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Identification and Analysis of Key Consideration Factors for the Efficient Deployment of Wireless Sensor

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Abstract

Wireless sensor network acquires information from the surroundings using sensor, processes it, and then delivers it to other sensors or sink nodes through wireless interface. This kind of application of wireless sensor network can be used for various areas such as army, private sector, hospital and so on. To improve the efficiency of wireless sensor network, the study on the effective sensor placement methods is being conducted in many ways. Most of these studies do not mention that the environmental factors affect nodes when placing nodes. The reason is because there are too many environmental factors or sensors to be considered that affect other sensors, and because these factors are not easy to be recognized or classified. However, this study classifies and recognizes the factors that we need to consider when placing wireless sensor nodes. In addition, it finds how the sensor's coverage affects those recognized items. By doing this, this study can be a foundation for the effective placement of sensor nodes in the future when wireless sensor network is built.

Keywords: *WSN, Sensor Deployment, Consider Factors of Sensor*

1. Introduction

Though wireless sensor network has a variety in its application fields, the most proper application field is to detect any trespassing or objects. Wireless sensor network acquires information from the surroundings using sensors, processes it, and then delivers it to other sensors or sink nodes through wireless interface. Therefore, the sensor itself plays a role of the watcher who acquires information from the surroundings, and if necessary, it can keep the track of place or information.

Currently, the studies related to the sensor network [1, 2] have been conducted in many ways, and also the studies on the effective placement of the sensor network have been actively conducted. But, most studies related to the placement do not consider the various factors that can be problematic when placing sensor network at the actual environment.

Most of the current studies have a restriction rule that sensor network should be placed at just flat land, indoor, underwater [3] or city [4], or they have a restriction rule that considers

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just sensor's effective range for obstacles. In addition, the study on the building a wireless sensor network and detecting a military purpose or invasion [5-9] has been made. However, it is very difficult for us to consider every factor since there are too many factors to be considered when placing sensor in order to build a wireless sensor network at the actual environment, and there is no definite answer to these factors to be considered. These factors can be a fatal one that paralyzes sensor network itself or deteriorates its performance.

Nevertheless, the reason that the study on the factors to be considered when placing sensor nodes is not active is because it is difficult to recognize the factors that affect other sensors, due to the characteristic of sensor's microscopic and micro-power and various software and hardware. In addition, there is not enough material related to environmental factors when placing sensors at outdoor as well as indoor, and lastly, because there are not many studies on the relation between environmental factors to be considered and a sensor network.

The purpose of building a wireless sensor network is usually to watch a certain area. Therefore, this study describes the method that can effectively place sensor nodes when actually building a sensor network, by recognizing and classifying the various factors that we need to consider when placing wireless sensor nodes to watch something.

The rest of this paper is organized as follows. In Section 2, we describe several existing node deployment schemes. Section 3 defines the issue on the reason these factors to be considered are needed and classifies the factors to be considered to place sensor nodes, and Section 4 recognizes the various factors that affect sensor nodes. Section 5 explains the factors recognized and classified in the previous section through a simple test, and Section 6 makes a conclusion.

2. Related Works

Wireless sensor networks (WSNs) have been used in various applications, such as a forest monitoring, a disaster management, a factory automation, a border protection and a battlefield surveillance. The problems associated with coverage and connectivity are caused by a limited detection range and communication range between nodes [10]. The coverage problem is essentially how to ensure that the sensor node can cover the entire area that should be monitored. Optimal node placement problems are very hard and have been proven to be NP-hard for most formulations of sensor deployment [9].

Most sensor nodes and relay nodes have certain constraints such as a restricted sensing and a communication range as well as a limited battery life. These limitations cause some technical issues in terms of coverage, network connectivity, network lifetime, scheduling, and data aggregation [11, 12].

Many researchers have been done to propose different approaches for the optimal node deployment [13, 14]. However most of the researches do not consider various environmental factors affecting the deployment of the sensor network. Therefore, they are too limited when applied to the real environments [13]. [13] proposed a node deployment strategy that considers environmental factors and a limited number of nodes for surveillance and reconnaissance sensor networks (SRSNs). However, it did not cover enough environmental factors.

This study describes the various problems that can happen when placing sensor nodes, and classifies them. It also recognizes each factor by largely classifying them into a sensor node factor and an environmental factor, and suggests the solutions.

3. Classification of the Factors to be Considered when Placing Wireless Sensor Nodes

3.1. Definition of the problem

In this section, we raise the problem and define it, why we should analyze the factors when placing wireless sensor node for watch system, and then in the next section, we further analyze the factors that are raised as problems.

Even if many studies on sensor network have been progressed continuously domestically/overseas, most of the sensor network-related studies mainly focus on sensor node itself and protocol. The studies on the methods for effectively placing sensor network are just in the beginning stage, and these studies are not mentioning the various factors to consider.

Sensor network technology is mainly used for scientific public area and military purpose, and it varies depending on application purpose. The reason is because there may be so many problems that the previous studies cannot solve the problem when actually placing sensor. For example, if sensor is covered by snow after sensor is placed for watch system, sensor network itself can be paralyzed since snow greatly affects sensor's communication and sensing. Actually, in case we place sensor in the area like mountain, the height of grass or movement of animals can affect vibration sensor or sound sensor, and communication problem can happen because visibility is not secured.

Therefore, even if the studies on energy efficiency for watching-invasion system, clustering or other things may be considered important, the factors to consider when placing sensor network should be fully reflected, and they are also important that much.

This study suggests that it is worthy of fully considering the above matters when building a sensor network by placing sensors for watch system, classifies and recognizes the factors to consider when actually placing sensor network.

3.2. Classification of the factors to consider

There are so many factors to consider in order for us to build wireless sensor network in the actual environment. Figure 1 shows the factors to consider when placing wireless sensor network. What is important in the watch system, which is used to detect invasion or for detection, is the scenario for the object of detection and the watch system. Here, scenario means for what use the watch system will be used.

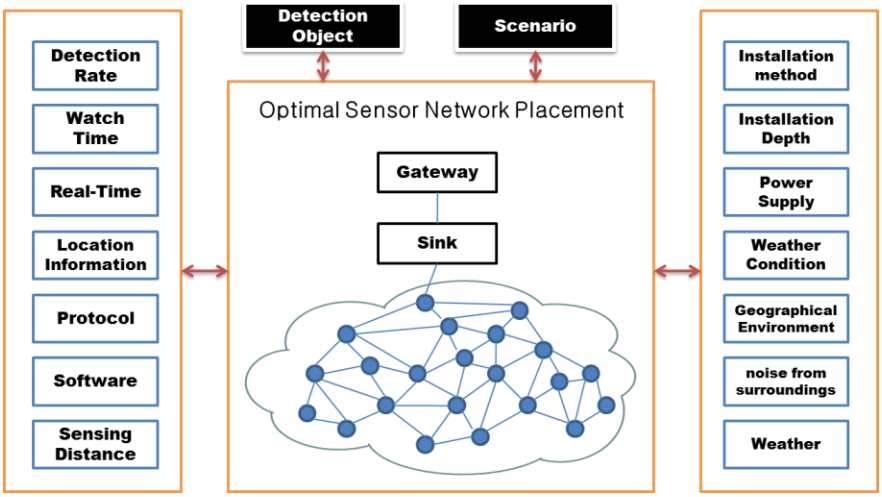

Figure 1. Factors to consider when building wireless sensor network

Thus, the most important thing with watch system is the scenario of how the watch system will be used, and who is the object for watching, and therefore the factors to consider are as shown in Figure 1.

Through the classification shown in the Figure 1, we need to analyze the factors that can be problems when placing wireless sensor node. For this, we have to consider all the factors that raise problems when placing, beginning from hardware related to sensor. Figure 2 shows that static factor is an item that has no change when actually placing sensor node, and dynamic factor is an item that can change.

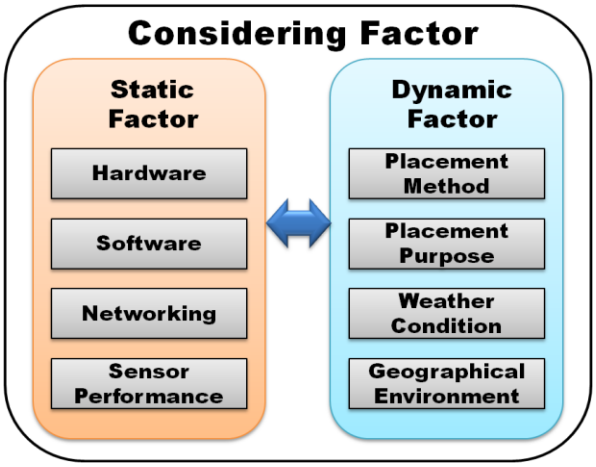

Figure 2. Factors to consider when placing wireless sensor node

Of course, even though the performance of networking and sensor may vary depending on circumstances, we defined static factor, based on sensor's maximum performance. The reason is because these values are changed, depending on dynamic external factors such as placement environment and placement method.

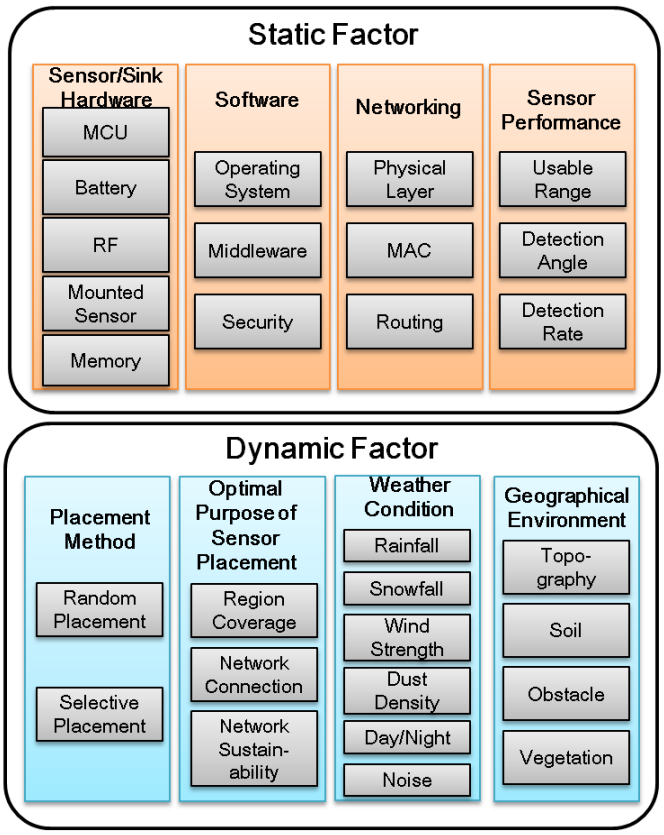

Figure 3. Factors to consider that are classified into static factor and dynamic factor in detail

This study classified in detail these factors into hardware of sensor and sink node, software, networking, placement method, placement purpose, weather condition and geographical environment, as shown in Figure 3. Of course, in addition to this, there may exist other factors to consider according to sensor's type, but we classified most of the factors to consider.

4. Recognition of the factors to consider

This study divided the factors to consider for scenario and detection object into two categories largely. First is the factor for operating sensor network and second one is the factor to consider when building sensor network. The former is the factor about how to operate sensor network according to detection object and scenario, and the latter is the factor about geographical environment or weather condition. We have to precisely analyze and recognize these two kinds of factors.

4.1. Recognition of the factors to consider when operating sensor network

4.1.1. Factors to Consider about Sensor/Sink Node: Sensor/sink node usually consists of MCU (Micro Controller Unit), battery, sensor RF (Radio Frequency), mounted sensor and memory. In this study, we distinguished the factors to consider, by "what is the object for sensing?", "how far is the sensing?", "how long should the watch time be?", as shown in Table 1.

Table 1. Factors to consider about sensor/sink node

Factors to consider	Content
Object for sensing	- sensor node MCU : divided into low and high capacity, depending on the object for sensing - sensor node memory : divided into low and high capacity, depending on the object for sensing - sensor type : sensor type is selected by the object for sensing(sound, vibration, chemical…)
Sensing distance	- sensor node RF : placement status varies, depending on sensor node's sensing ability
Watch time	- sensor node battery : battery selection and duty cycle varies, depending on uses

MCU should be classified according to the kind of sensing object. Since sensor node's performance is continuously upgraded, we will explain it by taking an example. For example, we have to distinguish them, 8~16 bit in case of general sensing data, and 16~32bit in case of high-performance sensing data such as image or video. In addition, we have to classify sensor node memory into 4~10KB in case of general sensing data, and over 64KB in case of high-performance sensing data. Sensor type also should be selected by the object of sensing data. Sensor network has a structure in which many sensors are placed, and in this case, sensor price can be a problem. Thus, sensor should be used by being classified into low/high performance sensor, according to sensing object.

Since sensing distance affects how many sensors should be placed when actually placing sensors, sensing distance also should be considered, and lastly, watch time can vary, depending on sensor node's battery, and even duty cycle should be considered, according to watch period. Here, duty cycle means the ratio of operating time and sleep time, and in other words, the ratio of the time to send wireless signal and the time not to send signal and just sleep. In addition, battery can vary depending on watch purpose and time, thus it can be the factor to consider. In addition to the factors about sensor node, the factors about sink node should be at least the same or higher than sensor node's performance, and duty cycle should be higher than general sensor node.

4.1.1. Network Protocol Stack: It is effective to use ISM (Industrial Scientific and Medical) band in order to avoid confusion made by frequency overlapping in the physical class, and in the data link class, it takes charge of multiplication of data stream, detection of data frame and access to media and error control, and especially in multi home sensor network environment, it is not suitable because of energy consumption and overhead. Therefore, it is more desirable to use FEC method than ARQ method. In addition, MAC protocol function in sensor network includes energy efficiency, self constitution, self maintenance, generating network infra, expandability, dynamic network possible to change, effective resources sharing, reduced conflict, connection based on competition or schedule. The factor causing energy consumption in the sensor itself includes collision, overhearing, idle listening and protocol overhead. If we consider these factors, node's lifespan may prolong, but the time necessary for delivering packet gets longer, and it can be undesirable in case of data, which need fast real-time transmission.

MAC protocol based on competition is a random access method and it consumes much energy, but there are MACA, S-MAC, T-MAC, and PAMAS as a method of avoiding conflict by using RTS/CTS. MAC protocol based on schedule has little

overhead because it does not use RTS/CTS, but it has a weakness that it does not well adjust to the change of additional memory for time scheduling and dynamic sensor network topology. Thus, in case dynamic topology change or fast real-time is required, MAC protocol based on competition such as Adaptive S-MAC, DSMAC is suitable, and if there is no big change after placing sensor node and it does not require sensing data, MAC protocol based on scheduling is suitable.

For watch system, Routing protocol as well as MAC protocol is also one of the factors to consider. The function of routing protocol includes breakdown-proof, energy efficiency, data-centered, integrated data collection, scheduling, address based on attribute, location recognition, providing location information, stability, security function, self-constitution, and dynamic network. Routing protocol can be largely divided into data-centered routing protocol, location-based routing protocol, and clustering-based routing protocol. Data-centered routing protocol lets network know what data it wants when sink node tries to get data, and the protocol getting data includes SPIN, Directed Diffusion, Rumor Routing, and location-based routing protocol means the protocol that routes, by using node's geographical information. If we use location-based technology, routing becomes easy, it can easily adjust to the change of network topology, and there is an advantage that it is ok only if each node just keeps the information of neighbor node, and LAR and GPSR belong to this. In addition, ,clustering-based routing protocol has an advantage that it binds sensor network partially, and selects cluster header among sensor nodes by considering energy. Thus, it has the strength of data overlapping or energy efficiency, and LEACH, TEEN, APTEEN belong to this.

Here we can know that routing protocol has a limitation against the number of network node and network diameter. And, if we intend to use it for detecting and keeping track of transportation means or large scale army, we should consider the protocol that provides location information, has little data overlapping and energy consumption and has reliability. In case of watch system network for long time, the method using GPS may not be necessary in the aspect of power management or other aspects.

4.2. Recognition of the environmental factors such as geographical environment or weather condition

In regard with sensor placement for watch system, it is not determined just by sensor's performance, but by other factors to consider. This study largely classified these factors into three categories such as artificial environment, weather condition and geographical environment, and then recognized them.

4.2.1. Artificial Environment: Artificial environment includes sensor installation method, installation location, installation depth, power supply, noise and jammer. These are listed in Table 2.

Table 2. Artificial Environment

Artificial environment	Content
Installation method	Unmanned aircraft, unmanned vehicle, rainwater path
Installation location	Road, flat land, mountain, riverside
Installation depth	Mud, river bank, snow, water
Power supply	Battery, solar battery, wind generator, electricity
Noise	Sound of animals, birds, fallen leaves, broken branches
Jammer	Road, flat land, mountain, riverside

As shown in the Table 2, we cannot place the rainwater path for the topography difficult to place sensor, we have to place it using unmanned aircraft or unmanned vehicle. Here, if we consider other factors, it is most proper for a man to pace rainwater path to improve sensor's performance, but, in case of placing it by unmanned aircraft or unmanned vehicle, the sensor's performance would be little bit downgraded, and thus, when we place it by unmanned aircraft or vehicle, it may be a more effective method for improving watch system's efficiency, if we place sensors more densely. In addition, the installation location should be considered when placing sensor node because sensor's performance varies depending on installation location, and the installation depth is also one of the factors to consider since sensor's performance is downgraded since the installation depth can be deeper if the soil of the installation location is snow, mud or river bank. In case of power supply, we can think of self-power supplied method when it can affect watch system due to frequent communication error of sensor or sink node or lack of energy.

4.2.2. Geographical Environment: One of the most important things in placing sensor node is geographical environment. It's because how sensor node is distributed and placed is determined, depending on at which place we place it. In regard with this kind of matter, we can recognize it according to geographical environment, as shown in the Table 3.

Table 3. Recognition by geographical environment

Topo-graphy	Characteristics	Factors affecting sensor
Mountain / Forest	Up and down of topography is so serious that communication or detection error can happen if we build sensor field with density the same as flat land	Disturbing visibility. Disturbing sensor node placement. Disturbing communication and detection.
Road	Generally, as a flat topography, it does not affect sensor node placement	In case of city area, noise can disturb it.
Open land	Placing sensor with even density on the whole open land	Movement of big animal can affect sound sensor.
River/ Riverside	Topography has a weak land base and much water, and communication and detection error can happen	Decrease of detection rate (especially vibration / sound sensor), disturbing visibility.

As mentioned in the Table 3, road or open land does not greatly affect sensor's ability, but river/riverside or mountain/forest can greatly affect it, depending on topography. The topography of mountain/forest can be a problem in placing sensor, and we can place it by using another means, and if visibility is not secured, it may become an obstacle against communication or detection. In addition, in case of river/riverside, it has a weak land base and much water, so it can greatly affect vibration or sound sensor's performance. Accordingly, in case we place sensor at mountain/forest topography, it may be a good method to tie it with tree or grass and distribute it, in order to heighten the height of sensor/sink's antenna, and in case of river/riverside, it may be a good method to put sensor in the water-proof container and place its.

4.2.3. Weather Condition: The factor to consider in addition to artificial or geographical environment when actually placing sensor node is weather condition. Weather condition includes rainfall, snowfall, dust density, operating temperature, operating humidity, noise, day/night, and weather, as shown in the Table 4. This kind of weather condition can affect sensor device itself, and can disturb sensor network communication. To solve this problem,

we have to minimize what affects sensor's performance. For this, we explained the affecting factors like this in the Table 4, and then arranged the requirements. These affecting factors need different requirements, depending on country. In the Table 4, we classified them as factors, taking an example of our country.

In the Table 4, we arranged the requirements, due to the effect that weather condition has on sensor network, and the detail is as follows;

- Rainfall: Communication error, fail to secure visibility, sensor's movement or loss can happen. The methods to solve these problems are described in the Table 5.
- Snowfall: Like rainfall, communication error and fail to secure visibility can happen.
- Dust density: In case of dust density, we can classify it into yellow sand and fine dust. By our country's characteristic, the season having the most dust is April, and usually it does not exceed 100 $\mu g/m^3$, and the average is about 60 $\mu g/m^3$. Therefore, we should make it not affect sensor's performance under the general condition of 100 $\mu g/m^3$.
- Operating temperature: Since the operating temperature for general devices ranges between 45~95 degrees, weather or season(spring, summer, fall, winter) does not greatly affect sensor.
- Operating humidity: It does not greatly affect sensor, but if sensor is placed in much humid area, we should place it by using water-proof container.
- Noise: In case of weak noise, it may not be a big problem, but very big noise such as heavy snow, heavy rain and rainstorm can affect much the whole sensors.
- Day/Night: Sensor's detection rate for vibration and sound can increase since sound goes farther in the night
- Weather: On a clear day, sensor can have its fullest performance
- Fog: In case of our country, we can have difficulty in securing visibility since fog frequently happens, and this can affect sensor. Therefore, our country classifies fog strength into low level(1~0.5km), middle level(0.5~0.2km) and high level(below 0.2km), and fog should not cause any problem with sensor's performance, even under the middle level of 0.5~0.2km.

Table 4. Recognition of the factors weather condition affects on sensor network

Weather condition	Factors of effect
Rainfall	In watch system, it should endure even 100mm rainfall in a day
Snowfall	In the much-snow region, it should be provided in the way that the effect on sensor's communication and performance should be minimized through artificial means
Dust density	Usually, even under 100 $\mu g/m^3$, it should not affect sensor's performance.
Operating Temperature	It does not greatly affect sensor.
Operating humidity	It does not greatly affect, but it can be a problem if the place has much humidity.
Noise	It does not greatly affect, but the noise from weather condition can be a problem.
Day/night	Sensor's detection rate for vibration and sound increases since sound goes farther in the night
Weather	On a clear day, sensor can have its fullest performance
Fog	Fog should not greatly affect sensor, even under the middle level of fog among the fog strength levels, which means visibility is 0.5~0.2km

The Table 5 shows some methods that can solve the problems in the Table 4. Actually, there may exist some more solutions, but this study classified them into the ones shown in the Table 5. In addition, as we looked into it in this section, we can know that the environmental factor also greatly affects wireless sensor node, which can be used for watch system, when placing sensor, and thus more studies on the measure to counteract it should follow.

5. Test through the Recognition of Factors when Placing Wireless Sensor Node

5.1. Relation between wireless sensor node and placement environment

As mentioned in the above, there are many factors to consider in order to place wireless sensor nodes. In this section, we will recognize the relation between sensor node and placement environment, in case we place sensors considering these problems.

The most cases of placing sensor node is mainly to watch something, and here, sensor network is used, and for this, we have to place sensors in the way that they can cover the area to be paid attention on. Therefore, we have to place them by recognizing the factors that are to be considered essentially when placing sensors. For this, we have to first recognize the factors related to sensor's sensing range. At this point, the factors accompanying sensor network operation that we reviewed in the above do not become a big problem. The reason is because sensor's specification is decided as sensor device comes, so it cannot be regarded as a central factor to consider. Thus, the essential factors to consider include artificial environment, geographical environment and weather condition.

Table 6. Factors to consider and methods according to environment

Environment	Factors to consider	Methods
Geographical environment	Disturbing visibility	heightens antenna's height, and places sensors by tying with tree or grass for camouflage
	Disturbing sensor node placement	Placement by unmanned aircraft or vehicle, if necessary, mounts the container for absorbing shock
	Disturbing communication/detection	heightens antenna's height, and places sensors by tying with tree or grass for camouflage
Weather condition	Rainfall	Mounted by water-proof container, should resist even 100mm rainfall.
	Snowfall	Mounted by water-proof container, should resist even 20cm snowfall.
	Dust density	Performance should not be affected even under 100 $\mu g/m^3$
	Fog	Manufacturing the sensor, sensor's performance should not to be disturbed even in fog visibility distance 0.5~0.2km

The Table 6 shows the factors and methods about this. In addition, this study expressed the figure of the relation between environment and the factors affecting it, as shown in Figure 4.

This figure is the one that expresses the relation between geographical environment and weather condition, only with vibration, sound and infrared ray sensors among the various sensors, and whichever sensor it is, we have to consider the relation between the central factors, depending on the sensor to be used, as shown in the Figure 4. That is, the factors to consider can vary depending on sensor type, and we have to effectively place sensors by classifying and analyzing the factors that affect coverage when placing sensors, and extracting the most central factors.

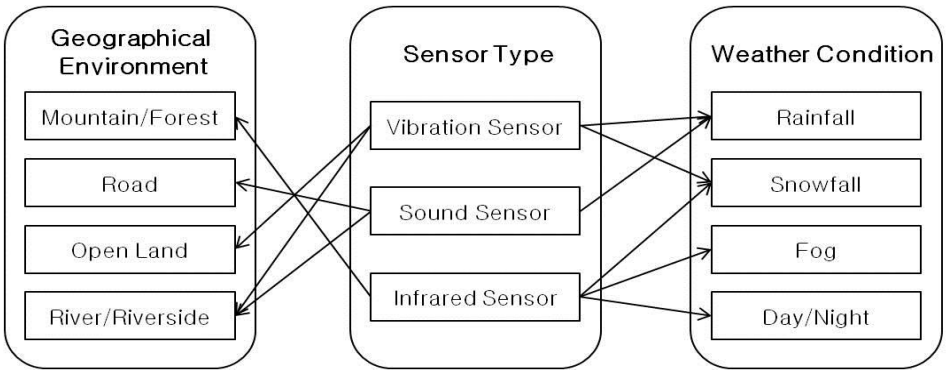

Figure 4. Relation between sensor and environment

5.2. Experiment

This study realized the program that seeks for sensing range, depending on the factors that affect sensors when placing sensors. For test, since we need the placement scenario according to the factors to consider, we made the scenario, as shown in the Table 7.

Table 7. Placement scenario according to the factors to consider

Scenario / Factors to consider	Placement scenario 1	Placement scenario 2
Deploy Environment	Flat land	Riverside
Environmental Noise	No noise	Noise 7
Rainfall Rate	No rainfall	Rainfall 40%
Snowfall Rate	No snow accumulated	No snow accumulated
Line of Sight	Securing line of sight, 5m	Securing line of sight, 3m
Sensor's main activity time	Morning	Midnight
Sensor type	Vibration sensor	Vibration sensor
Sensing range	30m	30m

We can see that sensing range is determined through the scenario presented in the Table 7, and the detection rate is as shown in the Figure 5. The Figure 5 is the case of the placement scenario 1, and we can see that it does not affect sensor's sensing range since the factors don't affect sensor's performance on the whole.

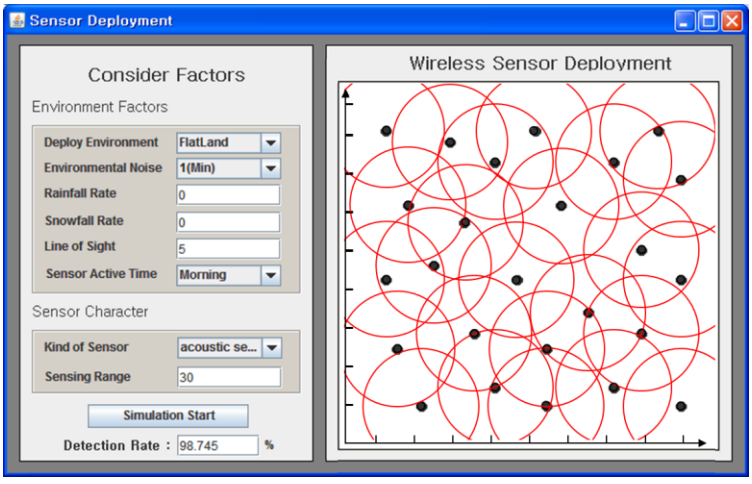

Figure 5. Sensor node placement scenario 1

In case of the Figure 6, it shows the one that applied the placement scenario 2. Like this, this study gave weight to the factors, according to their importance. Through this granted weight, sensing range decreased, and thus detection rate decreased. Though this weight can vary depending on actual sensor's characteristics, we applied the simple formula in the following.

- Sr : sensing range to which environmental factors are applied

$$Sr = \sqrt{2}\, r \times w \times g \quad (\mathrm{r}:\text{sensing range},\ \mathrm{w}:\text{weather},\ \mathrm{g}:\text{geographical type})$$

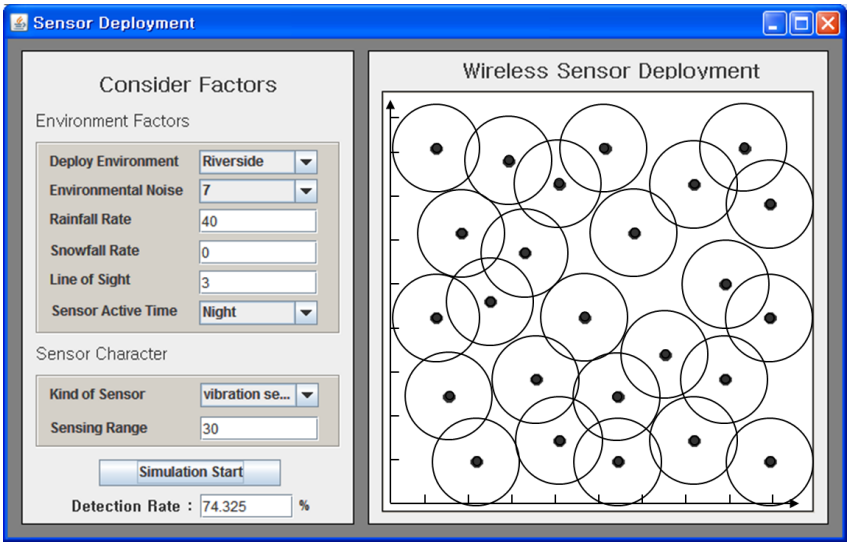

Figure 6. Sensor node placement scenario 2

Table 8 and 9 are classified tables for the experiments in this study. Table 8 shows exponential values of the performance of each sensor according to geographical environment referred to Army Research Lab's "Sensor Characteristics"[2]. The data on the degradation of sensors' performances is exponentiated according to the geographical environment in Table 8 setting the best case of the sensor performance as 100 percent since the exponential values of the actual sensor performance are not fixed.

Table 8. Sensor performance according to the geographical environment

Sensor Type / Geographical Environment	Infrared sensor	Magnetic sensor	Sonic sensor	Vibration sensor
Road	100%	90%	100%	100%
Stream	100%	100%	75%	50%
Mountain	75%	100%	60%	90%
Tree Groove	25%	100%	25%	65%
Urban Area	25%	20%	10%	10%

Table 9 shows four phases of climatic atmosphere which is an influential factor for sensors. The reason why the four phases are divided is that it is difficult to exponentiate or quantify the value of the non-quantified data and information in the case of wide or deep spectrum of the value. Therefore, the climatic environment is divided into several steps according to certain criteria in this study, and these separated items are exponentiated.

Table 9. Amount class according to the climatic environment

Environment / Sort	Rainfall	Snowfall	Dust Density	Fog (Distance of visible)
Large	90mm or above	20mm or above	intensity 2	less than 0.2km
Medium	90~30mm	20cm~5cm	intensity 1	0.5~0.2km
Small	below 30mm	5cm or below	intensity 0	1~0.5km
Weak	little	little	little	little

This study simply experiments the relation between the detection rate and the number of sensor nodes based on the contents suggested above. Figure 7 shows the relation between the number of sensors and the detection rate according to the information of geographical altitude and sensor range considering the experimented geographical and climatic environment in this study. Three cases which are the placement on flats and hills reflecting geographical and climate factors each other, and the placement on hills in cloudy weather. The comparison with previous studies is not performed since the existing studies related to this study did not consider the influential factors on the geographical, climate, altitude, etc. which are considered as the input data in this study. The sensor number for the coverage of each case is different because the sensing range changes according to the climate and geographical factors. In Figure 7, it is confirmed that the detection rate and the sensor number for the coverage of the detection area increase as the geographical and climate factors deteriorate.

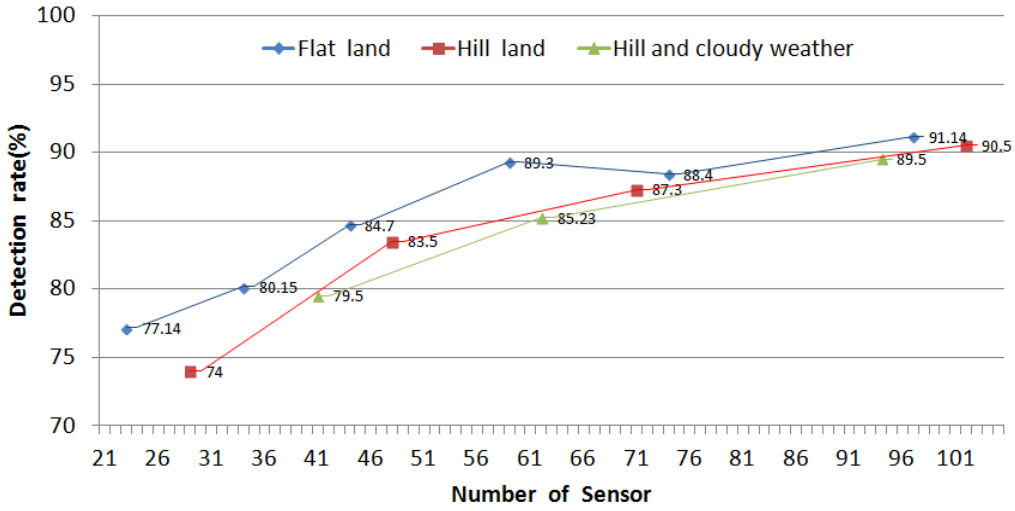

Figure 7. Detection rate considering geography and climate

Besides, as shown in the experiment result, 77.14% detection rate is indicated with 23 sensors in the case of flats but 74% detection rate is shown with 6 more additional sensors in the case of hills. Therefore it will be a better way for the WSN manager to deploy suitable sensors for the application through the appropriate trade-off according to the wireless sensor network's purpose of use

6. Conclusion

Though many studies on sensor network have been made currently, there are a few studies on the factors to consider that can be a problem when actually placing sensor network.

Therefore, this study classified and recognized the factors to consider when placing sensor nodes. These factors are the central items that affect sensor node, and they can paralyze sensor network itself or cause lower performance, depending on sensor node's performance.

This study described the various problems that can happen when placing sensor nodes, and classified them. It also recognized each factor by largely classifying them into sensor node factor and environmental factor, and suggested the solutions.

In addition, it described the relation between sensor node and placement environment, since we have to consider the placement environment when placing sensor nodes in the wireless sensor network, and realized the results and tested them. The future study will draw the exact values by further analyzing the recognized factors. And, it will also do simulation work for detection rate after placing wireless sensor network, by giving the exact weight based on the analysis result of sensor node, and do the research for effectively placing sensors at the actual environment.

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