and other actors are rewriting and transcribing algorithms. Algorithms are collectively produced, and they are subject to the construction of social relations and social discourse.

The addition of algorithmic technology to the media field has increased the anxiety of the original actors, and different actors have used different discourse strategies around "algorithmic legitimacy", reflecting the game and interaction between technical power, political rights and commercial capital, and reflecting the interaction between algorithmic technology and social contexts. The State Internet Information Office, the Ministry of Propaganda and others recently announced the "Guidance on Strengthening Comprehensive Governance of Internet Information Service Algorithms", pointing out that it is important to prevent the risk of algorithm abuse, maintain the order of communication, market order and social order in cyberspace, prevent the use of algorithms to interfere with social opinion, suppress competitors and infringe on the rights and interests of netizens, emphasizing that algorithms, as a technical means, must be guided by correct values, and that the government constantly constructs a discourse of standardized algorithms to regulate algorithmic technology. Traditional media and portals once jointly resisted the algorithm technology of Today's headlines, and on June 3, 2014, Guangzhou Daily sued Today's headlines, followed by an editorial in Xinjing Daily, "Today's headlines", whose "headlines" are "Today's headlines", attacking its copyright infringement. In the second half of 2017, the People's Daily published a number of editorials on the rapid rise of today's headlines and other information clients due to algorithmic recommendations, while the lack of value, "information cocoon", vulgar content and other issues. Platform media take the initiative to construct the legitimacy of the algorithm, but at

the same time make improvements according to the criticism of the party media, such as the response of Today's Headline to the People's Daily's "three comments on algorithmic recommendations", "face up to the shortcomings and forge ahead". Market-oriented media emphasize the use of algorithm technology to serve mainstream ideology and lead correct values, such as Cover Media's emphasis on "integrating human wisdom and technical intelligence into news clients, strengthening value connections, correcting algorithm deviations, and implanting a values soul into the technical engine". It can be seen that in the game around algorithmic technology, political power is regulating algorithmic technology, and political logic is the underlying logic of technology in social and cultural applications.

VII. Reflections on the "Visibility" of Algorithms in Senior Life

According to Thompson's definition, "visibility" means "what can be seen and what can be perceived in the field of view", while invisibility means being invisible. [10] The network of technical practices of the Internet infrastructure is at different levels of social agents and has different degrees of "visibility", but it maintains the greatest degree of "transparency" (transparency) among ordinary users. +However, the destructive nature of the algorithmic recommendation mechanism itself has gradually begun to receive attention, and criticisms of "information cocoon", "algorithmic black box", and "algorithmic bias" have been heard, and algorithmic technology has From "behind the scenes" to "in front of the stage", it has become the focus of people's attention. Some users compete for "algorithmic visibility" through "algorithmic games". 360 Security Technology Company big security intelligence bureau released algorithm recommendation research data report shows that 57.07% of people said they want to escape the fetters of the algorithm, and many people have started the "anti-algorithm" attempts.

However, although the elderly, who are digitally disadvantaged, have been actively digitally integrated, the high threshold of algorithm technology and the sense of authority of information in the elderly group make most of them still in a state of "algorithms unconsciousness". They are not aware of the existence of algorithms in their lives, so they fall into "digital addiction", which affects their health, and they are also prone to fall into scams and suffer from monetary losses. For example, the elderly are often scammed by fraudsters in the name of investment and wealth management or in the name of health care and old age, Tencent 110 platform released a white paper on anti-fraud among the elderly, only in the first half of 2019, the platform received more than 20,000 reports of fraud among the elderly, of which 97% of the victims of fraud had suffered financial losses. Seaver argues that to open the " algorithmic black box", one needs to participate in the operation, production and flow of algorithms through an ethnographic approach in order to observe and understand the diversity and different paradigms of algorithms. This does not apply to the elderly. To enhance the "visibility" of algorithmic technologies in the lives of the elderly, the joint efforts of actors in the "actor network" are needed. For example, the Ministry of Industry and Information Technology and four other departments recently jointly issued the "Internet Information Service Algorithm Recommendation Management Regulations", which came into effect on March 1, 2022, requiring the provision of intelligent and age-appropriate services for the elderly, and detailed regulations on the content of algorithm recommendation services for the elderly population. At the same time, it is necessary for children to carry out digital feedbacks, enhance the algorithmic literacy of the elderly and avoid the elderly group falling into the algorithmic trap.

Algorithms, as infrastructure, are quasi-transparent presences in older life, relegated to the background level of life so that they are difficult to notice and think about in everyday life, which reinforces the illusion of unmediated practices of interaction. Algorithms are material in their technological, spatial, and discursive dimensions, intertwining and interacting with social contexts. Society needs to recognize that the elderly are in a state of "algorithmic unconsciousness" and inject humanistic care into them, so as to lead them to perceive the existence of algorithms, see the impact of algorithmic technology, understand the logic of algorithmic technology, domesticate algorithms, and realize the symbiosis between technology and people.

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