"Urban Brains": Theoretical Model and Key Issues

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This paper reflects on the "urban brain", and points out that its system is faced with four te chnical challenges, such as multi-layer agent decision-making pressure, information explosion, inefficient transmission and database capacity limitation, which are difficult to meet the need s of urban modernization three-dimensional decision-making. This paper puts forward and des cribes the model transformation from "urban brain" to "urban brain", takes social intelligence as a typical feature, expounds the definition and learning mode of "urban brain", breaks throu gh the bottleneck of single brain system, and constructs a new AI model that learns from urb an society, an advanced intelligent life community, to adapt to complex tasks. Further, nine k ey issues, such as the transformation origin, decision-making structure, linkage and overlappin g, function distribution, digital simulation, iterative upgrading, governance mapping, ternary in teraction and community interaction, are put forward and discussed. The organization, operati on and evolution characteristics of urban brains are discussed in depth, and the contribution o f urban brains to the future development of smart cities is pointed out, providing a vision for follow-up research.

Key words: AI; Multiple brain model; Swarm intelligence; Smart City; Urban brain

Since the concept of smart city was put forward, its designers and builders have been co mmitted to endowing the city with technical arms for a long time, so as to make it have "wi sdom". In recent years, with the rise of AI technology represented by deep learning, installin g "brain" for cities has become a consensus work in modern urban development, and extensi ve urban needs have brought great opportunities for intelligent infrastructure construction. Ho wever, there are many problems in the practice of smart cities. The author once reflected on the past development model, and thought that the smart system relying on a single brain stru cture could no longer meet the requirements of urban internal organizations [1]. Constructing an intelligent system to meet the needs of complex urban society poses a new model challen ge to AI algorithm. For a long time, the development of AI algorithm relies on imitating hu man brain or natural biological community to build intelligent algorithm [2]. However, the or ganization of urban society is neither a single-agent decision-making problem, nor an instincti ve organization of lower biological communities such as bee colony and ant colony. It is co mposed of a large number of people with diverse characteristics and interrelated. It is a comp lex intelligent life community phenomenon in which each individual has independent wisdom and decision-making ability, and it is a complex, dynamic, borderless and uncertain system [3, 4]. Therefore, the author thinks that taking the organizational model of urban society as e nlightenment, it can explain the high-level group intelligence structure of the cooperative mec hanism among complex life communities, and the conception of "all brains" model is derived from this. Breaking through the single brain model and moving towards the multi-brain mod el is no longer imitating the organizational relationship within a single living body or a lower living community, but starting to learn the complex community of urban society. The constr uction of the "public brain" model stems from the long-term observation of urban society and reflection on urban intelligence, but it is not only used to solve urban problems, but also ca

n propose a new possible direction for the theoretical structure of the new generation AI technology, and promote scientific reorganization at the structural level above the algorithm.

1 Systematic challenges faced by the "urban brain"

1.1 The "Center" and "Brain" of Smart City

In 2005, in order to solve the scientific problem of Expo site planning, the CIM system of Expo site was introduced, and the BIM technical standard for all 265 venues to be delivered to the overall planning of Expo site was standardized, making the 6.28 km2 Expo site a common prototype of CIM digital platform for future cities. In 2007, IBM proposed to build a theme pavilion of "SmartPlanet" in the World Expo, which was finally integrated with the theme of "BetterCity, BetterLife" to form the theme word of "Smart-City", and established the world's first IBM "Smart-City" research center in Tongji University. As the chief planner of Shanghai World Expo 2010, the author constructs a smart city prototype based on urban life, and points out that a smarter city should have a central system based on the material foundation of the city, including "brain", "cerebellum", "central nerve" and "peripheral nerve". Inspired by Academician Jiang Yi, he puts forward "vagus nerve system", which thinks that some contents should not go directly to the brain, and a large number of contents that do not need brain processing have been processed in the vagus nerve system. Based on this assumption, a command center system for the 5.28 km 2 park is constructed to ensure the safe operation during the Expo. In 2008 IBM has released "Smart City" to the world [5].

The smart city structure announced in 2008 inherits the essence of the overall urban central structure of the World Expo. The central system [6-7] consists of five components: ① urban intelligent decision-making system (brain), which is responsible for decision-making assistance for major and key issues of urban development; ② Urban coordinated operation system (cerebellum), which is responsible for information transmission and resource coordination among functional departments; ③ Information central system (central nervous system), which is responsible for collecting, processing and two-way feedback of a large number of sensory terminal information in cities; ④ Vagus nervous system, which is responsible for a large number of daily reactions of non-brain decision-making; ⑤ Neurons are responsible for sensing and executing two key points.

citybrainsys. tem (CBS) is an important part of the urban center in the process of urban intelligence. In February, 2016, Alibaba Cloud team went to Wenyuan Building of Tongji University to exchange the scheme of urban central machine brain. Alibaba Cloud released the "City Brain" 1.0 intelligent city control system in Hangzhou, which uses the cloud edge collaborative computing method to manage the city's million-level traffic flow data, and applies it to improve traffic efficiency and shorten traffic time [8]. Subsequently, the "urban brain" system developed to 2.0, which was applied in intelligent decision-making in more urban fields. The concept of "urban brain" was widely accepted by academic circles and industries, and was popularized in urban construction all over the country, becoming a basic configuration of intelligent infrastructure and endowed with more connotations. In the past 10 years, "urban brain" has been generally understood as a system that assists urban decision-making with intelligent technology.

The smart city scheme is originally a systematic scheme, and it is also an urban intelligent system engineering with five parts in the whole central nervous system. However, after bei

ng simplified into the brain, all the decision-making pressure is concentrated on the brain, wh ile the vagus nerve system and edge decision-making system are largely ignored in practice b ecause of the lack of display, which leads to the simplification in the process of advancing s mart city and forgets the original meaning of its system engineering. It is not a wise solution to rely on only one brain to solve urban problems, which will cause brain overload and grea t pressure, and is called "urban brain" by Academician Wu Hequan.

What's more, the brain is turned into an exhibition hall of a city. A large amount of tech nical investment is only put on the display demand of a city, which lacks problem orientation and wastes a large amount of hardware investment. In fact, it is out of touch with the real o peration of the city. The exhibition hall mode causes the intelligent system to be idle, delays the intelligence of life, ecology, production and governance, hinders the modernization and de viates from the mainstream of urban intelligence.

The "urban brain" needs to be alert to the existing exhibitionmode of false wisdom, and should return to the correct track of intelligence that facilitates people's daily life and modern ization of urban governance.

1.2 Technical challenges faced by the "urban brain"

1.2. 1 Multi-level agent decision pressure

Data barrier is a consensus issue in the process of smart city construction and operation, which has been discussed a lot. With the gradual integration of systems, platforms and data of various departments, the main pressure has changed into how to effectively coordinate the management demands of various departments when making decisions with these multi-source and heterogeneous data. This contradiction is more prominent when dealing with a wider ran ge of subject demands. It is difficult to give overall consideration to the decision-making req uirements of different ports with a single brain structure, so it is short of money in actual ma nagement.

1.2. 2 Information explosion

Chips with high computing power and high-speed and low-delay communication network s provide the necessary conditions for city-level data analysis and calculation. With the acces s of massive data, the "urban brain" system needs to constantly pursue greater computing po wer [9]. Urban data not only comes from the collection of real urban data, but also includes new data far exceeding the existing data in the process of learning and iterating by collecting and obtaining urban data with AI algorithm. Despite the introduction of infrastructure with u ltra-high computing power, the "urban brain" is still difficult to solve the problem of excessiv e data volume and slow response, which brings more uncertainty to urban decision-making.

1.2. 3 Conduction inefficiency

In the "urban brain" system, information is transmitted from top to bottom, and data coll ected from different channels are finally merged into an overall model. This transmission mec hanism plays a very limited role in emergencies including major epidemics [10], and it is an intractable dilemma for only one "urban brain" to complete the feedback of all information a nd the allocation of resources in the middle of the network. In the future, with the large-scale popularization of commercial 5G technology, with the characteristics of high speed and low delay, more new products and services will appear, and urban information transmission will b ecome more networked, gradually developing from "Internet of Everything" to "Interaction of

Everything". Therefore, it is more urgent to establish a new smart city system to solve this problem structurally.

1.2. 4 Database capacity limits

Data resources are becoming more and more convenient and cheap to obtain. Through various sensors, Internet of Things devices and other sensing means, the data within the monitored control range can fully flow in all levels of urban management systems [11]. The ultra-high frequency, ultra-large range and ultra-high precision data in different regions and systems bring incalculable challenges to the database capacity of the "urban brain". Therefore, distributed data storage has become an inevitable trend.

1.3 Three-dimensional decision-making needs of urban modernization

1.3. 1 Dealing with the interests of multi-heterogeneous subjects

The multi-layer subjects in urban society constitute a heterogeneous social system. There are many ways to classify urban subjects, which can be usually classified into six categories from the perspective of influence in urban development decision-making: ① urban decision-makers. Including the secretary of the municipal party Committee, the mayor, the CPPCC of the Municipal People's Congress, the competent departments of the city, the districts and counties and their competent departments, etc., are responsible for formulating and implementing urban development and safety decisions. Business leaders and business leaders. Investors, entrepreneurs and small and medium-sized business owners also play an important role in urban development decisions. Their economic activities and investment decisions have a direct impact on the development of cities. ③ Professional scholars. Management scholars, economists, environmentalists, engineers and other professionals provide professional opinions and suggestions for the development of cities. ④ Street committees and neighborhood committees. It is the decision-making unit of the basic social unit of the city, which organizes the social life, spatial arrangement and daily operation of the community. ⑤ Urban and rural people. Urban and rural people are the main body of the whole city, the starting point and the ultimate belonging of the city. Everyone's behavior determines the mental state and vitality of a city, and the city values and people's lifestyle determine the quality of the city. ⑥ Media. Although the media are not directly involved in decision-making, they influence public opinion and policy makers' decisions through reporting and analysis. There are great differences in the characteristics, behavior patterns and vision and demand for urban development of each type of subject. Although in most cases, China's urban development is usually made by the decision makers in the region, the process is often influenced by many factors, which are usually made after accepting the opinions of other urban social participants and after comprehensive trade-offs, which are most in line with the actual situation of the region and take into account the overall development interests and the individual needs of the city.

1.3. 2 Game and synergy in coping with decision-making process [12-13]

Urban decision-making in China generally follows the following principles: decision-making reflects the value orientation of urban development, and its basis comes from the convergence of various opinions; Decision-making can be refined into strategic decision-making and daily management decision-making; Each unit makes decisions on the part it manages, and does not raise all problems to the next higher level; When making decisions, each unit should consider the impact on other decision-making units and predict the overall interests; It is not

a simple game, but a judgment decision on the chain reaction of each other's decisions. In th e previous research, the author summarized the space of urban and rural people's needs as "te n yuan", that is, nature, governance, residence, travel, commerce, medical care, education, ind ustry, innovation and infrastructure [14]. Meeting the needs of urban and rural people is the b asic orientation of urban development and decision-making of other participants. The current smart city system is based on the artificial intelligence "single brain" system, which cannot ef fectively deal with the above decision-making problems.

2 The theoretical model from "urban brain" to "urban brain"

2.1 Theoretical Understanding of Social Intelligence

In the field of sociology and neuroscience, we began to pay attention to the existence of socialintelligence (SI) in the early 20th century [15], and further verified its significance in promoting group competition, coordination and cooperation in terms of individual differences [16]. Kliemann et al. [17] pointed out that the key feature of social intelligence is that compa red with lower creatures who decide their own behaviors according to environmental feedbac k, social subjects must flexibly adjust their decision-making modes according to other people' s behaviors, and model their own goals and internal processes to adapt to behaviors, commun icate and coordinate the pursuit of goals. Chen et al. [18] pointed out another key feature, th at is, individuals will also predict and respond to other people's short-term or long-term beha viors in the common social environment. Kingsbury et al. [19] systematically summarized the interaction pattern in this social group, and thought that it would present a multi-brain struct ure. The development of social intelligence model provides a theoretical basis for swarm intel ligence to move towards a higher form. However, in fact, few AI-related studies have discuss ed it from the perspective of social intelligence model, and the only studies have only partiall y improved its collaborative mechanism on the basis of multi-agent model [20], which is diff icult to reflect the characteristics of social intelligence well. The reason is that although the e xisting literature recognizes the significance of social intelligence, it still does not clearly exp lain the elements of social intelligence model and their overlapping, so it is difficult to guide the construction of AI model because it stays at the conceptual level. Cities are the largest a nd most complex artificial creations and coexist with human society. Under the current techn ological environment, the author thinks that it is difficult to meet the needs of modern gover nance by relying solely on a "urban brain" model. Therefore, based on the observation of urb an social organizations, this paper puts forward a theoretical model of "urban brains" model, and combines urban science with the new generation AI technology to build a new network f or complex heterogeneous communities.

2.2 Definition of "urban brains"

In this paper, "urban brains" is defined as an advanced social intelligence model. Its goal is to let AI learn how a social community organizes, cooperates and acts, so as to divert inf ormation into a multi-layer and three-dimensional decision-making mechanism, and finally see k a win-win strategy for heterogeneous subjects to promote the development of overall perfor mance.

2.3 Learning Mode of "Urban Brains"

The essence of the multi-brain model is the change of learning mode. The learning proc ess of multi-brain model has two characteristics, one is community and the other is heterogen

eity. The learning process of multi-brain model is different from that of single brain. Not only do participants need to build a network according to their own development needs, but also take into account the behaviors and decision-making patterns of other subjects to optimize their own behaviors. The learning mode of the multi-brain model is a holistic learning for complex behaviors such as cooperation mode, game relationship and cooperation strategy in social communities [21]. It can be divided into three stages, as shown in Table 1. (1) Stand-alone society. A rudimentary model of swarm intelligence, though each agent makes its own decisions, still needs to be controlled by a whole model. This learning mode improves the swarm intelligence models such as ant colony and bee colony, and has independent consciousness and decision-making ability. ② Multi-machine society. Different from the previous stage, each subject will have the ability to build an information network according to its own needs, seek the subject of competition and cooperation around its own development purpose, and build a new structure conducive to the completion of the goal, which further increases the differences among subjects. ③ Learning society online. Furthermore, while completing their own goals, each individual can cooperate with the individuals who pursue their own goals and seek common motives. There are both cooperation and competition among the subjects, and their identities change accordingly. This is a unique learning mode of mass brain model compared with other swarm intelligence models.

3 Nine Key Issues of "Urban Brains"

3.1 Topic 1: Why should the intelligence of cities change from one brain to multiple brains?

Urban brain is closely related to AI technology, and solving urban problems with AI model is an important means of urban brain. In the development of AI, the research paradigm of imitating and learning the structure and behavior of human brain with the help of intelligent machines has long dominated, and two directions have been derived: First, the artificial neural network combined with brain science and neuroscience, and the machine learning and deep learning theory established by imitating neurons and neural networks [22-23]. Secondly, the cognitive-decision model produced by combining with cognitive science (CS) reveals the deep principles of human beings in discovering, thinking and solving problems by studying the working mechanism of human brain or mind, and learns from the thinking mode of human brain [24-26]. Single brain model is essentially a predictive decision-making model based on knowledge imitating human brain. Urban brain is an integrated application of technologies such as visual and auditory perception, brain decision-making and information transmission of nervous system, which takes the city as an intelligent living body. However, known algorithms can never break through the construction within a system, and rely on individual decision-making model, so it is very limited in the complex environment of group collaborative decision-making. Therefore, it is necessary to construct a system of urban brains to break through the limitations of a single brain system.

3.2 Topic 2: How to structure the city's brains and represent which decision-making objects in the city?

From the perspective of composition, because the composition of social groups is very complex, from the perspective of their role in the system, the elements of urban multi-brain model can be abstracted into four categories: main brain, auxiliary brain, sub-brain and telence

phalon. Among them:

(1) corebrain (CB). Function is the decision response of key issues, and only receives necessary information and gives feedback. For example, decision makers in urban society deal with key issues such as urban development strategy and deployment of major events, which need to coordinate the whole system.

(2) asistantbrain (AB). Function is subsystem decision-making, providing more comprehensive and balanced information for the main brain. For example, in urban society, various commissions, offices, bureaus and other functional departments aim at urban traffic problems,

Energy problems, environmental problems and other problems that need to be solved in coordination within the system.

(3) distributedbrain (DB). The function is to complete self-organization and self-operation decision-making in local space, such as sub-functional departments in various urban areas and social organizations in different fields.

(4) Terminalbrain 1 (TB1). The function is to make reflective decisions in the terminal perception center, and report when abnormal terminal data is found, such as responding and making decisions in streets and community neighborhood committees.

(5) Terminalbrain 2 (TB2). A large number of spaces in cities are determined by a single owner and decision maker. Universities, troops, large enterprises, development zone spaces, etc. should also be simulated as decision-making units in cities, and become simulation objects in urban brains.

(6) Terminalbrain 3 (TB3). In addition, the special space across the administrative space in the city should also be included in the decision-making end, for example, the river chief participates in the decision-making of a river and the street chief participates in the decision-making of a street.

3.3 Topic 3: How do brains link?

First, the primary and secondary synergy. It refers to the organization mode in which one of the instructions is given priority to and the other parties cooperate between the main brain and the auxiliary brain. In the primary-secondary synergy relationship, the final decision will be completed by the main brain, and the main decision is based on different dimensions of information provided by the auxiliary brain.

Second, hierarchical synergy. It refers to the organizational model of hierarchical decision-making formed by distinguishing sub-brain and telencephalon from main brain and auxiliary brain. In the hierarchical cooperative relationship, all levels of brain systems can make independent decisions and filter information for transmission. For example, in the construction of urban intelligent system, the author once put forward the idea of "vagus nervous system" [27]. Its purpose is to use hierarchical data governance mode to divert and process complex urban information locally, so as to avoid redundancy of urban central information.

Third, community synergy. It refers to an organization mode composed of multiple independent brain systems, which includes one-way instructions and network cooperation and coexistence. In the community synergy relationship, each subject needs to deal with the complex information flow in multiple systems on the basis of balancing common goals and individual needs, so as to realize the dynamic process of continuous autonomous learning and improvement. Compared with the former two, the community synergy establishes a more complex network, in which information can be transmitted directly, thus avoiding the one-way flow of info

rmation and forming a loop.

3.4 Topic 4: How to structure the community of urban brains and the functions of each brain?

The three links are integrated into one system, and the prototype map of community structure of urban brains is constructed (Figure 1). Therefore, different brains form a dynamic and interactive community system, and realize the coordinated development of the whole system.

3.5 Topic 5: How to simulate urban brains digitally?

3.5. 1 Giving a single node the ability to perceive and predict groups

Each kind of agent in urban decision-making has specific goals and needs, and the agent of the model should no longer be limited to the perception ability of a single intelligent system, but realize group active perception. In addition to perceiving the environment, individuals also perceive the needs of other individuals, and this perception is an active process, that is, to obtain the needs and behavior information of stakeholders according to their own needs, and to make decisions according to the complementarity with the needs of other individuals, such as multi-agent adaptive network based on reinforcement learning method [28-30]. On the basis of group perception, the individual of the model should also have the ability of system dynamicprediction (SDP). It is reflected in the following aspects: First, the future can be predicted according to laws and empirical knowledge, and the current behavior can be corrected according to the results of the prediction; Second, we can not only predict our own behavior, but also foresee the behavior of other subjects; Thirdly, it should have the ability to predict the overall changes of the system, and be able to predict the results of changes over time for the whole network according to the behaviors of itself and other participants. System dynamic prediction is different from traditional distributed computing. Nodes not only deduce their own development process, but also consider the evolution of other factors related to their interests, so as to make decisions conducive to future value enhancement. Group perception and prediction can overlap the demands of different participants in urban governance in a top-down and bottom-up way.

3.5. 2 Key to Constructing Cooperative Decision-making of Heterogeneous Agents

The main principles of heterogeneousagentcoordination (HAC) are seeking common ground while reserving differences and complementing each other's strengths and weaknesses, which are reflected in some distributed machine learning tasks [31]. For the same environment, in most intelligent models, their judgments are similar because of the oneness of agents. In fact, the agents of the model should not only reflect the environment differently, but also seek other agents with common decision goals in this process. Heterogeneous agents have more complex collaborative mechanisms, which are mainly reflected in: the decision-making objectives of agents themselves are significantly different; In addition to the relationship with the environment, the relationship between agents should be further strengthened, and the prediction of other agents' behaviors should be considered when agents make decisions; The decision-making of each subject has overall motivation, which is different from the multi-agent system that pursues the maximum of its own interests. The model needs to find a balance between individual and overall value. In the single brain structure, the goal is single, that is, it conforms to the interests of the only subject; In the cooperative mode of heterogeneous agents, the goals are pluralistic or even conflicting, and each agent is balancing its own expectations with tho

se of other agents. With the development of the system time, the overall goals will change ac cording to the states of different agents. Therefore, the model should pay more attention to th e heterogeneity of each node in the expected goal, perception ability, model structure, behavi or and other aspects, and the difference of system evolution results caused by it.

3.6 Topic 6: How do urban brains iterate?

Urban intelligent system can be described as three stages, which are developed from sin gle brain system and low-level swarm intelligent system to multi-brain system. The evolution process is shown in Table 2.

3.7 Topic 7: How to map the relationship between brains in virtual space to the re al governance of cities?

In terms of system structure, for example, in the wisdom construction of Shanghai Jindin g, a multi-brain parallel AI scene group was constructed to realize people flow perception an d three-dimensional traffic push Performance, industrial operation diagnosis, automatic drivin g service, function configuration and other multi-dimensional information interaction and reso urce scheduling, as shown in Figures 2 and 3. Each system can run independently, and coope ration can be realized through the interaction of data, algorithms and calculation results.

In the aspect of terminal perception, such as "urban digital retina" perception-decision sy stem [32]. With the help of the terminal decision-making system, the situation of relying only on the urban brain for decision-making is broken, and the zoning and hierarchical decision-making are realized, and the one-way instruction model is transformed into a self-organizing model, as shown in Figure 4, which is more suitable for the needs of governance. In addition, the emergence of a large number of mobile apps has formed a new business model, which s olves the problem of accurate matching of individual needs of users and directly improves th e convenience of users [33]. Through micro-loop, the self-organization decision-making mech anism of tedious needs of urban residents and employees in daily production and life is const ructed, and the balance of the whole system is guaranteed through diversion.

3.8 Topic 8: How to form the interaction among material, social and digital ternar y worlds?

People extract knowledge from material space, and in turn intervene in material space, t hus forming a basic closed loop of urban evolution. With the popularization of digital technol ogy, after introducing the concept of digital space, a layer of "number" is added between ma n and the real world, forming a ternary interactive structure of "man-digital space-material sp ace". Among them, material space and digital space form a pair of mappings, which were lat er called "digitaltwincity"; Digital space transmits information and knowledge to people in th e form of data, and realizes the ternary interaction among real material world, social space an d digital space. The structural change brought by urban brains simulates the operation of the whole social space in the digital world, not just building a digital twin city. Therefore, the rel ationship between subject and object of urban intelligence has changed, and cities can activel y learn and iterate, see the future urban evolution in advance, and then map to the process in the real world.

3.9 Topic 9: How should the brains of cities be structured?

After constructing a set of multi-brain system for each city, the connection between citie s will be closer, not only the linkage between the main brain decision-making level or the m anagement level, but also the close information interaction between the brain systems at all le

vels. The transmission of these cross-city information will also become the resources in the multi-brain decision-making system, thus realizing the multi-brain system of urban communities on a larger spatial scale.

4 Conclusion

The traditional "urban brain" is faced with some problems in modern governance, such as relying on single decision-making model, lack of group perception and prediction ability, and difficulty in coping with heterogeneous subject cooperation. Learning from the organizational model of urban society to establish a "urban brain" system that is more suitable for the complex demand environment of multiple heterogeneous subjects is not only a way to break through the bottleneck of the development of "urban brain", but also a new direction of AI technology research and development. From "urban brain" to "urban brain", the following historic progress has been completed in essence: ① Artificial intelligence has moved from learning single intelligence to learningThe intelligence of social communities. ② The intelligence of the city depends on a super intelligent brain to a group of intelligent brains. ③ Human civilization does not transfer the IQ of all social communities to one brain, but a group of independent IQ cooperates to complete the development of civilization, and the brains are the intelligent model mapping of this civilization progress. ④ Different from the decentralization and spontaneity of swarm intelligence such as birds, fish and ants, all brains call brains at different levels to construct the model framework of main brain, auxiliary brain, sub-brain and telencephalon. The primary and secondary synergy, hierarchical synergy and community synergy among these brains jointly promote the operation of the "urban brains" model. ⑤ Just as Chinese medicine adopts the prescription composition principle of "monarch, minister, assistant and envoy", the overall synergy of compound thoughts is fully reflected and deductively developed in the brain structure.

Urban brain structure can be divided into multiple technological revolutions: philosophy layer, theory layer, technology layer, hardware layer and operation layer. This paper mainly discusses nine key issues, such as transformation origin, decision-making structure, linkage and overlapping, function allocation, digital simulation, iterative upgrading, governance mapping, ternary interaction and community interaction, and expects more issues to emerge to promote the continuous iterative update of "urban brains".

Notes

① "Center" refers to the centralnervoussystem (CNS) in physiology, which is composed of brain (including brain and cerebellum) and spinal cord. Its main function is to receive the afferent information of the whole body, which is transformed into motor efferent after integration and coordination, or becomes the neural basis of learning and memory after storage and transformation. The central nervous system is the main part of thinking, decision-making and action of living beings.

References

[1] Wu Zhiqiang, Wang Jian, Li Deren, et al. Academic talk on "cold" thinking under the upsurge of smart city [J]. Journal of Urban Planning, 2022 (2): 1-11.

[2] Pan Yunhe. AI and the new direction of robots [J]. Robot Technology and Application, 2 019 (4): 19-20.
[3] Zhang Tingwei. Complexity theory and artificial intelligence in planning
Application of [J]. Journal of Urban Planning, 2017 (6): 9-15. [4] Wu Zhiqiang. On Urban Pl anning and Its Ecological Rationality in the New Era
Kernel [J]. Journal of Urban Planning, 2018 (3): 19-23.
[5]CHOURABIH,NAMT,WALKERS,
etal.Understandingsmartcities: aninte. grativeframework [J]. IEEEComputerSo. ciety, 2012.
Wu Zhiqiang, Gan Wei, Zang Wei, et al.Concept and development of urban intelligent model (CIM) [J]. Urban Planning, 2021, 45 (4): 106-113.
Gan Wei, Wu Zhiqiang, Wang Yuankai, et al.Construction of theoretical model of AIGC aide d urban design [J]. Journal of Urban Planning, 2023 (2): 12-18.
[8] Hua Xiansheng, Huang Jianqiang, Shen Xu, et al. Urban Brain: Cloud Edge Collaborative Urban Visual Computing [J]. Artificial Intelligence, 2019 (5): 77-91.
[9] Gao Wen. Pengcheng Yunnao Open Source Ecology [J]. Software and Integrated Circuits, 2021 (6): 50-51.
[10] Wu Zhiqiang, Lu Feidong, Yang Ting, et al. The test of urban spatial governance under the impact of major epidemic [J]. Urban Planning, 2020, 44 (8): 9-12.
[11] Li Deren, Yao Yuan, Shao Zhenfeng. Big data in smart cities [J]. Journal of Wuhan Uni versity (Information Science Edition), 2014, 39 (6): 631-640.
[12] Lai Shigang. Theoretical Framework of Complex Urban System Planning [J]. Urban Dev elopment Research, 2019, 26 (5): 8-11.
[13] Fan Ruguo. Collaborative innovation of social governance under the paradigm of comple x network structure [J]. Chinese Social Sciences, 2014 (4): 98-120.
[14] Wu Zhiqiang. Artificial Intelligence Assisted Urban Planning [J]. Time Architecture, 201 8 (1): 6-11.
[15]MCCLATCHYVR.Atheoreticalandstatisticalcritiqueoftheconceptofsocialintelligenceandofatte mptstomeasuresuchaprocess[J].JournalofAbnormal&SocialPsychology,1929,24(2):217-220.
[16] CONZELMANNK, WEISS, HEINZ-MARTINS å. Newfindingsaboutsocial
Intelligenceddevelopment and application oftheMagdeburgTestofSocialIntelli m. gence (MTSI) [J]. JournalofIndividualDif
ferences,2013,34(3):119.
[17] KLIEMANND, ADOLPHSR.Theso m. cialneuroscience ofmentalizing: challenge m. esan drecommendations [J]. CurrOpinPsychology, 2018, 24: 1-6.
[18]CHENP,HONGW.Neuralcircuitmechanismsofsocialbehavior[J].Neuron,2018,98:16-30.
[19]KINGSBURYL,HONGW.Amulti-brainframeworkforsocialinteraction[J].TrendsinNeuroscienc es,2020,43(9):651-666.
[20] ROUCHIERJ.Socialintellectuenceforcomputers [M]//DAUTENHAHNK, BONDA, CA ñ AMEROL, etal.Sociallyintellectuentagents.multiagentsystems, anti. ficialsocieties, andsimulated organizations,
vol3.Boston,MA:Springer,2002.
[21] VANDIJKE, DEDREUCKW. Experience. mentalgamesandsocialdecisionmaking [J]. Annu alReviewofPsychology, 2021 (72): 415-438.
[22]LECUNY,BENGIOY,HINTONG.Deeplearning[J].Nature,2015,521(5):436-444.

[23] HUJie, SHENLi, SUNGang.Squeeze-and-excitationnetworks [C]//ProceedingsoftheIEEEConferenceonComputerVi. ionandPatternRecognition (CVPR), 2018: 7132-7141.
[24] LECUNY, BOTTOUL, BENGIOY, etal. Gradient-basedlearningappliedtodoc. umentrecognition [J]. ProceedingsoftheIEEE, 1998 (11): 2278-2324.
[25]HINTONGE,SALAKHUTDINOVRR.Reducingthedimensionalityofdatawithneuralnetworks [J].Science,2006,
313(5786):504-507.
[26] BENGIOY, COURVILLEA, VIN m. CENTP.Presentationlearning: are m. viewandnewperspectives [J]. IEEEtrans m. actionsonpattern analysisandmachine m. torque, 2013, 35 (8): 1798-1828.
[27] Wu Zhiqiang, Gan Wei, Liu Chaohui, et al. AI City: Theory and Model Architecture [J]. Journal of Urban Planning, 2022 (5): 17-23.
[28] JANGJSR.Anfis-adaptive-network-basedfuzzyinferencessystem [J]. IEEETransactionsOnSystemsManandCyber
netics,1993,23(5):665-685.
[29] OLFATI-SABERR, FAXJA, MUR. RAYRM.Concersusandcooperationinnetworkedmulti-agentsystems [J]. Pro. ceedingsoftheIEEE, 2017, 95 (1): 215-233.
[30] MNIHV, KAVUKCUOGLUK, SIL vis VERD, etal.Human-levelcontrolthroughdepreinforcementlearning [J]. Nature, 2015, 518 (7540): 529-533.
[31]XINGEP,HOQ,DAIW,etal.Petuum:anewplatformfordistributedmachinelearningonbigdata[J].IEEETransactions
onBigData,2015,1(2):1335-1344.
[32] Gao Wen, Tian Yonghong, Wang Jian. Digital retina: the key link in the evolution of smart city system [J]. Chinese Science: Information Science, 2018, 48 (8): 1076-1082.
[33] Zhang Xumei, Liang Xiaoyun, Dan Bin. O2O business model of "internet plus" fresh agricultural products supply chain considering consumer convenience [J]. Contemporary Economic Management, 2018, 40 (1): 21-27.