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TSOIA: An efficient node selection algorithm facing the uncertain process for Internet of Things

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ABSTRACT

Perception nodes in Internet of Things are vulnerable to the external environment and the characteristics of them are stochastic and dynamic. In this paper a new optimization algorithm for Internet of Things to support applications which do not need to discrete the solution space has been proposed. The proposed algorithm which is called TSOIA divides perception nodes into three groups to search the global optimal solution. TSOIA algorithm adopts random search, local search and orientation search to adjust the group size and the step length adaptively. In order to show the performance of the TSOIA algorithm, computer simulations have been conducted and the results obtained are compared with that of the two existing search algorithms. The results of comparison show that the proposed algorithm outperforms other search algorithms in terms of search ability, energy consumption and network delay.
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1. Introduction

The Internet of Things (IoT) is a technological revolution in computing and communications. It depicts a world of networked smart devices, where everything is interconnected (ITU Internet Reports, 2005) and has a digital entity (Pascual et al., 2011). Everyday objects transform into smart objects which is able to sense, interpret and react to the environment, thanks to the combination of the Internet and emerging technologies such as Radio-frequency Identification (Amaral et al., 2011), real-time localization and embedded sensors (Carmen Domingo Mari, 2012). This technological evolution enables new ways of communication between people and things and between things themselves (Tan and Wang, 2010).

Sensor networks function as a key infrastructure for Internet of Things (Jabeur et al., 2009). Many sensor networks such as habit monitoring and intruder tracking (Xu and Qi, 2008) need to handle physical entities that move in the environment (Mpitziopoulos Aristides, 2010). Only sensors which are close to an interesting physical entity should participate in the aggregations of data associated with the entity, as activating far-away sensors wastes precious energy but it does not improve the sensing fidelity (Akyildiz et al., 2002). To continuously monitor a mobile entity (Rogers et al., 2009), Internet of Things must maintain an active sensor group that moves at the same velocity as the entity (Levis and Culler, 2002). The combination of entity mobility and spatial locality, introduces unique spatiotemporal constraints on the communication algorithm.

Genetic algorithm is more robust than that of the traditional search method (Zhang and Zhang, 2007). Genetic algorithm is good at global search (Smith, 2007). However its local search ability is relatively weak (Salcedo-Sanz and Yao, 2004). It will take much time to achieve the true optimal solution.

The algorithm processes of FLAGA and GA are the same. However FLAGA is easy to implement. It can find the numerical solution with high precision in a short time. It has strong local search ability when there are dense and multi-peak values in the neighborhood of the optimal solution (Salcedo-Sanz and Xu, 2006). The global search performance of FLAGA is good, while the adjustment of the control parameters is difficult.

In recent years many scholars have done a lot of research in the improvement of the algorithm (Marinakis and Magdalene, 2009). The optimization ability was improved in certain space complexity and the application fields were expanded (Xianmin, 2011). The discrete nature of the ant colony is very suitable for solving the combinatorial optimization problem in fact (Keivan and Behnam, 2010). However it is difficult to construct the optimization algorithm and the slow convergence speed. Ant colony algorithm in solving optimization problem is lack in general (Jiajia and Zaien, 2012).

At present the ant colony algorithm thought used for the continuous space optimization are mostly as follows. First the solution space is discrete, then the classical ant colony algorithm is improved appropriately for applications. The calculation and

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reserves are proportional to the scope of the search field and the number of search space dimensions. For high dimensions or a wide range of optimization problem, the optimal time and the memory space are too difficult to accept. In this paper a new optimization algorithm is proposed for sensor networks to support applications which do not need to discrete the solution space. The proposed algorithm which is called TSOIA.

The rest of this paper is organized as follows. In Section 2 the load model of sensor node is described. In Section 3 the acquisition tree topology of Internet of Things is presented. TSOIA algorithm is explained in Section 4. Section 5 gives the simulation results and discussions. Finally, the paper is concluded in Section 6.

2. Load model of sensor nodes

It is assumed that all the nodes are using the same frequency channel. t_s is the biggest transmission range of the sensor nodes. The sensor nodes can be kept the network connectivity in the distribution areas of high density. There is one same transmission range within a jump around the sink node. The node's transmission range is defined to be the function of distance between the node O and itself. It is assumed that t_0 is the minimum sending range in sensor networks which is set as the optimization parameter.

$\varepsilon(d)$ is defined as the energy of a unit of data sending by the node and d is its distance from the central O. It is assumed that the energy can be ignored in the process of data receiving.

It is assumed that $\varepsilon(d)=c(t(d))^{\alpha}$, where c is a constant and a is attenuation index. And its value range is $2 \le \alpha \le 4$. It is assumed that the network life cycle is the period of time from the node which is first deployed to the decrease of its coverage. It is assumed that each node has a limited range of perception. The load model of sensor node is shown in Fig. 1.

The load of energy is defined as the expectations of the energy consumption from one node whose distance is d. Due to its internal symmetry, the average energy consumption level is distributed in space around the sink node. The expression of $L(d)$ is got analysis by the expansion of the ideal geographical model.

As described in Fig. 2, the average load of the node n is s_1/s_1+s_2 where s_1 and s_2 can be estimated as follows.

$$s_1 = \begin{cases} \frac{\beta(d)}{2}\left(D^2-d^2\right), t \ge t_0 \\ \frac{\pi}{2} t(d)^2, t < t_0 \end{cases}$$

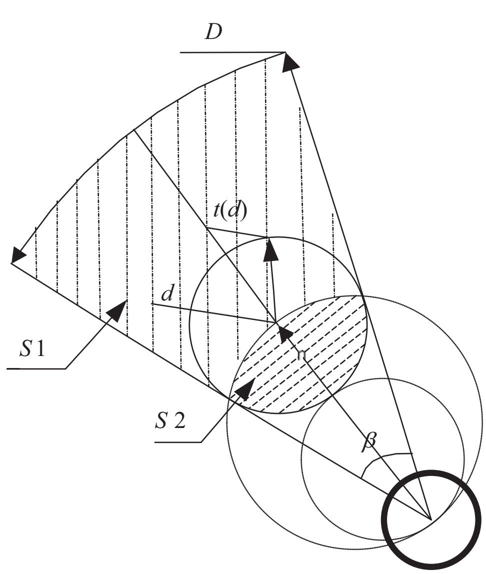

Fig. 1. Load model of sensor nodes.

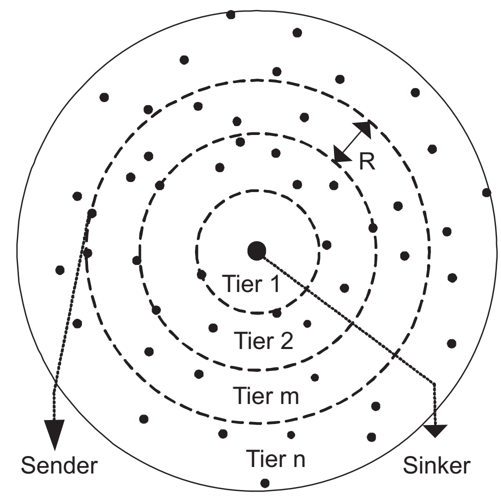

Fig. 2. Acquisition tree network topology.

$$s_2 = \begin{cases} \frac{\pi}{2} t(d)^2, t \ge t_0 \\ \pi t(d)^2, t < t_0 \end{cases}$$

Where $\beta(d) = 2\arcsin(t(d)/d)$.

$$L(d) = \frac{(s_1+s_2)\rho_s \lambda \varepsilon(d)}{s_2\left(\rho_s+\rho_\gamma(d)\right)} = \frac{\left(\frac{\beta(d)}{2}\left(D^2-d^2\right)+\frac{\pi}{2}t^2(d)\rho_s\lambda\varepsilon(d)\right)}{\frac{\pi}{2}t^2(d)\rho(d)} = \frac{D^2\rho_s\lambda\varepsilon(d)}{t^2(d)\rho(d)}$$

3. Acquisition tree network topology of internet of things

In many applications of data acquisition in sensor networks, communication process is launched by many sensor nodes and terminated by a single sink node. The path tree structure can be formed by multi-jump path from sensor node to the sink node. The acquisition tree network topology is shown in Fig. 2.

The sink node of the networks broadcast the radio signal downward. The node distribution in network is round. Nodes which are Distributed in the environment collect data and send information to the central node. So the central nodes in the network not only need to send their own data frame but also transmit information from lower levels.

In the case of each node of sensor networks has the same transmitting power, the energy consumption of the central node is significantly higher than that of the edge node in sensor networks.

If the launch power of the edge node is increased, it will lead to the increase of the energy consumption from the edge node and reduce the hops. So the energy consumption of the central node can be saved. To achieve the purpose of keep the energy consumption balance, the transmission power may be distributed in different parts of the network reasonably.

4. TSOIA algorithm

4.1. Discrimination mode and search mode of swarm category

For convenience of description, the group is subdivided into three categories. The first is DNL which does not learn. DNL only

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