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APIT를 이용한 군집로봇의 위치 측정

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Localization for Swarm Robots Using APIT

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Abstract- In the wireless sensor network (WSN) environment, the approximate point-in-triangulation (APIT) is a kind of range-free localization algorithm. This algorithm provides high precision, however, the coverage rate is somewhat poor. In this paper, we propose an improved APIT algorithm for the localization of swarm robots, which is based on the received signal strength indicator (RSSI) and the center of gravity (COG) methods.

key words - Swarm robots, localization, APIT, RSSI, COG.

1.Introduction

WSN is getting the spot light in the localization of swarm robots because the computing power and the communication technology have developed rapidly. In addition, WSN is widely used in various fields such as the military equipments and the environmental detecting devices [1-10]. The existing localization algorithms can be classified into two categories: the range-based and the range-free localization. The range-based localization in general has high precision, but needs high requirements which cause energy losses during localization. On the other hand, the range-free localization has relatively low precision, but does not need high requirements [2].

In this paper, we propose a localization algorithm to improve the precision and the coverage rate, which is based on the range-free localization. To do this, we combine APIT with RSSI and COG.

2. APIT Location Algorithm

APIT divides all anchor nodes within the radius of communication of the unknown node into triangular form, and then takes the mass center of each overlap region of the triangles as the estimated position of the unknown node [3].

2.1 Conventional APIT algorithm

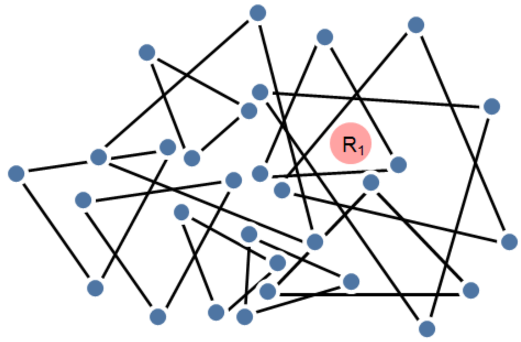
First, any three anchor nodes around a unknown node are chosen, and the triangle consisting of the anchor nodes is checked whether it contains the unknown node. Repeating the test with different combination of anchor nodes, the location precision of the unknown node is improved. Finally, the centroid of the intersection of all triangles provides the location of the target node as shown in Fig. 1. The detail procedure of APIT is as follows:

(1) Preliminary Stage: The unknown node collects the information of anchor nodes within its radius of communication such as positions and identification numbers, etc. Then they exchange their information with their adjacent nodes.

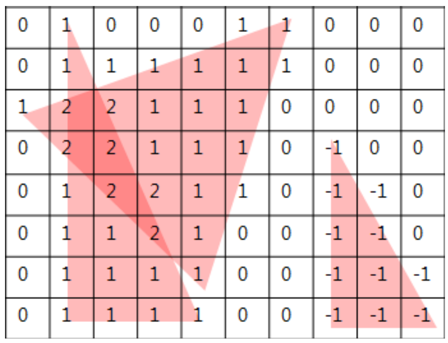
(2) Approximate Point in Triangulation Test: Test whether the unknown node is included in the triangles formed by different anchor nodes.

(3) Counting the Overlap Regions: Record the triangles including the unknown node and mark the overlap regions of all the triangles as shown in Fig. 2.

(4) Calculating the Positions of the Unknown Nodes: Assign the mass center of the overlap regions as the positions of the unknown node.



<Fig. 1> Overlapping places

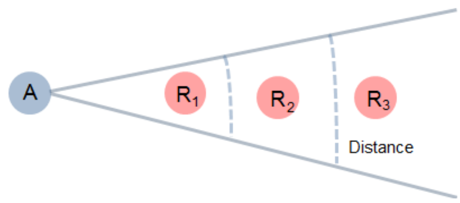


0	1	0	0	0	1	1	0	0	0
0	1	1	1	1	1	1	0	0	0
1	2	2	1	1	1	0	0	0	0
0	2	2	1	1	1	0	-1	0	0
0	1	2	2	1	1	0	-1	-1	0
0	1	1	2	1	0	0	-1	-1	0
0	1	1	1	1	0	0	-1	-1	-1
0	1	1	1	1	0	0	-1	-1	-1

<Fig. 2> APIT

2.2 Improved APIT algorithm

RSSI is a ranging scheme which can approximate the distance between two nodes by using the received signal attenuation. We can measure the receiving power of the signal, and convert the propagation loss to the distance according to the signal propagation model.



<Fig. 3>Signal strength on the different distance

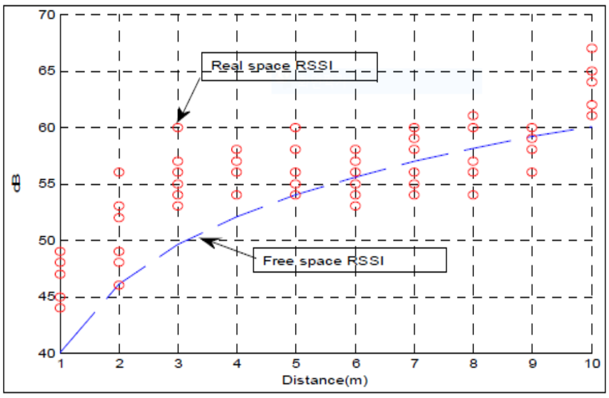
Measuring the distance using RSSI method is shown in Fig. 3. Anchor node sends a signal when it receives a signal of the robot path. The power loss caused by signal attenuation on the path is given as Friis eqaution (1)

$$L = 20 \times \log_{10}\left(\frac{4\pi d}{\lambda}\right)\ [dBm], \quad (1)$$

where λ is the wavelength of the signal, and d is the distance which is represented as

$$d = \frac{\lambda}{4\pi} \times 10^{\frac{L}{20}} = \frac{c}{4\pi f} \times 10^{\frac{L}{20}}, \quad (2)$$

where f denotes the frequency of the signal, and c represents the propagation velocity of the signal. Here, the propagation velocity is assumed to be the speed of light. Fig. 4 shows the difference between the ideal RSSI and the real one.

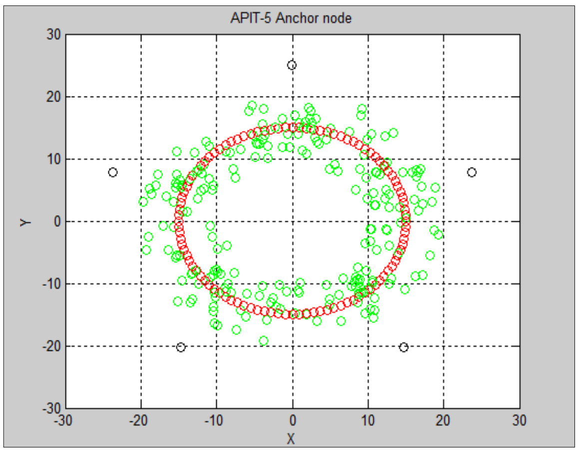


<Fig. 4> The real RSSI

COG is a geometric property of any object. The center of gravity is the average location of the weight of an object. We can completely describe the motion of any object through space in terms of the translation of COG. We can make the receivers around the robots to receive the signal of any directions. The signal from a anchor node to the robot is used to approximate the distance between them by measuring RSSI.

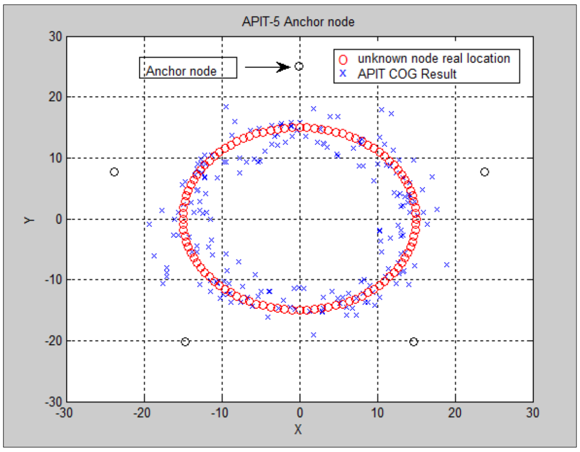
3. Simulation Results

The five anchor node are denoted by the black circles as shown in Fig. 5. The localization results by APIT are the green circles, and the actual unknown nodes are the red circles.



<Fig. 5> The localization result by APIT

The blue crosses in Fig. 6 are the final localization results which are obtained by COG of the green circles in Fig. 5.



<Fig. 6> The final localization result

4. Conclusion

In this paper, we proposed an improved APIT localization algorithm which consists of RSSI and COG. Comparing with the conventional localization algorithm, the proposed method requires less computation power, and provides the sufficient accuracy of the localization.

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