

A survey on node localization

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Outline

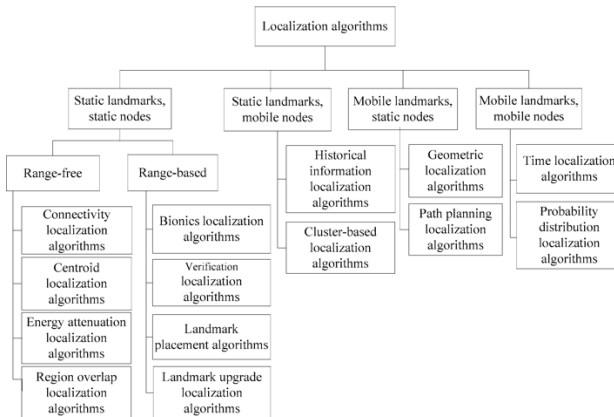
1 Classification

2 Summaries



Localization algorithms classification

We reclassify the localization algorithms based on the mobility:



Localization algorithms classification in WSNs

localization algorithms are classified into four categories:

- 1. static landmarks, static nodes
- 2. static landmarks, mobile nodes
- 3. mobile landmarks, static nodes
- 4. mobile landmarks, mobile nodes



1. static landmarks, static nodes

- 1.1 Range-free localization algorithms

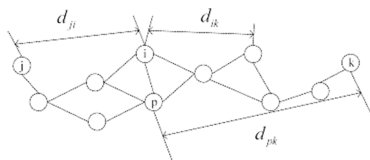
Range-free algorithms do not need to measure the distance or angle information between unknown nodes and landmarks, which estimate the distance between two nodes by the connectivity information, the energy consuming information, or the area information of the superimposed region of the landmarks.

- 1.1.1 Connectivity localization algorithms
- 1.1.2 Centroid localization algorithms
- 1.1.3 Energy attenuation localization algorithms
- 1.1.4 Region overlap localization algorithms

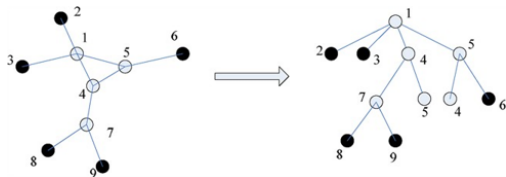


1.1.1 Connectivity localization algorithms

- DV-hop
- Formation of the BN tree



DV-hop localization algorithm

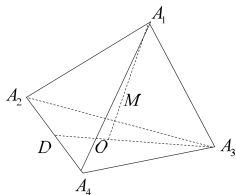


Formation of the BN tree

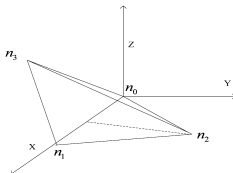


1.1.2 Centroid localization algorithms

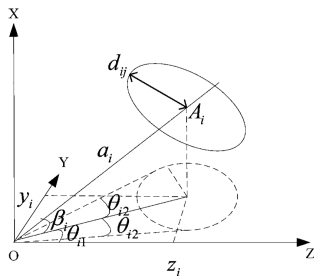
- Tetrahedron method
- Assumption Based Coordinates (ABC) method
- Three-dimensional centroid algorithm



Tetrahedron method



ABC method

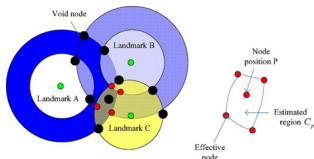


Three-dimensional
centroid algorithm

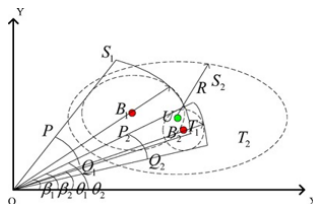


1.1.3 Energy attenuation localization algorithms

- Energy grade overlap graph
- Beacon Signal Ring (BSR) localization algorithm



Energy grade overlap graph

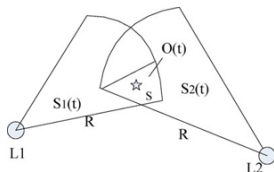


Sketch map of target region

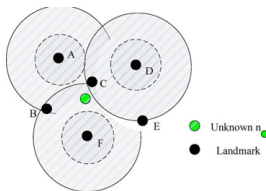


1.1.4 Region overlap localization algorithms

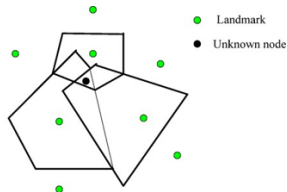
- Region overlapping
- Spherical shells overlap
- Voronoi graph



Region overlapping



Spherical shells overlap



Voronoi graph



1.2 Range-base localization algorithms

Range-based localization algorithms have highly localization accuracy. But they usually require more hardware in order to measure the distance between sensor nodes. The typical distance measurement techniques include RSSI, TOA, TDOA, AOA, and etc.

- 1.2.1 Bionics localization algorithms
- 1.2.2 Verification localization algorithms
- 1.2.3 Landmark placement localization algorithms
- 1.2.4 Landmark upgrade localization algorithms



1.2 Range-base localization algorithms

- 1.2.1 Bionics localization algorithms

The core idea of bionics localization algorithms is to combine the model of biological motion with the localization process of unknown nodes.



1.2 Range-base localization algorithms

- 1.2.2 Verification localization algorithms

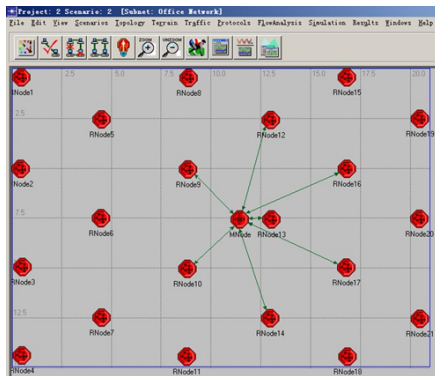
The core idea of these localization algorithms needs to verify the distance value between unknown nodes and landmarks using RSSI value.



1.2 Range-base localization algorithms

- 1.2.3 Landmark placement localization algorithms

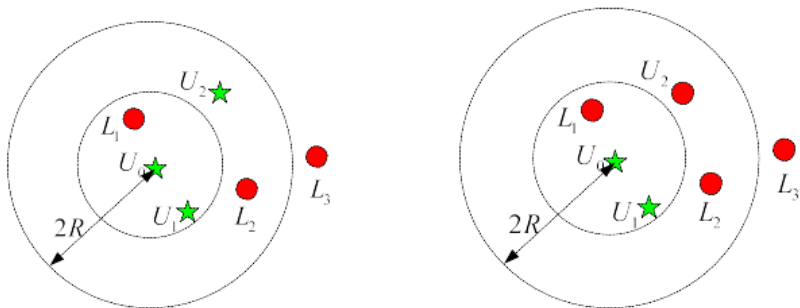
Landmark placement has great relationship with the localization error of unknown nodes. Therefore, the geometry relationship of landmarks is used to improve the localization accuracy of unknown nodes.



1.2 Range-base localization algorithms

- 1.2.4 Landmark placement localization algorithms

A novel landmark upgrade localization algorithm, which upgrades a node with high localization precision to a landmark.



1. static landmarks, static nodes

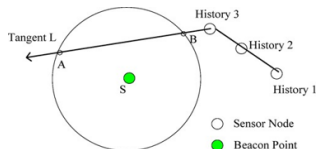
We have analyzed the static landmarks and static unknown nodes localization algorithms in the aspect of localization accuracy, node density, landmark density and energy consumption, as shown in Table 1.

Localization algorithms		Localization accuracy	Node density	Landmark density	Energy consumption
Connectivity localization algorithms	DV-Hop	Better	Greater	Smaller	Greater
	LCB	Average	Greater	Average	Average
Centroid localization algorithms	Centroid	Average	Smaller	Greater	Greater
	ABC	Better	Smaller	Average	Average
	Three-dimensional centroid	Better	Smaller	Smaller	Greater
Energy attenuation localization algorithms	Source energy attenuation	Average	Average	Average	Average
	BSR	Better	Average	Average	Greater
	Energy intervals	Better	Average	Average	Greater
Region overlap localization algorithms	HiRLoc	Average	Smaller	Average	Average
	APIS	Better	Smaller	Greater	Smaller
	Voronoi	Average	Smaller	Greater	Average
Bionics localization algorithms	Honey bee orientation	Average	Average	Smaller	Greater
Verification localization algorithms	weighted centroid algorithm	Average	Average	Greater	Average
Landmark placement localization algorithms	RNST	Better	Smaller	Average	Smaller
Landmark upgrade localization algorithms	Landmark sparse	Average	Smaller	Smaller	Greater

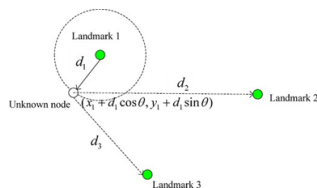


2. Static landmarks and mobile nodes

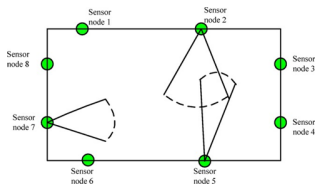
- Historical information localization algorithms
- Cluster-based localization algorithms



Distributed mobile localization algorithm



DTN localization algorithm



Target localization algorithm



2. Static landmarks and mobile nodes

Historical information localization algorithms consume a lot of energy due to frequently record problem. Cluster-based localization algorithms can save energy in some extend.

Localization algorithms		Localization accuracy	Node density	Landmark density	Energy consumption
Historical information localization algorithms	Distributed mobile localization algorithm	Better	No effect	Smaller	Average
	DTN	Better	No effect	Average	Greater
	Target tracking localization algorithm	Average	No effect	Greater	Smaller
Cluster-based localization algorithms		Average	No effect	Greater	Smaller



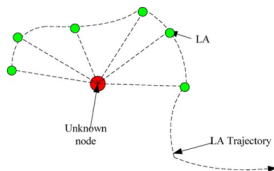
3. Mobile landmarks and static nodes

- Geometric localization algorithms
- Path planning localization algorithms

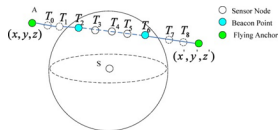


3. Mobile landmarks and static nodes

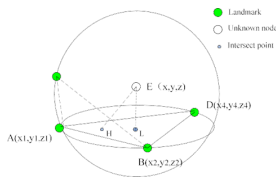
- Geometric localization algorithms



LA localization algorithm



Sphere-based localization algorithm

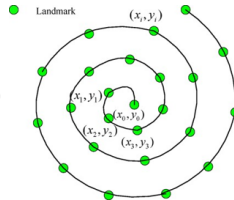
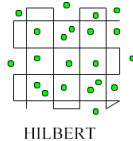
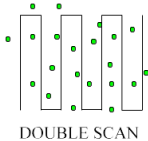
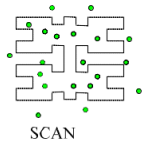


Flying landmark localization algorithm



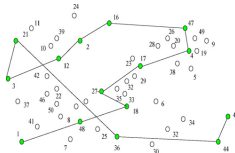
3. Mobile landmarks and static nodes

- Path planning localization algorithms

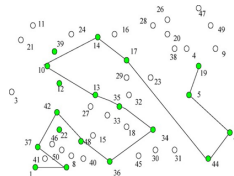


Three different travelling trajectories

Spiral trajectory



Backtracking greedy algorithm



Breadth-first algorithm



3. Mobile landmarks and static nodes

We have summarized mobile landmarks and static nodes localization algorithms in the aspect of localization accuracy, node density, landmark density, travelling speed and energy consumption, as shown in Table 3.

Localization algorithms		Localization accuracy	Node density	Trajectory length	Travelling speed	Energy consumption
Geometric localization algorithms	LA	Average	No affect	Shorter	Average	Smaller
	Sphere-based algorithm	Better	Average	Average	Greater	Average
	Flying landmark algorithm	Better	Average	Average	Greater	Average
Path Planning localization algorithms	S shaped trajectory	Average	Smaller	Average	Average	Smaller
	SCAN, etc.,	Better	Smaller	Shorter	Greater	Average
	Gauss-Markov trajectory	Average	Average	Longer	No affect	Greater
	Spiral trajectory	Better	Smaller	Average	Average	Average
	Intelligent trajectory	Average	Greater	Longer	No affect	Average



4.Mobile landmarks and mobile nodes

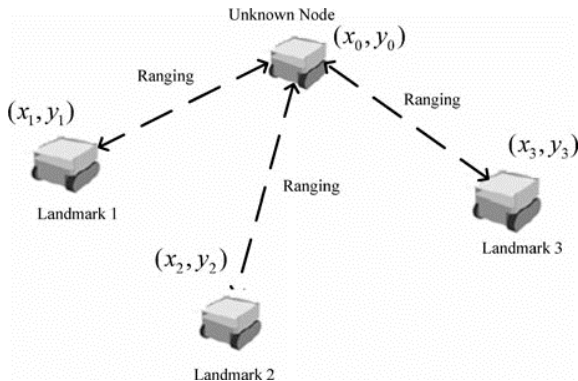
- Time-based localization algorithms
- Probability distribution localization algorithms



4. Mobile landmarks and mobile nodes

- Time-based localization algorithms

The idea of these algorithms is to calculate the positions of unknown nodes in a very short time interval.



4.Mobile landmarks and mobile nodes

- Probability distribution localization algorithms

The algorithm contains two stages:

At the prediction stage, the unknown node predicts its estimated location using distributed switching equipment based on the reserved information and the mobile information of the mobile landmark.

At the filtration stage, the unknown node removes the inconsistent information from the estimated location.



3. Mobile landmarks and mobile nodes

We have summarized mobile landmarks and mobile nodes localization algorithms in the aspect of localization accuracy, node density, landmark density, travelling speed and energy consumption, as shown in Table 4.

Localization algorithms		Localization accuracy	Node density	Landmark density	Travelling speed	Energy consumption
Time-based localization algorithms	Self-organizing localization algorithm	Average	Greater	Greater	Greater	Greater
Probability distribution localization algorithms	MCL	Better	Smaller	Smaller	Average	Greater



Summaries and outlook

We believe that in addition to the existing research issues of localization algorithms, the possible hot research topics are

- Evaluate the performance model of localization algorithms, and improve the landmark selection and filtering mechanisms to reduce the localization time.
- Randomly deploy the nodes on the surface of the actual land-based, and study the localization performance of actual land.
- Find a localization algorithm which is suitable for resource-constrained sensor nodes, and reduce the localization error caused by random distribution of nodes.
- Research a self-adjustment localization algorithm in the mobile network environment, and simulate the localization algorithm performance in the low mobility of sensor nodes.
- Research the optimal path planning in which mobile landmarks can traverse the entire network.

