# Evolutionary Algorithm for Optimal Anchor Node Placement to Localize Devices in a Mobile Ad Hoc Network during Building Evacuation

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## ABSTRACT

Using mobile devices to support the evacuation of a building is a relatively new and promising research field. An essential requirement to realize this endeavor is to be able to track the location of the mobile devices. Since GPS is generally not available in buildings, alternative localization methods, i.e. methods to determine the devices' locations, need to be used. Many of these alternative localization algorithms use a small number of so called anchor nodes which are assumed to know their positions to derive the locations of all other devices in the network. The placement of these anchor nodes is essential to the accuracy of the derived locations and has, so far, been mainly studied for static networks. Mobile networks pose different challenges, especially when used for evacuation support, where devices are simultaneously moved towards the exits of a building. Here, we present an Evolutionary Algorithm in combination with a multi-agent simulation to optimize the placement of anchor nodes in order to localize devices during evacuation. It is shown that the proposed Evolutionary Algorithm is a suitable instrument to find a good placement and some essential criteria for such a placement are identified.

## **Categories and Subject Descriptors**

C.2.1 [Computer-Communication Networks]: Network Architecture and Design —*Distributed networks, Network* topology

## Keywords

Evolutionary Algorithm, Mobile Ad Hoc Networks, Localization, Evacuation

## 1. INTRODUCTION

The fast growing world population increases the demand for buildings to become larger and more complex. At the same time, progress in architecture and civil engineering

*GECCO* '13 Companion, July 6-10, 2013, Amsterdam, The Netherlands. Copyright 2013 ACM 978-1-4503-1964-5/13/07 ...\$15.00. makes the construction of such buildings realistic and affordable. In contrast to the advancements in building construction, their preparation for evacuation in case of an emergency is comparatively underdeveloped. In general, there are static and analogous signs distributed in the buildings which are supposed to guide people to exits. The main problem with these installations is that they are easy to overlook and cannot adapt to the current situation. For example, blocked passages, due to fire, smoke, damaged walls, or waiting people are not recognized and treated respectively. On the other hand, the increasing number of mobile devices with wireless communication abilities opens up a new possibility for evacuation support in buildings. Ideally, a person is alerted by its smart phone in case of an emergency via ringing or vibrating. A map of the building is then displayed on its screen and the user can be guided safely to an exit by pointing out the right direction. The advantage of using mobile devices is that they can be carried around and the information displayed on the screen is adaptable to the current situation. When mobile devices are able to communicate with other nearby devices, they form spontaneous networks, so called mobile ad hoc networks (MANETs) [13]. In these networks, messages can be forwarded by other devices enabling a multi-hop communication which can be used to transport information over longer distances. For example, fire sensors could inform nearby mobile devices about dangerous areas and this information can be forwarded to other devices in the network via multi-hop communication. In order to be able to guide its user to an exit, the device must know its current position in the building and, with GPS not being available indoors, this alone becomes a challenge. On the other hand, GPS-less localization of devices in ad hoc networks is a well-studied task (cf. [2] for an overview). Many of the proposed localization algorithms make use of special devices, so called anchor, which know their locations, for example due to a priori configuration, and are used to derive the positions of the other devices in the network. For building evacuation support, it is conceivable to distribute such static anchor devices in a building and configure their individual location information. A building equipped like this could enable the localization of mobile devices and consequently provide navigation support in case of an emergency.

The placement of anchor nodes plays an important role for the quality of the derived locations [21, 2] and the question arises where the anchor nodes should ideally be placed in order to make localization as good as possible. So far,

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localization and associated with it the optimal placement of anchor nodes are mainly studied for static networks. While anchor placement in static networks can often be reduced to an optimal coverage problem, this is not necessarily the case for dynamic networks. Mobility is accompanied by different demands for anchor node placement because the connectivity of the network and, as a consequence, the ability to communicate with certain static anchor nodes varies over time. During evacuation, for example, all devices are moved simultaneously towards certain directions, leaving parts of the building empty and others more frequented. Intuitively, one might expect anchor nodes to be more important in higher frequented areas but since the density of mobile devices is higher there as well, the chance to maintain connection between mobile and anchor nodes via multi-hop communication is better compared to low density regions. As a result, less anchor nodes might be needed to supply the devices with information. Additionally, the position information of at least three anchor nodes is needed for localization [21], which distinguishes the problem further from an optimal coverage problem where coverage from one node can be enough. Placing three anchors close together might be of more use than a uniform placement, even though, overall a smaller area is covered.

Little is known about the characteristics of a good solution and the search space is large since we are looking at a steady two or even three dimensional environment. For these reasons and in accordance with the criteria listed in [7], we approach the problem with an Evolutionary Algorithm (EA), i.e. a heuristic optimization and search method based on the principles of natural evolution. For this, an appropriate evaluation method is needed to assess the quality of a given solution. Here, we use a multi agent simulation (MAS) to evaluate the accuracy of the localization of mobile devices in a simulated building evacuation scenario given a specific anchor node placement.

Experiments show that the scenario indeed differs from an optimal coverage problem and that the proposed Evolutionary Algorithm optimizes the placement of anchor nodes for a building evacuation supported by mobile devices.

This paper is structured as follows. Section 2 gives an overview of related work and Section 3 introduces the relevant basics. In Section 4 the design of an Evolutionary Algorithm for optimal anchor node placement is explained in detail and experiments to investigate the performance of the proposed algorithm are presented in Section 5. Section 6 concludes the paper.

## 2. RELATED WORK

Using mobile devices for building evacuation support is a relatively new research area and there are only few publications addressing this scenario. In [28], it is proposed to use mobile devices which are able to read QR-codes or scan RFID chips distributed in the building. This location information is sent to a central server which calculates a load balanced route for all devices in the building. The evacuation system proposed in [6] consists of a static sensor network and a dynamic network of mobile devices, similar to the scenario proposed here. The mobile devices connect to nearby sensor nodes in order to gain information about the condition of corridors lying ahead. In contrast to our work, sensor node placement and their usage for localization are not considered. Merging GPS-less localization with a building evacuation scenario, is suggested in [12] and [19]. While [12] concentrates on the localization service, [19] focuses on the routing and a distributed evacuation planning approach is proposed which assumes known locations for the mobile devices.

Optimal node placement in sensor networks receives some attention. However, the main focus lies on achieving an optimal coverage of a certain area while simultaneously minimizing the necessary number of nodes (cf. for example [8, 15, 26, 14, 4]). In general, this problem is referred to as minimum disc cover problem and can be solved in time  $\mathcal{O}(n \log n)$  with n denoting the number of nodes in the network (cf. [27]). Besides, there is some work concerned with anchor node placement for localization in static sensor networks. For example, in [25], it is recommended to place anchor nodes at the edges of a sensor network field. In [1] and [29] guidelines for anchor node placement for specific localization algorithms are developed. [3] introduces an approach for adaptive anchor placement in case of node failure and similar events. [24] shows a lower bound for localization accuracy and investigates the impact of anchor node placement. Using mobile anchor nodes to improve localization is subject to research in [17] and [16].

## 3. BASICS

In the following, the basics of Evolutionary Algorithms and anchor based localization in MANETs are explained and an algorithm to compute the coverage-degree of an anchor node placement is introduced which is then, among other methods, used for evaluation of specific anchor node placements in the Evolutionary Algorithm.

## **3.1** Evolutionary Algorithms

Evolutionary Algorithms (EAs) represent a search strategy following the example of natural evolution based on Darwin's theory [5]. Genetic operators known as reproduction, mutation, and selection are used in order to search for good solutions to a given optimization problem. Figure 1 visualizes the process.



Figure 1: Procedure of an Evolutionary Algorithm.

Initially, a set of possible solutions, which is called a population, is chosen, for example randomly. Each individual is evaluated with respect to the given optimization objective and a fitness value is assigned to it representing its quality with respect to the objective. In the next step, several individuals are selected for recombination where their genome is merged in order to form new individuals, so called children. These children are subsequently modified (mutation) and the next population is created. The exact implementation of the genetic operators can vary and is determined in Section 4. The process is repeated iteratively for a certain time or until a sufficiently good solution is available. For more details refer to [30, 7].

#### 3.2 **Anchor-Based Localization in MANETs**

For the localization of a device in multi-hop communication networks a method called *Multilateration* can be used [21]. For this, all devices forward known coordinates of anchor nodes and estimate their distances to these anchors. When three anchor nodes' positions are known, the devices iteratively compute their own coordinates by minimizing the error between estimated distances and real distances. Algorithm 1 shows the necessary computations. The search for coordinates finishes when the error improvement is not greater than a specified value  $\epsilon$ .

Algorithm 1 Computes coordinates for device *i* using iterative Multilateration according to [21]

**Require:** Set of anchor coordinates  $C_i$ , set of distance estimates to these anchors  $\hat{D}_i$ 1: Select closest anchor m with  $\hat{d}_{im} \leftarrow min(\hat{D}_i)$ 2: Initialize:  $\bar{c}_i \leftarrow c_m \in C_i, \, \Delta(E) = \infty$ 

3: while  $\Delta(E) > \epsilon$  do

coordinates  $c_i = (x_i, y_i) \leftarrow \bar{c}_i$ 4:  $\Delta x_i \leftarrow 0, \, \Delta y_i \leftarrow 0$ 5:

for all  $c_a \in C_i$  do 6:

- $d_{ia} = EuclideanDistance(c_i, c_a)$ 7:
- $E \leftarrow E + (d_{ia} \hat{d}_{ia})^2$ 8:
- $\Delta x_i = \Delta x_i + (x_i x_a)(1 (d_{ia}/\hat{d}_{ia}))$ 9:
- $\Delta y_i = \Delta x_i + (y_i y_a)(1 (d_{ia}/\hat{d}_{ia}))$ 10:
- end for 11:
- New coordinates:  $\bar{c}_i = (x_i \alpha \ \Delta x_i, \ y_i \alpha \ \Delta y_i)$ 12:
- $\bar{E} = \sum_{C_i} (EuclideanDistance(\bar{c}_i, c_a) \hat{d}_{ia})^2$ 13:

14:  $\Delta(E) = E - \bar{E}$ 

- 15: end while
- 16: **return** coordinates for device *i*:  $c_i$

There are various methods for the estimation of distances to anchor nodes (cf. for example [22, 21, 11, 18, 9, 20]). Here, we implement two distance estimation algorithms which are based on different concepts so we can subsequently investigate the impact of the selected distance estimation algorithm on the evolved anchor node placement.

#### 3.2.1 Hop Count Based Distance Estimation

Firstly, the minimum number of communication hops between the mobile devices and the anchor nodes are determined. For this, the anchor nodes send messages with value 0 and each device collects the messages received from its neighbors, i.e. devices within communication range. The minimum value is then selected and incremented by 1 in order to compute its own hop count which it, in turn, communicates to its neighbors. After some time, all devices in the network know their hop count and the distance estimate is calculated using Equation 1.

$$\hat{d}_{ia} = r \cdot \left(\frac{h_{ia} + \sum_{j \in N_i} h_{ja}}{|N_i| + 1} - 0.5\right) \tag{1}$$

With  $N_i$  denoting the set of neighbors of device i,  $\hat{d}_{ia}$  the distance estimate and  $h_{ia}$  the hop count between i and an-



(a) The central 2nd-degree node covers an area.

(b) Treatment of overlapping perimeter covers.

#### Figure 2: Perimeter coverage illustrations.

chor a, and r the equal and known communication range. The computations to determine a device's hop count, distance estimate, and coordinates are constantly repeated in order to be able to adapt the coordinates to a new position after the device has been moved.

#### 3.2.2 Geometric Distance Estimation

The second distance estimation approach is presented in [20]. Here, the distance estimate between two neighbors is derived from the ratio of shared to total communication partners using Equation 2.

$$\hat{d}_{ia} = \hat{d}_{ia} + r \cdot (3.9R^3 - 4.16R^2 + 3.04R + 0.04) \quad (2)$$

With r denoting the equal and commonly known communication radius, j being the neighbor of i with minimal distance estimate  $\hat{d}_{ja}$  with respect to anchor a, and  $R = \frac{|S_{ij}|}{|N_i|}$ , with  $S_{ij}$  denoting the set of common neighbors of device iand j and  $N_i$  the set of all neighbors of i. Similar to the hop count based approach, the anchor node sends a message with value 0 indicating a distance estimate of 0 and each device looks for the neighbor which communicates the minimal distance estimate. The device then estimates its distance to this neighbor using Equation 2 and adds this value to the neighbor's communicated distance estimate. Now, the device in turn is able to communicate its estimate and sends a message which contains the calculated value. The process is, again, constantly repeated to be able to adapt the estimate when a device is moved.

## **3.3** Perimeter Coverage Approach

In [10], an approach is presented to compute the coverage degree of an area occupied by a network of nodes. The algorithm decides if and how often the perimeter of a node, i.e. the border of its communication range, is contained in the communication range of other nodes. An area which is not within communication range of a node is denoted as uncovered. An area which is covered by a node without perimeter coverage is denoted as one-degree covered. If an area is covered by a node with a perimeter that in turn is covered n times, the area is denoted as (n + 1)-degree covered. Figure 2(a) shows an example two-degree covered area. If two adjacent nodes cover the same slice of the perimeter the overlapping part is counted for the next coverage degree. Figure 2(b) illustrates this procedure.



Figure 3: An individual anchor node placement and its genetic representation.

## 4. EVOLUTIONARY ALGORITHM FOR AN-CHOR PLACEMENT IN MANETS

To optimize anchor placement for localization of mobile devices, we design an Evolutionary Algorithm as follows. The genome of one individual in the population is selected to be a set of two-dimensional coordinates, each representing the position of one anchor node. Figure 3 shows an example for one individual and its genetic representation.

#### 4.1 Selection

During the selection process, a certain number  $n_{parents}$  of individuals are chosen from the population which are then used to create descendants by recombination. We decided for a standard selection method, called *binary tournament selection*, where two individuals are randomly selected from the population and compared with respect to their fitness value. The individual with higher fitness is then added to the mating pool. Both individuals stay available for further selections. The calculation of an individual's fitness value is described in Section 4.5. Figure 4 illustrates the tournament-selection process.



Figure 4: Illustration of the tournament-selection.

## 4.2 Recombination

For recombination, two random individuals are chosen from the mating pool and recombined to create two children. For the recombination procedure we implemented two standard approaches which are both tested in the experiments. The first recombination is called *uniform crossover* where the genomes of the parents are traversed and for each gene it is decided with a probability p to be part of the first or, otherwise, second child. The second recombination procedure is called *one-point crossover*. Here, a random position is selected at which the genomes from both parents are cut. The first child consists of the first half of the first parent and the second half of the second parent and vice versa for the second child. Figure 5 shows an example for both recombination approaches.



Figure 5: Implemented recombination operators.

## 4.3 Mutation

When recombination is completed, the created children are mutated as follows. With a certain probability  $p_{mut}$  a number  $n_{mut}$  genes are altered according to equation 3.

$$c = (\mathcal{N}(x,\sigma), \mathcal{N}(y,\sigma)) \tag{3}$$

With c denoting the new coordinates after mutation, x and y represent the two-dimensions of the coordinates before mutation and  $\mathcal{N}(m, \sigma)$  is a normally distributed random value with mean m and standard deviation  $\sigma$ . Using a normal distribution for finding new coordinates ensures that the new coordinates are around the current ones, with the possibility to adjust the proximity by modifying the standard deviation.

## 4.4 New Population

To create the new population for the next iteration of the evolutionary algorithm, the  $(\mu + \lambda)$  approach is taken where  $\mu$  denotes the size of the current population and  $\lambda$  describing the number of children. Here, the next generation is built by selecting the  $\mu$ -best individuals from the combined set of old population and children [30].

## 4.5 Fitness Evaluation

For fitness evaluation, we propose two methods. Firstly, a multi agent simulation is used in which all agents, i.e. devices in the mobile ad hoc network, compute their location applying the algorithm described in Section 3.2 with either of the suggested distance estimation techniques (Hop count is further denoted as HC and Geometric distance estimation as Geo). The fitness of an anchor node placement is calculated as the average deviation between real and estimated positions of the devices during a simulation period T. For this, the simulation duration T is divided into time steps t after which the localization is recomputed. After recomputing their location, the devices are moved towards a designated exit (cf. Section 5.1 for details). The fitness value is defined as the reciprocal of the average deviation. Equation 4 describes the fitness evaluation with simulative localization. D is the set of all devices,  $c_t(d)$  denotes the real position of device d at time step t, and  $\hat{c}_t(d)$  its estimated position.

$$F_{Pos}(HC/Geo) = \frac{|T| \cdot |D|}{\sum_{t \in T} \sum_{d \in D} |c_t(d) - \hat{c}_t(d)|}$$
(4)

Additionally, we propose a fitness value which computes the percentage of devices which estimate their position to be in the correct room of the considered building environment as shown in Equation 5. We choose this criteria since estimating the correct room might be enough to navigate people to a safe exit during evacuation.

$$F_{Room} = \frac{1}{|T|} \sum_{t \in T} 1 - \frac{|\{d \in D : room(c_t(d)) = room(\hat{c}_t(d))\}|}{|D|}$$
(5)

Besides, the perimeter coverage described in Section 3.3 is used to compute a fitness value for an individual. For this, the considered building environment is discretized into a certain number of squares and for each square the coveragedegree is computed. Since the position information of three anchor nodes is needed for localization, we define a thirddegree covered area to be most valuable. Equation 6 shows the fitness calculation for an individual. S denotes the set of squares in the environment.

$$F_{PC} = \sum_{i=1}^{3} i \cdot \frac{\sum_{s \in S} i \text{-cover}(s)}{|S|} \tag{6}$$

With i-cover(s) = 1 if square s is *i*-th-degree covered.

## 5. EXPERIMENTS

Experiments are performed to test the effectiveness of the presented Evolutionary Algorithm and to compare the performance of the proposed fitness evaluation methods. For this, a building evacuation scenario is simulated as follows.

#### 5.1 Simulation and Settings

The simulation of a building's evacuation is set up by placing D mobile devices randomly in an environment which represents the building. The environment is simulated as a twodimensional square plane which is discretized into squares and each agent, i.e. mobile device, occupies one square and can move to a square within its von Neumann neighborhood (cf. Figure 7(a)) at each time step t. The square has to be empty, which means it cannot be occupied by another agent or be a part of a wall. Figure 6 illustrates the experiment scenario.

If there is no free square in the von Neumann neighborhood, the Moore neighborhood (cf. Figure 7(b)) becomes accessible for movement. While respecting this rule, all agents are moved on the shortest path towards a designated exit.

The agents are able to exchange messages at each time step t with all agents within their communication range, i.e.



Figure 6: Evacuation scenario with mobile devices (grey circles with arrows) and anchor nodes (black circles).



Figure 7: Von Neumann (a) and Moore (b) neighborhood.

agents that are located at a distance less or equal to r, before they are moved. This reflects the fact that the device does not know if it is moved and, as a consequence, is not able to determine its new location directly after each movement. All specified dimensions are measured relative to the width (height) of the rectangular plane which has a width (and height) of 1. This allows an easy translation of the simulative results to a building with arbitrary dimensions. The communication range r is set to 0.1 which, thus, corresponds to 10% of the plane's width (height). For a detailed description of the simulation environment, refer to [19]. The parameters for the Evolutionary Algorithm are listed in table 1.

To be able to assess how much two individuals differ from each other, the Hausdorff-distance [23] is used as shown in Equation 7. A(i) refers to the set of anchor nodes from individual *i*.

$$hd(i,j) = max_{\forall a_i \in A(i)}(min_{a_i \in A(j)}d(a_i, a_j)) \tag{7}$$

The Hausdorff-distance is zero for identical individuals and otherwise reflects the maximum distance between an anchor node from individual *i* and the closest anchor node from the other individual *j*. Since hd(i, j) and hd(j, i) are not symmetric, we compute the average as  $\overline{hd}_{ij} = \frac{1}{2}(hd(i, j) + hd(j, i))$ .

Parameter Name	Value
Population size $(\mu)$	10
Probability for mutation	0.3
Standard deviation for mutation	0.05
Mating pool size $(n_{parents})$	10
Number of anchor nodes	20
Number of mobile devices / agents	100
Evolutionary iterations	1000

Table 1: Parameter settings in the experiments.



Figure 8: Progress of fitness during evolution.

#### 5.2 Results and Discussion

At first, we look at the behavior of the fitness value during evolution. Figure 8 shows this progress for the four proposed fitness evaluation criteria using the two recombination operators introduced in Section 4.2.

We tested a mutation of 1 and 5 genes per iteration each with a probability of 0.3. It can be observed, that the fitness increases for all proposed fitness criteria during evolution. When comparing the fitness value of both simulative approaches, it becomes apparent, that localization with hop count based distance estimation achieves lower localization error (deviation of estimated from real coordinates) than Geometric distance estimation. This comes as a surprise, since the Geometric distance estimation is shown to be more accurate in [20]. There are two possible reasons for this behavior. Firstly, the Geometric localization is less suitable for networks with a directional movement or, secondly, finding a good anchor placement for Geometric localization is harder than for a hop count based localization approach. Figure 9 displays the individuals from the final population with the highest fitness values  $F_{Pos}(HC)$  and  $F_{Pos}(Geo)$ .

It becomes obvious, that a good anchor node placement for Geometric localization looks differently from a good anchor node placement for hop count based localization. The corresponding average Hausdorff-distance is  $\overline{hd}_{HC,Geo} = 0.25$ . Hence, the used localization algorithm on the mobile devices plays an important role, when optimizing the anchor placement in a building.

To make the results from all four Evolutionary Algorithms comparable, we take the final population and compute the localization error with hop count based localization in a sim-



Figure 9: Individual with highest fitness value using simulative Geometric localization (a) and hop count based localization(b).



Figure 10: Comparison of the last populations evolved with various fitness criteria in terms of localization error.

ulative run, since the results for this localization approach are better. Figure 10 shows the comparison.

The localization error is lowest with individuals evolved using the simulative hop count based localization as fitness criteria. The perimeter coverage results are only slightly worse, followed by the simulation with Geometric localization and individuals evolved using correct room mapping criteria. From this evaluation, it becomes apparent that a low localization error is not necessarily the same objective than a good room mapping of the resulting coordinates. Besides, it is noticeable, that the individuals evolved with the perimeter coverage fitness criteria perform almost as well as the population evolved with simulative hop count based localization. At first, this seems to contradict the initial considerations about the difference between an optimal coverage problem and an optimal anchor node placement for mobile networks, but this can be refuted by further investigations. Figure 11 displays the two best individuals from the perimeter coverage evolution in terms of fitness (a) and localization error (b).

While the fitter individual has a wider area covered by anchor nodes, the individual with lower localization error has a sightly denser anchor node placement leaving more squares uncovered. We conclude that the emphasis on thirddegree coverage is the reason for the good performance of the perimeter coverage evolution rather than pure area coverage. Figure 12(a) displays the best individual in terms of localization error from the final population evolved with simulative hop count based localization. This seems to confirm our initial assumption that placing anchors along a path which leads to an exit seems advisable. When comparing the re-



Figure 11: Individuals with highest fitness value (a) and lowest localization error (b) evolved with perimeter coverage fitness criteria.



Figure 12: Individuals with lowest localization error evolved using simulative hop count based localization (a) and correct room mapping (b).

sults with the best perimeter coverage individual in Figure 11 (b), the evolved anchor placements look rather different. In fact, their average Hausdorff distance is  $\overline{hd}_{PC,HC} = 0.25$ . On the other hand, the average localization error for both individuals is very similar with 0.11 for perimeter coverage and 0.10 for simulative hop count based localization. We conclude from this, that an optimal placement has to fulfill both criteria, being close to the path leading towards the exit and at the same time having good third-degree coverage.

The importance of a dense anchor node placement is reinforced when looking at the best individual in terms of fitness evolved with the room mapping fitness criteria illustrated in Figure 12(b). Obviously, coordinates can be mapped well to their corresponding room when anchors are placed densely, although the coordinates have a comparatively high error (cf. Figure 10). As a consequence, it is essential for the placement of anchor nodes to know whether localization error or correct room mapping has higher priority for the specific application case of the MANET.

## 6. SUMMARY AND CONCLUSION

We present an Evolutionary Algorithm in order to optimize the placement of static anchor nodes for distributed range-free localization in a mobile ad hoc network. The application scenario we are looking at is the evacuation of a building where mobile devices are used for navigation. The evacuation scenario poses special challenges to an optimal anchor placement because the devices are moved simultaneously towards the direction of building exits. Hence, we argue and confirm in experiments that optimizing the coverage of the anchor nodes is not enough to achieve good localization results. In simulative experiments, we investigate the presented Evolutionary Algorithm and compare two recombination operators and four different fitness evaluation criteria. Two of these criteria are simulative approaches which use a multi agent evacuation simulation and two different range-free localization algorithms. We show that the selected algorithm influences the evolved anchor placements. Further, an algorithm to determine the coverage degree of nodes in a sensor network is modified and used as fitness criteria. With this approach we reach a similar localization error compared to the simulative localization which has the lowest localization error. At the same time, there is no need for a computational intensive simulation of the evacuation scenario. It is further shown that minimizing the localization error leads to different anchor placements compared to the objective of finding the right room with the calculated coordinates. In summary, anchor placements alongside a path which leads towards an exit, as well as a high thirddegree coverage are identified to be essential criteria for low localization error. For future work, we want to refine the configuration of our Evolutionary Algorithm and combine the presented fitness criteria.

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