Research Article

A Study on the Relationship between Artificial Intelligence and 5G Network Construction and the Level of Economic Development of Regional Cities

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Urban digital governance represented by digital city and smart city is becoming an important direction of urban agglomeration development. It is necessary to reexamine the internal relationship mechanism between local government digital action and regional governance behavior. Based on the theory of collective action and network governance, this paper discusses how the economic development level of local government interacts with the cooperative network status of urban agglomeration and affects the tendency of digital governance strategy of local government. By constructing the configuration matrix of “economic development level” and “cooperative network status” of local governments in urban agglomerations, this paper extracts the possible “center” and “follow” governance strategies that local governments in different configurations may adopt in the digital field. The ant colony optimization algorithm proposed in this paper consists of two parts—ACO initialization and ACO optimization. ACO initialization describes how to map the path of ants to the solution of the problem, that is, the combination of orders. In addition, ACO initialization will also define and initialize the pheromone and heuristic information model compatible with the solution. ACO optimization updates the pheromone model to heuristic guide ants to build paths, so as to iteratively find the optimal solution. The case study of 26 cities in the Yangtze River Delta of China shows that most of the digital governance strategies of local governments are in line with the selection logic of their configuration status of “economic level network status”. The study results proved that the proposed model has provided effective accuracy of 96%. However, driven by selective returns, there are still some “abnormal” governance tendencies.

1. Introduction

With the continuous development and progress of the economy and science and technology, various new technologies have emerged and been applied, especially in the mobile data widely used to vigorously promote the change of business data at the same time but also to accelerate the construction of smart cities. Mobile communication networks are very important in the construction and development of smart cities, especially in late urban planning, and operators should focus their network planning on key areas to enhance the effectiveness of smart city construction. Out of consideration for urban network planning, the application of gigabyte optical fiber in urban areas can not only continuously improve network communication infrastructure, but also meet the needs of solid urban planning [1]. At the same time, for mobile operators, strengthening the comprehensive layout of 5G test networks is the basis for promoting the development of smart cities towards informatization and for the long-term development of their own enterprises. Under the premise of clear 5G mobile network planning requirements, combined with the current situation of the development of smart cities, make preparations for the comprehensive layout of 5G mobile communication networks, which is conducive
to the comprehensive construction of high-speed broadband to provide basic protection at the same time, can also actively promote the development of the industry towards modern, information technology and intelligence, and gradually form a good situation for sustainable development [2].

The arrival of the 5G era has changed the way of production and operation in various industries and fields [3]. To a certain extent, strengthening cloud protection for large enterprises can enhance their ability to resist illegal networks and malicious attacks, thereby maintaining the stability and healthy development of large enterprises and the security of their network environment. In order to further enhance protection efforts, build a security foundation system, with data flow as the core, and pay attention to data production, transmission, and processing analysis, etc., to enhance the effectiveness of smart city construction; at the same time, for the network defense performance improvement, from the operation, big data and emergency response three aspects to strengthen the application of security operation technology and the formation of dynamic operation system, both to achieve the effect of improving the smart city network defense performance. It can also better solve all kinds of new problems and new situations in the process of smart city construction. For the smart city network operation mode, in addition to the need for support and cooperation from all sectors of society, it is also necessary to pay attention to the basic technical issues, so that it can enhance the confidentiality and security of urban information [4].

The current state of development of smart cities in China is to promote the rapid and healthy development of artificial intelligence to point the direction; in recent years, more than 500 cities are clearly proposed building smart cities, with the emergence of government-driven and high-tech, smart cities came into being. Smart cities are an important stage in the development of modern cities, upholding the concept of intelligence, harmonious, energy-saving, and green urban development [5]. The development of smart cities has gone through three main stages, the first is the digital stage, mainly to complete the establishment of the city database, to achieve the process of urban information and digitalization; the second is the network stage, that is, based on big data technology to achieve networked management of the city; the third is the wisdom stage, that is, adhering to the “people” development concept, the use of artificial intelligence technology to create a smart ecosystem of the city and the use of artificial intelligence technology to create an urban wisdom ecosystem and build a city wisdom brain.

The construction of smart cities in China is still in the development stage; as a new form and model of cities, how to quickly improve urban governance and modern management and better make cities serve people is one of the topics to be considered and explored at this stage [6].

The contribution of this paper is as follows:

(i) It focused on constructing the configuration matrix of “economic development level” and “cooperative network status” of local governments in urban agglomerations

(ii) It aims at the possible “center” and “follow” governance strategies that local governments in different configurations may adopt in the digital field

(iii) It proposed ACO initialization and ACO optimization for evaluating the enhancement of economic and cooperative network status

(iv) It consider case study of 26 cities in the Yangtze River Delta of China

2. Knowledge Background

2.1. Artificial Intelligence in Smart Cities. The application of artificial intelligence technology in urban management. With the arrival of artificial intelligence, the mode of operation of urban management has changed, and urban management is gradually being upgraded from digital to intelligent. Image recognition technology is used in urban management to many applications, especially in urban security [7]. For example, intelligent recognition system, the system for the whole city to provide monitoring functions, will be integrated with the city public security department monitoring system which can be automatically identified in the city problems and cases for real-time reporting and dispatched to the relevant departments for processing; similarly, for the establishment and maintenance of civilized cities, image recognition technology is also a great credit [8].

For example, the automatic identification of problems, such as rubbish piles, vehicles parked indiscriminately, illegal operations, and other problems affecting urban order and the city’s citiescape, greatly improve the effectiveness of urban management. Artificial intelligence can effectively reduce human time and energy spent on repetitive tasks, effectively free human hands and brains, and can help humans to achieve more meaningful and valuable things. In citizens’ lives, AI technology can be applied to various aspects of healthcare, education, transportation, and urban ecology and has greatly improved citizens’ living standards and ecological environment [9]. In some cities with large populations, the rapid expansion of population and building scale has led to a relative lag in the construction of community public service infrastructure, with problems such as inadequate infrastructure and insufficient supply of resources, especially in older urban areas, making the construction of community micro-infrastructure particularly important. By using technologies such as 5G and artificial intelligence, we can digitize and intelligentize the community and surrounding service scenarios, and transform the city into a “micro-unit” of governance [10].

2.2. Trends in Digital Governance Strategies for Local Governments in Urban Agglomerations. Among the established objective conditions of local governments in urban agglomerations, the level of economic development becomes an important basis for the choice of governance methods and the innovation of governance mechanisms, so that the economic base of each city has an important influence in the field of digital governance. On the one hand, in terms of actor attributes, the level of the economy affects the
strength of factor integration and technological innovation [11]. The transformation of the urban economy increases both the extent to which interactive information technologies are used in the urban environment and the impact on the formation of smart, modern urban space that is in line with the level of social development [12]. The process of informing, digitizing, and smartening the smart economy and the technological, environmental, and community factors creates a structural system that can effectively improve the ranking of smart cities [13]. On the other hand, from the logic of collective action, the economic level at the regional level influences the digital governance decisions of local governments. As regional collaborators, local governments recognize each other’s motivation to make rational choices and make specific implementation decisions based on cost-benefit considerations of governance strategy choices, and economic and social characteristics are important factors influencing local governments’ digital governance strategy preferences in this process [14]. In addition, the development of digital governance by local governments is also promoting the development of local economic quality, advancing their own strength [15] and providing new momentum for regional economic development [16]. Based on a study of four approaches to digital economic cooperation between China and South Korea, some scholars have proposed that multilevel cooperation in digital governance with highly complementary areas is important for promoting digital economy governance [17].

It can be inferred that the higher the economic level of a city cluster, the stronger the incentive to adopt urban digital governance, and the easier it is to develop its own advantages and thus more inclined to a central strategy in digital governance, i.e., a construction and diffusion-oriented path oriented to the construction of a regional hub, attracting other cities to join, learn, and imitate through platform construction and experience sharing. On the contrary, the lower the economic level, the more complex the social and economic problems, and thus the constraints on digital governance [18], the more inclined to choose a low-cost follow-the-leader strategy, i.e., tend to share and learn type of path, management-oriented construction and development of digital governance, or actively seek to share and imitate the object of learning [19].

3. This Paper Optimizes the Ant Colony Optimization Algorithm for Combinations

The proposed ACO algorithm consists of two parts—ACO initialization and ACO optimization—ACO initialization describes how the paths of the ants are mapped to the solutions of the problem, i.e., how the orders are combined. In addition, pheromones and heuristic information models compatible with the solution are defined and initialized in the ACO initialization, and the ACO optimization iteratively finds the optimal solution by updating the pheromone models to heuristically guide the ants in their path construction. Figure 1 illustrates the framework of our proposed ACO algorithm.

3.1. ACO Construction. When using an ant colony optimization algorithm to solve a particular problem, it is first necessary to address how the paths of movement of the ants in the ant colony algorithm can be mapped to the solution of the problem. A concrete way of mapping the paths of ants into complex order combinations is illustrated in Figure 2.

In Figure 2, the squares represent orders, and the several orders within the blue dashed boxes are a complex order. The diagram uses solid arrows to connect orders between complex orders and dashed arrows to connect two complex orders. By moving ants between all the orders, we end up with a feasible solution.

When the ant is selecting the next order for the current order to be combined, we need to consider the selected order, the current order, and the order to be selected in the same complex order. To simplify the problem, we only prioritize the relationship between the current order and the order to be selected [20]. Once the path construction is finished, we will check each complex order containing more than two orders and prune the orders that do not satisfy the complex order constraint until they do. Clipped orders are kept until the next car pool dispatch. In the revolution carried out by the ant colony algorithm, the ants perform the construction of the solution heuristically through pheromones and heuristic information. Therefore, the construction of pheromone and heuristic information models directly affects the effectiveness of the ACO. The pheromone matrix and heuristic information matrix defined in this paper are expressed as the following.

$$P = \begin{bmatrix} \tau_{0,0} & \cdots & \tau_{0,n-1} \\ \vdots & \ddots & \vdots \\ \tau_{n-1,0} & \cdots & \tau_{n-1,n-1} \end{bmatrix}$$

$$H = \begin{bmatrix} h_{0,0} & \cdots & h_{0,n-1} \\ \vdots & \ddots & \vdots \\ h_{n-1,0} & \cdots & h_{n-1,n-1} \end{bmatrix}$$

Figure 1: Framework of the ant colony optimization algorithm.
Since the ants only prioritize the selection of the next order for the current order for the combination of complex orders, the pheromone and heuristic information models only need to contain information between two orders. So when there are \( n \) orders, the size of both matrices is \( n \times n \).

The pheromone matrix is initialized according to Equation (1), where \( \tau_0 \) is the initial value of the pheromone and \( \text{fe}(a, b) \) is used to determine whether order \( b \) can be formed with order \( a \) to form a complex order starting with order \( a \).

\[
\tau_{a,b} = \begin{cases} 
\tau_0, & \text{if } \text{fe}(a, b) \text{ is true}, \\
0, & \text{otherwise}. 
\end{cases}
\]  

The heuristic information matrix is initialize according to Equation (2). The initialization of the heuristic pheromone involves more information, including the gender of the passenger, the distance between the border origins, and the detour rate of the order, all of which are directly relevant to the passenger experience as defined in this paper. In this case, \( \text{gen}(a, b) \) returns true only when the gender of the two-order initiators is the same as

\[
h_{a,b} = \frac{S_{a,b}}{\text{Dist}(O_{\text{start}a}, O_{\text{start}b}) + (\text{rate}_{a} + \text{rate}_{b}) \times \text{ORDER\_LIMIT}}.
\]

\[
S_{a,b} = \begin{cases} 
0, & \text{if } \text{fe}(a, b) \text{ is false}, \\
1, & \text{if } \text{fe}(a, b) \text{ is true}, \\
2, & \text{if } \text{fe}(a, b) \text{ is true and } \text{gen}(a, b) = \text{true}. 
\end{cases}
\]

3.2. ACO Optimization. Ant chooses a random order as the starting order when building the path. If the selected order has no orders with which it can be combined to form a complex order, we randomly select one order from all remaining orders as the starting order for the next complex order. If there is only one order that can be combined with it to form a complex order, we simply select that order as the next order. If the selected order has two or more orders with which it can be combined, two orders are randomly selected from among them and the border with the higher transfer probability calculated according to Equation (4) is chosen as the next order. We then select the next order for the newly selected order in the same way until all orders have been selected. In this way, we obtain a candidate solution to the problem. It is worth noting that in order to ensure that each order is selected only once. The orders that have been selected are not combinable for any order.

\[
\text{pro}_{a,b} = (\tau_{a,b})^\alpha (h_{a,b})^\beta.
\]

After obtaining the final solution, we evaluate the resulting solution using Equation (5), which contains the sum of heuristic information about the paths taken by the ants and the evaluation of all complex orders.

\[
f(s) = \sum_{(a,b) \in E} h_{a,b} + \sum_{O \in S} \frac{\text{EVA}_{O}}{\text{sizeof}(O)},
\]

where \( L' \) is the solution obtained by ant \( s \), 111 is the amount of heuristic information on path \( ab \), \( O \) is the set of complex orders obtained by ant \( s \), returns the number of orders in the complex order, and the constant EVA is used to balance the number of orders in the complex order and the goodness of the complex order to avoid the complex order containing too many orders. After evaluating the obtained solution, the algorithm will update the pheromone model based on the obtained results and the following three equations. One of them, Equation (6), is designed to improve the exploratory power of the ACO.

\[
\tau_{a,b} = \tau_{a,b} \times (1 - \rho) + \sum_{s \in S} \Delta \tau_{a,b}(s),
\]

\[
\Delta \tau_{a,b}(s) = \begin{cases} 
\frac{Q}{f(s)} \tau_s, & \text{if } \text{fe}(a, b) \text{ is true } (a, b) \in L', \\
0, & \text{otherwise}.
\end{cases}
\]

\[
\tau_{a,b} = \begin{cases} 
\theta_0, & \text{if } \tau_{a,b} < \theta_0, \\
\tau_{a,b}, & \text{otherwise}.
\end{cases}
\]

\( \Delta \tau_{a,b}(s) \) is the amount of pheromone placed by the ant \( s \) on path \( ab \). \( S \) is the set of elite ants, i.e., the top \( K \) ants with the highest evaluation value in this generation. \( q \) is the total amount of pheromone that can be released by each elite ant. After sorting the elite ants in descending order of assessed value, for the elite ant \( s \) in the \( i \)th position, \( f(s) \) is the assessed value of the \( (K - i) \)th elite ant. \( \theta_0 \) is the minimum value of pheromone.

4. Case Studies of 26 Cities in the Yangtze River Delta

4.1. Case Selection and Data Sources. As a key strategic city cluster for China’s coordinated regional development, the Yangtze River Delta is a lead in promoting regional cooperation and integrated development and has also vigorously promoted the creation of the “Digital Yangtze River Delta” through its policies, achieving many results in the area of digital construction, for example, digital governance innovations such as the promotion of full coverage of medical insurance settlement in Jiangsu, Zhejiang, and Shanghai; Alipay’s support for the implementation of “one network for all”; and digital technology to promote the integration of environmental governance [21].

This paper chooses the full domain data of the Yangtze River Delta Intergovernmental Joint Conference 1992-2019 as the basis of the regional governance collaboration.
network, which originated in 1992 when the governments of several cities, including Shanghai, Hangzhou, and Nanjing, jointly negotiated to establish the “Joint Conference System of Directors of Collaborating Departments of 14 Cities in the Yangtze River Delta.” The “joint meeting” is a deliberative and coordination mechanism in the Chinese context [22], a self-organized coordination and cooperation mechanism developed through voluntary talks and negotiations in order to solve public governance problems or to further promote the development of regional cooperation between governments [23]. As a typical representative of intergovernmental agreements, the collaborative network structure built by the Joint Committee has continuously promoted the integrated development of the region [24]. Based on this, this paper adopts a data collection approach combining crawler software and manual identification to retrieve information in the form of “A + B,” where A is based on the geographical scope of the major cities of the Yangtze River Delta, the Yangtze River Delta, and the submetropolitan areas of the region explored in this paper and B is based on the joint meetings; interpretational joint A is based on the geographical scope of the Yangtze River Delta, the Yangtze River Delta, and the submetropolitan areas in the region, while B is based on the horizontal coordination organization such as the Joint Conference, the Intergovernmental Joint Conference, and the Coordination Committee [25].

The relevant materials mainly come from government information, news information, and academic research results; the main information obtained is the cooperation practice and news reports of the Yangtze River Delta Intergovernmental Joint Conference within the time period, including the relevant detailed agreements, statements, declarations, and speeches [24]. The cooperation practice has been obtained from the news report and conference [25]. 364 valid data of the Yangtze River Delta Intergovernmental Joint Conference were obtained through coding, organizing, and analyzing the data; as shown in Figure 3, the yellow line is the data of the method in this paper, and the blue is the regression line.

As shown in Figure 3, this paper selects digital construction agencies established in 26 cities in the Yangtze River Delta (e.g., Shanghai Big Data Center and Nanjing Big Data Administration) as the specific behavioral decision-making and implementation subjects of digital city construction and identifies the main behavioral characteristics through the collation of event news [26]. The data collection period is from the establishment of each city institution to December 2020, and the main behavioral data are news about the activities of each city institution during the specified period, which are obtained from the official website of each city government, the official website of the digital construction institution, and the news websites such as Baidu [27]. In the process of data collection, the digital governance behaviors of local governments were divided into the category of investment and construction, which emphasizes investment and construction of infrastructure and data platforms, and the category of diffusion and sharing, which focuses on exchanges, study tours, learning and experience promotion in the field of digital governance, etc. [26]. A total of 197 behaviors were collected, of which 81 were investment and construction and 116 were diffusion and sharing. On this basis, based on this paper’s definition of central and following strategies, manual screening was conducted, and the core behavioral characteristics and strategy selection tendencies
of local governments in the Yangtze River Delta city cluster in the field of digital governance were judged [27]. In addition, as shown in Table 1, the average GDP values of 26 cities from 2012 to 2018 (China’s smart city opening pilot in 2012) were selected as the basic data for measuring the economic level of local governments in the Yangtze River Delta city cluster.

4.2. Yangtze River Delta Regional Governance Structure Environment. In the overall structure of the region, the strength of cooperative relations between subjects can effectively reflect the density of the distribution of relations in the network; the greater the strength of cooperative relations, the stronger the ties between the members of the network, and the greater the influence of the structural environment formed by that network on the attitudes and behaviors of the actors in it [28]. As shown in Table 2, taking the data of the joint meetings carried out in cooperation between 26 cities in the Yangtze River Delta city cluster from 1992 to 2019, the overall number of cooperative relationships is calculated to be 23,736, and the intensity of cooperative relationships is 36.517, indicating that the Yangtze River Delta as a whole has closer cooperative relationships, with an average pair of cities participating in 36.517 joint meetings, reflecting the cities. This reflects the high frequency of contact between cities, the good foundation of city cooperation network, and the effectiveness of the network environment, which also indicates that the Yangtze River Delta can provide a good field to study the impact of the collaborative environment.

In the Yangtze River Delta city cluster, the 26 cities are divided into two levels of high and low degree centrality through a quantitative ranking distribution, which in turn presents two types of network locations for the cities. As shown in Figure 4, in the overall network environment of the Yangtze River Delta, cities such as Suzhou and Nanjing are located at the core of the network; cities such as Taizhou and Zhoushan are at the periphery of the network. Among them, the lower centrality of Shanghai stems from the fact that there is less collaboration involved at the municipal level compared to the provincial level. At the same time, the two-dimensional combination of economic development level and network status of the 26 cities responds to the theoretical inference, as shown in Figure 5 on the following page, which presents the basic distribution of the “economic level network status” of the Yangtze River Delta local governments’ city clusters as a whole.

| Urban agglomeration | Number of nodes | Number of agreements | Cooperation strength | Total number of partnerships |
|---------------------|-----------------|----------------------|----------------------|-----------------------------|
| Changjiang delta    | 26              | 364                  | 36.517               | 23.736                      |

Figure 4: Distribution of network status of the 26 cities in the Yangtze River Delta at high and low levels.
4.3. **The Central Strategic Act of Digital Governance for Local Governments in the Yangtze River Delta.** The manifestation of strategic tendencies in digital governance practice is essentially the decision-making of local governments in urban agglomerations as rational actors in an established structural environment, combining the distribution of economic level and network status with governance strategic tendencies as shown in Figure 6, which mainly presents the following characteristics: on the one hand, the tendency of digital governance practice of local governments in the Yangtze River Delta is consistent with the basic environment-collaborative network theoretical inference of the environmental effect is largely consistent. In terms of proportions, 90% of the cities in the (high, high) network tend to choose the central strategy; 66.7% of the cities in both the (high, low) and (low, high) networks choose the central strategy; and 80% of cities in the (low, low) network choose the follow strategy. On the other hand, there is diversity in the choice of strategies for digital governance among the different categories of subjects. Although the proportion of noncore tendencies is small, it shows that there are some subjects who try to break away from the existing influence of the existing environment and hope to achieve institutional innovation in the field of digital governance, which also reflects the existence of the logic of “exceptions,” especially the following strategy in the (high, high) portfolio and the following strategy in the (low, low) portfolio.

5. **Conclusion**

Based on theories of collective action and network governance, this paper explores how the level of economic development of local governments and the cooperative network status of city clusters interacts and influences the propensity...
of local governments to adopt digital governance strategies. The proposed ant colony optimization algorithm is validated by a case study of 26 cities in China’s Yangtze River Delta, where the majority of local governments’ digital governance strategies conform to the selection logic of their “economic level network status” group status. However, there are still some “anomalous” governance tendencies driven by selective benefits.

**Data Availability**

The data used to support the findings of this study are available from the corresponding author upon request.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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