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Research Article

An RFID-Enabled IoT-Based Smart Tourist Route Recommendation Algorithm

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With the rapid development and broad deployment of Internet of Things (IoT) technologies, the IoT are increasingly shifting away from "interconnection of everything" to "human-computer-thing" sensing integration. Although there are numerous sensing technologies available today, radio frequency identification (RFID) has emerged as useful medium for "passive sensing" due to its lightweight, taggable, and simple deployment properties. With the growth of social networks in recent years, it has become a significant research hotspot for the development of path suggestion systems that are tailored to the demands of individual users' preferences. This paper considers the relevant features of interest points, integrates the user's emotion and product similarity into the heuristic function of the ant colony algorithm, adopts the elite management ant strategy, maximizes the management ant strategy, and uses particle swarm algorithm to improve the initial pheromone distribution of the ant colony algorithm. The proposed model combines the ratings of 593 tourists and text comment information into one dataset and proposes a smart tourist route recommendation model. The improved ant colony algorithm is utilized to recommend the most popular tourist routes and recommend the tourist routes of the most popular tourist spots in the scenic area. The suggested method is more efficient in terms of accuracy and recall. The F measure value is derived from real-world dataset testing.

1. Introduction

Several intellectual notions including the IoT, the Industrial Internet, and Industry 4.0 have been introduced in recent years. The new computer models and perceptual technologies have been fully implemented in production and everyday life. The RFID has emerged as one of the most important supporting technologies for Internet of Things applications as an alternative to barcodes and two-dimensional codes. It is garnering significant attention both in academia and industry. The RFID tags are capable of transmitting across extended distances due to passive transmission. Features including communication and unique identification (alternative of barcodes) are increasingly being used on everyday objects and in a variety of intelligent applications such as logistics management, target detection, and security access control, making people's lives and jobs more convenient and intelligent experience [1–3].

Intelligence serves as a critical link between the computer world and the physical world, and it is also a critical building block of other intelligent applications when it comes to many intelligent applications. The traditional intelligence frequently makes use of dedicated sensors to measure specific sensing objectives and realize proper perception of the physical universe. For example, dedicated motion sensing modules with great sensitivity and accuracy are used in smart phones and smart bracelets to detect and perceive motion. The increased use of smart devices, particularly those based on ubiquitous smart devices, has steadily drawn attention to nonpassive sensing by contact. It can be sensed with a microphone and a speaker, for example, WiFi and other wireless devices widely deployed in daily environments. It provides users with multidimensional perception information. The visible light perception can use visible light sources widely deployed in the environment to identify user behaviors, and other technologies are being developed. In a passive perception network, the node does not rely heavily on its own power supply equipment but instead obtains energy from the surrounding environment. It is used to support its calculations and perceptions as well as its communication and networking functions. With RFID, the problem of multiple targets being distinguished by traditional passive perception technology is perfectly solved at the same time. The low price of RFID tags makes ubiquitous perception possible by deploying tags widely on everyday objects that is an effective way to perceive everything according to passive perception researchers. The RFID-based passive perception technology enables RFID to be implemented from the "recognition" through the "stages." The alteration of "perception" is a characteristic technique in markable passive perception and it has emerged in the field of passive perception during the past few decades [4–10].

This paper focuses on research into passive sensing technology based on RFID with the above considerations in mind. It takes the core technology of passive sensing that can be marked as the main starting point from the four aspects of sensing channel, sensing method (including RFID), sensing category, and sensing application in passive sensing application research. Assess and evaluate the results of the perception studies on RFID technology conducted at each level. According to general principles, the realization of a passive perception application must meet the requirements of the four tiers outlined as follows: (1) the signal of the perception channel is steady, (2) the deployment of the perception method is practical, (3) the target of the sensing category is accurate, and (4) the sensing application scenario is applicable to all environments. First and foremost, the sensing channel refers to the source of the signal characteristics that are being employed for perceiving the environment. Wireless signals are easily interfered with a variety of external sounds when used in the real world. Therefore, it is required to choose a sensing method that is both accurate and stable. The channels can provide the most significant fundamental guarantee when it comes to robust sensing applications.

Firstly, the sensing method relates to the signal model and scene deployment that have been used for sensing. Secondly, the perception equipment is essential for the practical application of perception applications. Thirdly, the perception category refers to the algorithm target that corresponds to the perception method. Determining the real and effective perception category and achieving accurate and robust target perception are the central issues in intelligent perception technology. Finally, the perception application refers to the real-world scenarios in which perception technology is used. Perception applications are typically required to have a given level of generalization and to be able to address a specific class of application scenarios. Passive perception research based on RFID is aiming for the ultimate goal of providing accurate perception.

2. Background and Literature Review

The prevalence of mobile devices along with the widespread usage of location-based services has resulted in an increase in the popularity of location-based social networks among its users. Additionally, an increasing number of social networking sites are allowing users to record and share their geographic location information. It is feasible to learn about users' personal tastes by analyzing massive amounts of such data and to give them with personalized services as a result. One of the most important research areas in this category is the recommendation of travel routes. Travel service information is complicated and diverse, and travel route selection is one of the most significant services provided by these organizations frequently. While it is true that most domestic mainstream travel service websites are currently designed in advance, it is also true that the routes provided by the relevant travel agencies are designed without taking into account the individual needs of users as it can be seen on the current domestic mainstream travel service websites. In spite of the fact that users are provided with points of interest (POI) reviews, these reviews are only used to inspire and guide new users to create orderly combinations of POIs that are in line with "popular" tastes and the reviews are only subjective rather than comprehensive and objective in nature.

The provision of a personalized online travel recommendation platform is popular among users and meets the specific needs of each user is therefore required [11–14]. This is provided by the travel service providers to recommend a travel path from a given entrance to an exit in a scenic spot that contains as many POIs as possible [15, 16]. The traditional and classical path recommendation algorithm is primarily considered from the views outlined in the following ways.

(1) Recommend a path online that can avoid the more congested route in real time, improve the efficiency of the tour, and maximize the user's personal satisfaction

(2) Use collaborative filtering in the recommendation system method, consider the activity trajectory of other users in the scenic area with high similarity to the user, and use the user's social relationship for group recommendation

(3) Use the idea of collaborative filtering in the recommendation system method, consider the activity trajectory of other users in the scenic area with high similarity to the user, and use the selection of a travel path that takes into account geography as well as social relationships

In contrast, the existing models and algorithms do not fully exploit the information related to tourism data and do not use the user's rating data and text comments for POI recommendation. It is resulting issues such as low real-time response times, low recommendation accuracy, and a nonoptimal recommendation path among other things. It causes the text comments from users are incorporated into the design of heuristic functions in order to address issues such as sluggish convergence, tailored suggestion, and recommendation by integrating ratings and text information to tackle these issues [17–21].

2.1. Perception Channels. It is the type of signal employed by the sensing technology that is referred to as the sensing channel. When a signal from a sensing channel is used as input to a sensing algorithm, the signal from the sensing channel typically contains both signals of different modalities (e.g., RFID signals and visual signals) and signals with different characteristics of the same modal signal (e.g., RFID signals and visual signals) (e.g., signal strength and signal phase in RFID signals). Taking one example, researchers in WiFi-related sensing research are breaking away from the traditional approach of gradually progressing from RSSI to CSI in order to complete more thorough and precise sensing tasks. The rational and flexible utilization of various sensing channels is critical to the realization of the corresponding sensing systems in sensing systems as a result. According to classic RFID systems, the primary function of RFID tags is to read the data stored inside the passive tag using the backscatter mechanism that allows the tag to be identified without the need for contact and to acquire information about the signal characteristics of the tag. Current mainstream commercial RFID devices frequently give a variety of various signal characteristics, so that the user can read the tag in addition to being able to discern between the state of the tag and the rest of the tag. These numerous signal features serve as the raw materials for perception using RFID tag-based perception systems. There are numerous possibilities for RFID systems to achieve from these various signal characteristics "Identification" "to" "Perception." The opportunity has arisen as a result of the transformation. A pure RFID-based sensing system can be divided into three types of signal characteristics based on the network level at which the RF signal characteristics are found. They are application layer signal characteristics, link layer signal characteristics, and physical layer signal characteristics. Additionally, the integration of RFID sensing channels with those of other modal devices for sensing is referred to as "multimodal sensing."

2.2. Read Rate at the Application Layer. Tag reading at the application layer is the primary source of signals in sensing applications while developing an RFID system during the early stages of system development. This type of task is typically approached using probabilistic estimate models and Bloom filters, which are the two most common ways.

(1) Probabilistic estimation model uses the unpredictability of the time-slot-frame ALOHA protocol. In this model, the number of tags can be calculated based on the responses of different time slots. The basic concept of this model is how to employ the smallest amount of tag reading time slots possible to accurately estimate the overall size of the tags in a given number of time slots

(2) Bloom filters take the advantage of the pseudo-randomness of tag responses to detect the presence or absence of tags based on the distribution of time slots inside a frame

Overall, the two models described above are utilized to estimate the tag read rate based on the randomness of the tag response because the information provided by the application layer is coarse-grained "read/lost" tag status information including the overall sensing granularity is also coarse, and the application form is single, and the sensing capability is likewise limited as a result.

2.3. Link Layer Signal Strength and Phase Are Important. One of the most often used channel characteristics in RFID sensing research is the signal intensity and phase of the signal at the link layer that are both measured at the link layer. The RFID tags have gradually overcome the limitations of traditional "identification" devices, resulting in the creation of a new class of "sensor" devices based on the RFID signal characteristics of passive sensing and based on the characteristics of RFID signals in tandem with the advancement of RFID research.

2.3.1. Signal Strength. The signal strength of RFID systems is the most frequent characteristic of a conventional wireless communication device, such as an RFID tag (RSS). Most of the time, signal strength-based sensing techniques may be classified into two categories such as signal attenuation models and reference tag models, respectively.

(1) Attenuation model for signal attenuation. Construction of a signal attenuation model between RSS and distance is the most direct method of signal strength sensing available at this time that allows the communication distance to be predicted directly from the recorded RSS value. We can further localize the target using set relations and other techniques based on the communication distance. Equation (1) is utilized as the signal attenuation function for received signal strength R of an RFID system in relation to communication distance r which is calculated as follows:

$$R = P_{TX} T_b G_{\text{reader}}^2 G_{\text{tag}}^2 \left(\frac{\lambda}{4\pi d} \right)^4, \quad (1)$$

where P_{TX} is the transmit power of the reader, T_b is the reverse transmission signal loss, G_{reader} is the signal gain of the reader antenna, G_{tag}^2 is the signal gain of the tag antenna, and λ is the signal wavelength. From Equation (1), it can be seen that the received signal strength R is an inverse proportional function of the communication distance d^4, so the communication distance can be estimated based on the signal strength R. However, in the actual environment, RSS is susceptible to multipath effect, wireless signal noise, signal absorption, and other environmental problems, which eventually causes the signal fading model of RSS to be extremely unstable in practice.

(2) Reference tag model. In contrast to the distance estimate technique based on the signal attenuation function, another type of perception approach is based on the measurement of the reference tag model. Using the stability and specificity of a signal fingerprint in a spatiotemporal relationship to develop a

fingerprint database and then using the fingerprints in the database to match the location while positioning is the underlying premise

Overall, the signal fading model can quickly estimate the position based on RSS values, making it relatively simple to deploy and implement; however, the sensing accuracy is low and it is easily affected by the dynamically changing environment; in contrast, the reference tag model can effectively capture the dynamic changes of the environment, increasing the sensing accuracy up to 30 cm^2 but increasing the deployment overhead. It should be noted, however, that the deployment cost of the reference tag is very high, and that for each localization, it is necessary to read and understand all of the reference tag's capabilities.

$$R = P_{TX} T_b G^2_{\text{reader}} G^2_{\text{tag}} \left(\frac{\lambda}{4\pi d}\right)^4. \quad (2)$$

2.3.2. The Phase of the Signal. It is most commonly used in poor precision sensing settings due to the coarse granularity of RSS signals and the susceptibility of the surrounding environment to the signals despite the fact that RSS may detect the location of a target. In addition to RSS, another important signal feature of RFID systems is the phase of the signal at the link layer that is extensively employed as another main signal characteristic. It has been shown that in RFID systems, the phase information is related to the transmission distance d and carrier wavelength of the signal as follows:

$$\theta = \left(\frac{d}{\lambda/2} \cdot 2\pi + \theta_{\text{offset}}\right) \bmod 2\pi, \quad (3)$$

where the RFID phase takes values in the range of 0 to 2π as a function of periodic variation and θ_{offset} indicates the phase shift caused by the hardware process. Signal phase-based work can usually be divided into two categories: single-tag phase-based and multi-tag phase-based sensing

(1) Single-tag phase. The simplest way to use signal phase is to sense directly using the signal phase of a single tag. It is found that the phase has more overall perceptual granularity and sensitivity than the signal strength when comparing the signal strength with the signal phase. However, the periodicity of the phase causes uncertainty in the placement of the tag

(2) Multi-tag phase. Since it is difficult to uniquely determine the location state of a tag with a single-tag phase, many research efforts use multiple tags to form a set of phases to sense the target state. Passive sensing based on RFID phase signals has considerably addressed the difficulties of low positioning accuracy caused by RSS due to low sensitivity and large signal noise and has achieved a breakthrough in RFID sensing

2.4. Physical Layer Primitive Signals. Researchers have introduced original signals into RFID systems to adequately display signal reflections such as multipath as complex multipath is typically depicted as a linear superposition of numerous original signals. In general, we may divide the original signal into two categories including synthetic signal and physical layer signal. Synthetic signal is the signal that is generated by a computer.

(1) Synthetic signal. This mainly refers to the synthesis of the RSS signal and phase signal provided by the commercial reader according to the model of the original signal. Assuming that the signal strength measured by the reader is r dBm and the phase measured is θ radians, the synthesized complex signal can be obtained as follows:

$$S = \alpha e^{\tau\theta}, \quad (4)$$

where τ is the unit imaginary number, S represents the complex signal composed of signal strength and phase, and α represents the signal amplitude calculated from the signal strength. Although it does not reflect the physical layer transmission fundamentally, it can still portray the changes of the signal during multipath transmission

(2) Physical layer signal. This refers to the signal that was received directly from the wireless device at the time of acquisition. Several researchers have investigated the sensing model of physical layer signals based on software radio technology as a result of the development of software defined radio technology and its development platform USRP (universal software radio peripheral) that has become a mainstream class of physical layer signal acquisition platform. The raw RFID signals obtained with the USRPN210 in a laboratory environment are depicted in Figures 1 and 2, respectively

2.5. RFID Signal Extension-Multimodal Sensing. The RFID signals have been fused with other sensing signals in order to obtain multimodal sensing capabilities along with employing RFID signals alone. Multimodal sensing is defined as the fusion of RFID signal characteristics with the signal characteristics of other sensing devices for the purpose of sensing in RFID systems. At the moment, the most popular kind of multimodal perception is a mix of RFID tags with computer vision technology. The RFID is utilized for object identification. The computer vision is used to capture images of the object and analyze the motion of the object for object analysis. The hybrid approach when the two are combined to make a thorough assessment of the object's motion and surrounding environment is used for multimodal perception.

The multimodal perception based on RFID technology is an extension of the RFID perception channel that is now mostly combined with computer vision technology. While the combination with other modal perceptions has yet to be investigated in more depth, this research direction is still grappling with the question of how to successfully create more precise and efficient sensing applications through

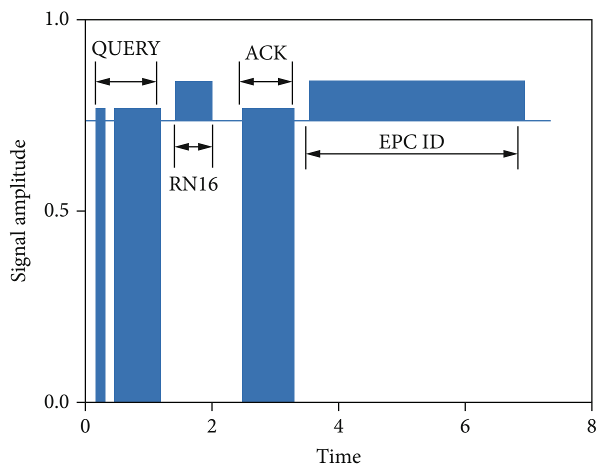

FIGURE 1: Characteristics of the physical layer signals collected by USRP.

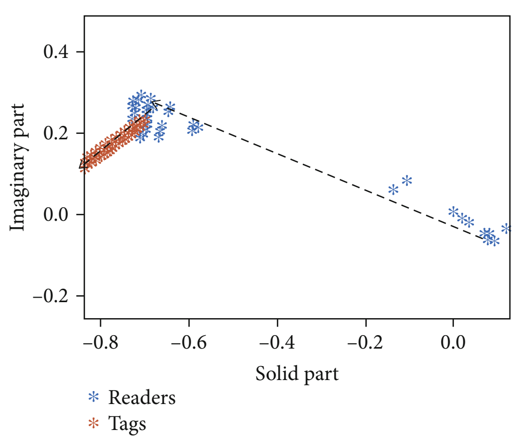

FIGURE 2: Characteristics of the physical layer signals collected by USRP.

cross-domain multimodal signal fusion. To achieve integrated sensing, the basic technology of multimodal sensing is to investigate the advantages and disadvantages of various modal signals and their complementarity as well as to leverage the advantages of other sensing signals to compensate for the shortcomings of RFID sensing signals.

2.6. Synopsis of the Sensing Channels. Active sensing technology based on RFID technology has advanced significantly in the last two to three decades, and researchers have achieved significant strides in the use of diverse signal characteristics for sensing. Read rate provides the research clues that will lead to the transformation from "recognition" to "sensing" signal strength which provides the fundamental solution for "sensing." The phase characteristics provide the assurance that fine-grained sensing will occur and synthetic and raw signals provide the possibility of fine-grained sensing, in that order. The combination of the synthetic signal and the original signal allows for fine-grained perception to be achieved. The development pattern of the sensing channel is depicted in further detail in Figure 3.

In general, RFID sensing channels show a tendency from the surface to the interior as they move deeper into the device. For a long period of time, RFID sensing channels were restricted to application layer signals; for a longer period of time, RFID sensing channels were gradually deepened and stretched into the link layer; and now, RFID sensing channels have been further extended to include physical layer signals. Today, numerous forms of feature signals are extensively employed, and many technologies will be intermingled with the use of sensing. Higher-order sensing, on the other hand, typically employs a higher degree of complexity and more underlying signal characteristics. Most of this can be attributed to the fact that it is difficult to achieve high accuracy and fine-grained sensing in terms of read rate and signal strength, whereas physical layer signals with features such as raw signal and phase are capable of sensing millimeter-level motion changes and are gradually gaining attention from scientists. In terms of sensing accuracy and perception capabilities, we can see that passive sensing based on RFID technology has advanced significantly since 2013, which has had a significant impact on the research of perception based on RFID technology. The development of RFID perception research has also included the incorporation of multimodal signal perception techniques, which has broadened the scope of applications for perception in RFID systems.

3. Proposed Model

This section provides the detail description of the proposed model. The proposed model considers the relevant features of interest points, integrates the user's emotion and product similarity into the heuristic function of the ant colony algorithm, adopts the elite management ant strategy, maximizes the management ant strategy, and uses particle swarm algorithm to improve the initial pheromone distribution of the ant colony algorithm.

3.1. Problem Description. The problem discussed in this paper can be abstracted as a TSP problem; that is, to traverse each node from any point in the weighted undirected graph, each node is visited once and only once, so that the total distance is minimized. Here, firstly, given the feature distance D is between any two POIs, the formula is given as follows:

$$\mathrm{Dis}(i,j)=\sqrt{A+\sum_{p=1}^{C}(1-\alpha)\times(\beta\times B+(1-\beta)\times D)}, \quad (5)$$

where $A=\alpha\times \mathrm{dis}^2(i,j)$, $B=\left(C_p^i=C_p^j\right)^2$, and $D=\left({C'}_p^i={C'}_p^j\right)^2$.

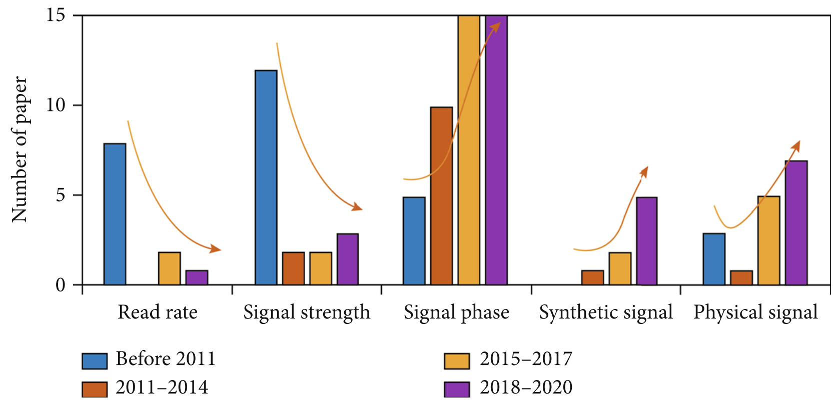

Figure 3: A summary of the evolution of perception channels.

Let the set of feature attributes of a POI be $C = U_C \cup U_{C'}$. U_C denotes the set of objective feature attributes of the POI itself, $U_{C'}$ denotes the subjective feature attributes of the POI, $1 - \alpha$ denotes the ratio value of the information value, and its calculation formula is shown in Equation (4):

$$\begin{cases} 1 - \alpha = \dfrac{IV_{i,j}}{\sum_P IV} = \dfrac{IV_i + IV_j}{\sum_P IV}, \\ IV_i = (\text{Rate\_good}_i - \text{Rate\_bad}_i) \times \ln \left(\dfrac{\text{Rate\_good}_i}{\text{Rate\_bad}_i} \right), \end{cases} \quad (6)$$

where IV_i signifies the information value of point i and Rate_good$_i$ and Rate_bad$_i$ denote the positive and negative rating rates of the point in question, respectively. The user's rating of POI is used as a criterion for judging the similarity of POI in this study as well, and the Jaccard (Jaccard) coefficient is introduced to increase the accuracy of judging the similarity of POI. The calculation formula for the Jaccard coefficient is presented as follows:

$$J(i, j) = \frac{\text{amount}\left(\text{poi}_i \cap \text{poi}_j\right)}{\text{amount}\left(\text{poi}_i \cup \text{poi}_j\right)}, \quad (7)$$

$$\text{poi\_sum}(i, j) = J(i, j) * \frac{\text{poi\_ratings}(i) * \text{poi\_ratings}(j)}{|\text{poi\_ratings}(i)| * |\text{poi\_ratings}(j)\,|}, \quad (8)$$

where $J(i, j)$ is the Gerard coefficient of any two points i, j, amount$(\text{poi}_i \cap \text{poi}_j)$ denotes the number of the set of users who jointly rate two POIs i, j, amount$(\text{poi}_i \cup \text{poi}_j)$ denotes the number of the set of users who rate two POIs i, j, and poi_ratings(i) denotes the number of points i rated by user rating vector of ratings.

The similarity of the POI and the relevant properties of the building are incorporated into the heuristic function as follows:

$$\text{Sim}(i, j) = \frac{\text{poi\_sim}(i, j)}{1 + \text{Dis}(i, j)}. \quad (9)$$

3.2. Related Definitions

Definition 1. (structure of a point). A point$i, j \in P$comprises a POI primarily in terms of its longitude and latitude, as well as the characteristic qualities of the POI.

Definition 2. (characteristic attributes of a point). The variables can be used to characterize the qualities of the POI depending on the user's comments on the POI such as "Yongzheng," "Yongle," and "Qianlong" in the user's comments to describe the POI's attributes. It is possible to tell if the POI has a certain amount of history by looking at the year of the emperor, for example, "Yongzheng," "Yongle," and "Qianlong." It is also possible to tell if the POI has a certain amount of architectural properties by looking at the "wooden structure," "brick house," and so on. User preferences vary depending on the qualities of the attractions that they are interested in exploring more. The degree to which various users enjoy certain qualities of the attractions differs depending on who they are. When it comes to mainstream travel social networking sites, the majority of point-of-interest ratings are calculated by weighting six characteristics of POI ratings including the history of the POI. Furthermore, consumers place greater importance on three objective aspects of POIs, namely, their historical significance, their directionality, and their architecture [8]. It has been determined that the three subjective features of POIs including picturesque, fascinating, and cost-effective are the ones that best match the interests of users using POI user ratings. In accordance with the proportion of relevant qualities subphrases in the total number of subphrases, the attribute values are allocated.

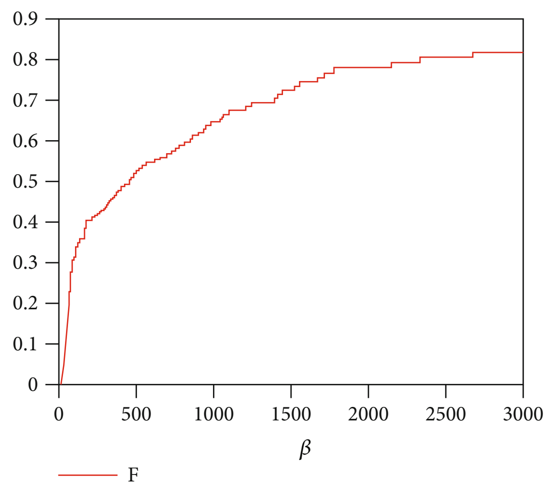

FIGURE 4: Parameter beta changes when beta takes various values.

3.3. RFID IoT-Based Algorithm for Recommending Popular Travel Routes. In this paper, we first introduce the ant colony algorithm, and the pheromone variation values of the legacy on each POI are shown in Equation (10).

$$\Delta\tau_{ij}^{k}(t+1) = \begin{cases} \dfrac{Q}{L_k}, & k\text{th ant passes route}(i, j), \\ 0, & \text{otherwise}. \end{cases} \tag{10}$$

The probability formula for transferring the next node is then shown in Equation (11).

$$p_{ij}^{k}(t) = \arg\max\left(\tau_{ij}^{k}(t)\eta_{ij}^{k}(t)\right). \tag{11}$$

The velocity and position of the particle are updated as follows:

$$\begin{cases} v = w * v + c_1 * r_1 * (p_{\text{best}} - x) + c_2 * r_2 * (g_{\text{best}} - x), \\ x = x + v. \end{cases} \tag{12}$$

The RFID Internet of Things-based popular tourist trail route recommendation approach is as follows. First, the subphrases that can be used to describe the qualities of I attractions are filtered out of the data provided by user u using the inverse document frequency technique. The attribute values of each feature attribute of I are determined by comparing the frequency of different feature attribute phrases to the overall frequency of feature phrases in the overall feature phrase set.

Another advantage of employing random components is that the time it takes for the ant colony algorithm to reach its final state can be significantly reduced. Furthermore, because the ant colony algorithm is unable to fully account for the behavioral preferences and emotional factors of the behavioral participants (travelers) when solving specific application problems, a new formula for measuring the distance between two points is used instead of a single Euclidean distance to express the distance between two points. The new approach suggested in this paper has the potential to significantly enhance convergence efficiency while also better reflecting the requirements of personalized design.

We can get the good results by limiting the range of pheromone values, increasing the search space of the algorithm, avoiding slipping into the local optimum, and preventing the algorithm from maturing prematurely. It is necessary to use the particle swarm algorithm in the first iteration in order to find the suboptimal solution of this problem and to adjust the distribution of pheromones in the first iteration in order to avoid the random distribution of pheromones in the first iteration by using only the ant colony algorithm; on this basis, the optimal solution of the combinatorial optimization problem is found more quickly. Moreover, the pheromone of the current optimal path is augmented by an additional l and the pheromone increment of the noncurrent optimal path is adjusted to be between 0 and 1 at the same time. At the end of the process, the recommended paths are compared to the paths indicated by the National Palace Museum's official website, and the performance of the modified algorithm is measured by the parameters of precision and recall.

4. Experiment Result

In this paper, we obtained 37 attractions (points of interest) with more than 100 views within the Forbidden City of Beijing from the Hornet's Nest website and counted the related reviews of these 37 attractions (points of interest). The algorithm proposed in this paper is used as a recommendation method inspired by the short paths and the attractions with high reputation. The performance of the PS-AC algorithm is reflected by the precision, recall, and F.

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}, \tag{13}$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}, \tag{14}$$

$$F = \frac{2 * \text{precision} * \text{recall}}{\text{precision} + \text{recall}}. \tag{15}$$

The experiment was performed 10 times according to the value in Figure 1, and the average values of time, accuracy, recall, and F value were recorded to find a better value of β. Parameter beta changes when beta takes various values is shown in Figure 4.

The results of accuracy, recall, and F value were found to be better. Therefore, $\beta = 0.4$ was chosen for the following experiments. The size of the vector dimension k directly affects the performance of the tourist route recommendation algorithm. k values that are too large will increase the computational stars and too small cannot represent tourist and route characteristics. Figure 5 gives the trend of the recommendation algorithm NDCG with the change of vector star dimension. From Figure 1, it can be seen that with the increase of vector dimension, the recommendation

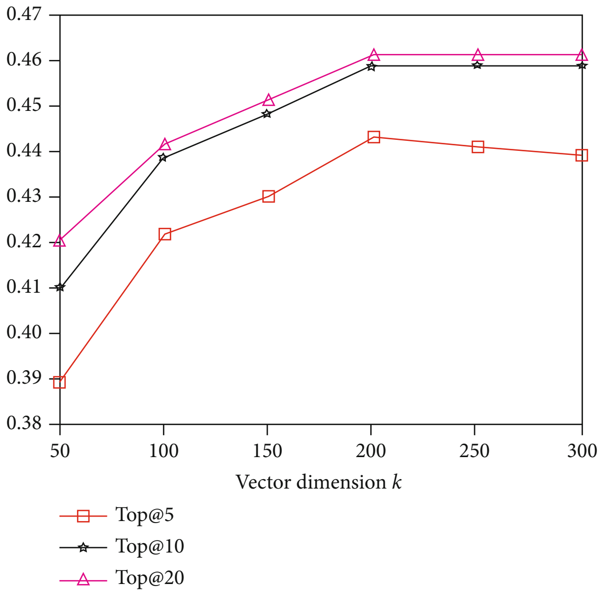

Figure 5: Effect of vector dimension on algorithm.

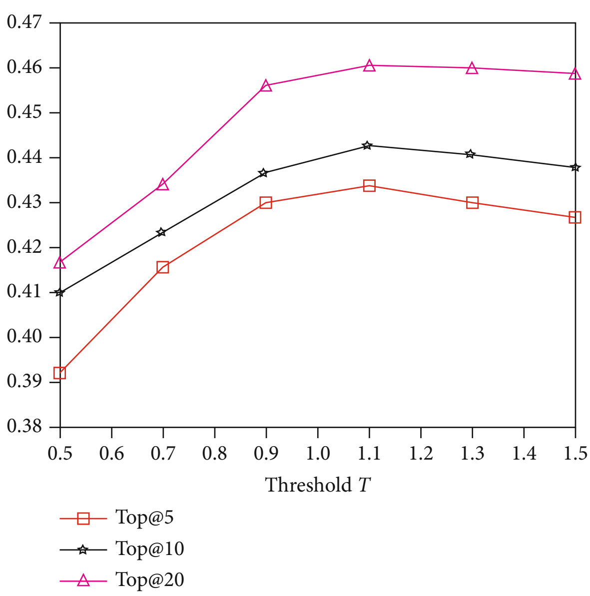

Figure 6: Effect of threshold on algorithm.

performance slows down after a rapid increase, and the folding point of performance transformation is near 200, so the vector dimension is taken to enable the algorithm performance to reach the highest 200.

The line vector distance threshold T determines the vector representation of visitors and affects the similarity calculation among visitors. If the threshold T is too small, similar routes cannot be incorporated into the similarity calculation; if the threshold is too large, dissimilar routes will be selected in. The trend of the performance of the recommendation algorithm NDCG with the threshold T is given in Figure 6. From Figure 2, it can be seen that as the threshold T increases, the performance of the algorithm first increases and then decreases, and the folding point of the performance transformation is near T is 1.1, so the threshold T is taken as 1.1.

Table 1: Comparison of three algorithms in each index.

Algorithm	Precision	Recall	F
EMAS	0.096	0.033	0.055
MMAS	0.097	0.048	0.062
Ours	0.114	0.051	0.065

Table 1 shows the comparison between this algorithm and the comparison algorithm in each index.

From Table 1, we can see that the proposed algorithm has better performance in terms of accuracy, recall, and F value compared with EMAS and MMAS.

5. Conclusion

In this paper, we propose a popular smart route recommendation algorithm based on RFID IoT that incorporates the relevant attributes of POIs and the similarity of POIs based on the user's rating matrix into the heuristic function of the ant colony algorithm. It combines the advantages of ant colony algorithm and particle swarm algorithm. It also introduces the mechanism of elite ants into the ant colony algorithm to improve the convergence efficiency and shorten the convergence time. The experiments show that PS-AC has good performance in precision, recall, and F indexes. However, the recommended method still has the following shortcomings in terms of dataset, evaluation method, and evaluation index: sparsity of dataset, inconsistency between objective and subjective evaluations, limited test dataset and cannot be generalized, only objective indexes can be reflected, and it is difficult to simulate the contextual environment. Future work is planned to focus on these shortcomings.

Data Availability

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

Conflicts of Interest

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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