# Development of a Context-Aware Sensor Network Algorithm to Optimize Sensor Coverage in a Smart City

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## Extended Abstract

### Introduction

A sensor network usually consists of numerous wireless devices deployed in a region of interest in a city. Despite the advances in sensor network technology, the efficiency and performance of a sensor network for collection and communication of the information in the cities may be constrained by the limitations of sensors deployed in the network nodes in urban areas.

These restrictions may include sensing range, battery power, connection ability, memory, and limited computation capabilities. These limitations create challenging problems for the users of the sensor networks and decision makers, which has pushed researchers from different disciplines in recent years to study various problems related to the design and deployments of efficient sensor networks regarding characteristics and requirements of the smart cities.

However, sensor networks deployment has some limitations when it comes to the modeling, monitoring, and detecting environmental processes. Urban environmental elements are also important to be considered in a realistic sensor networks deployment. Other examples of such elements include contextual information of the sensors environment and urban physical phenomena in distributed area of the network. Using such information in context of urban applications is necessary to perform an appropriate and efficient sensor network deployment. For this purpose, one needs to introduce relevant models of the type of urban phenomena, the accessibility or inaccessibility of the observation area in the city, urban environmental conditions, spatial relations between the objects as well as sensors, and different level of information availability. The complexity of the urban area as the sensing environment of sensor networks may result in several uncovered areas. Consequently, performing an optimized sensor placement affects how well an urban region is covered as well as the cost for constructing the network and connecting the networks elements. Hence, a fundamental issue in a sensor network in an urban area is the optimization of its spatial coverage. Based on previous studies, several optimization algorithms were developed and applied in recent years to meet this criterion. Most of these algorithms often rely on oversimplified sensors, their characteristics, and network models as well as simulation of the efficient urban model and its relevant elements.

### Methodology

Based on mentioned issues, this paper presents an approach to improve sensor deployment

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processes by integrating urban contextual information with optimization algorithms. To achieve this objective, the following approach containing three specific parts is defined.

First, a conceptual framework is proposed to integrate contextual information (CI) in sensor network deployment processes. CI defines the spatial dependencies between spatially adjacent nodes, nodes and obstacles, and obstacles themselves as well as the temporal dependencies between historical movements of nodes in the deployment process. The so-called CI is used in the proposed framework to find good alternative positions of sensor nodes to fill uncovered areas, and decide about the sensor's adequate actions in order to guide sensor network deployment.

Then, a local context-aware optimization algorithm is developed based on the proposed framework. The proposed method is a generic local algorithm, which accepts spatial, temporal, and thematic urban contextual information in different situations. In the proposed algorithm, sensors are ordered in a priority queue, in order to be sorted based on their coverage gain obtained by considering different CI, and following related moves in the network. Then, the sensor with the maximum gain is selected, and stands at the top of the queue. The movement types of sensors are related to the local CI as well as sensor network mission. By changing the position of the topmost sensor of the queue, the network configuration is updated. Then, the coverage gains of the adjacent sensors of moved sensor is recalculated and their ordering in the priority queue is updated. This optimization process is conducted iteratively until one of the predefined stopping criteria is reached.

Next, the accuracy assessment and error propagation analysis is conducted to determine the impact of the accuracy of contextual information on the proposed sensor network optimization method.

**Results and discussion**

The first category of CI is the terrain model and information on the network. The information can provide the elevation of the objects in study area and as a result the obstacles can also restrict the sensing field of the sensors. Thematic information is the next category of CI used in sensor network optimization. For example, several locations may be legally forbidden for the deployment of sensors. Given the restricted areas in context-aware optimization, sensor action is changed and new moves are defined. Desirability of coverage is another type of thematic information that can be considered in the optimization process. Suppose that there are some places in the study area, where sensors cannot be set up, but there is a high interest on those regions to be covered. Sensor placement in an environment with a critical asset is the next thematic CI side of the context-aware algorithm. Let assume a critical asset to be monitored for preventing any undesired access with a slight activity in its environment, which is located beside a street with high level of activities. Thus, there is an interest to monitor any intrusions within the fenced area, but not having the sensor always activated due to the traffic or other activity on the street.

**Conclusion**

The purpose of this paper is to prevent to overcomplicate the optimization process, but rather to find a flexible methodology that can locally accommodate all relevant information that would have an impact on sensor placement. To do so, a local optimization framework was introduced. The extended optimization algorithm can come up with different sensor placement configuration according to the various circumstances, environmental information, and/or sensor parameters encountered.

Consequently, if there are any changes in sensor parameters or environment, the context-

aware algorithm can simply take new contextual inputs and regenerate a new sensor placement design adapted to the new situation. The outstanding advantage of the proposed context-aware algorithm was that it was designed independent of any specific CI. Thus, it is able to take into consideration different types of information based on specific network applications at hand.

**Keywords:** Sensor Deployment, Urban Area, Contextual Information, Optimization, Context-Aware Algorithm.