A New Architecture of Robotic Sensor Networks for Air Quality Monitoring

Ade Silvia, Nyayu Latifah Husni, and Siti Nurmaini

Abstract—In this paper a new architecture of the Robotic Sensor Networks (RSNs) architecture for air quality monitoring is presented, due to air pollution is becoming a major concern for the health of the population. The proposed RSNs architecture uses two direction monitoring processes such as downloading data and uploading data between robots node and static nodes. In RSNs implementation sensor node in very small dimensions therefore the sensor nodes have the limitations both of processor and memory. Hence, the simple algorithm for overcome problem of minimal memory resources is desirable. In the future works there are development research in software and hardware design for supporting proposed RSNs architecture.

Keywords— air quality, architecture, robotic sensor network, static sensor node.

I. INTRODUCTION

NOWDAYS, the sources of air pollution can be from many activities such as industries, transportation, offices, and houses. These activities give the most contribution to the air pollution that releases to the air [1]. The source of pollution can also be contributed by the environmental activities, such as forest burning the explosion of the mountain, poisonous gas, etc. The effects of the air pollution will reduce the air quality that can harm the human health [2], [3], [4]. The reduction of air quality caused by the main pollutants monitored in the atmosphere including ozone (O3), nitrogen oxides (NO2), sulphur dioxide (SO2), carbon monoxide (CO), aromatic compounds and particulate matter. While CO, NO and aromatic compounds are mainly emitted by traffic, O3 and NO2 are originated by photochemical reactions [2]. Therefore to measure the level of air pollution is needed.

Currently, the control and monitoring system for air quality is developed by using sensor networks (SNs). Sensor networks promise to revolutionize sensing in a wide range of application domains because of their reliability, accuracy, flexibility, cost-effectiveness and ease of deployment. Several SNs applications have been described using gas sensors; despite of the youth of these devices, i.e. fire detection [5], chemical processes [6] and air quality monitoring [7]. In environmental monitoring, SNs are deployed to detect what is happening in it [8]. However, they are very limited in reacting to what they detect. On the other hand, if a large area is covered sparsely, the network may not be connected.

There has been a great deal of research on using mobility in SNs to assist in the initial deployment of nodes in air quality monitoring, due to under some conditions of weather and terrain, pollutants are accumulated in a confined area such as in street canyons and create local but intense pollution. In some situation, several target environments are often too dangerous or inaccessible to humans in such environment sensor network with mobile platform can make a significant contribution [9]. It will provide real-time information about the level of air pollution in these regions, as well as provide alerts in cases of drastic change in quality of air. This information can then be used by the authorities to take prompt actions such as evacuating people or sending emergency response team [8].

II. SENSOR NETWORKS ARCHITECTURE

A. Static Sensor

Over the last decade a large number of routing protocols has been designed for achieving energy efficiency in data collecting sensor networks. Applications which uses sensor network are characterized by limited resources in terms of memory, computational power, and energy [10]. In the early days, a typical sensor network was composed of static sensor nodes and a static sink placed inside the observed region. In such a setup, the major energy consumer is the communication module of each node. In practice, multi-hop communication is required for sending data from sources to sink nodes.

Consequently, the energy consumption depends on the communication distance. One way to reduce the communication distance is to deploy multiple static sinks and to program each sensor node such that it routes data to the closest sink. However, a major problem with multiple static sinks is that one has to decide where to deploy them inside the monitored region so that the data relaying load can be balanced amongst the nodes. [11]. But, if assume that location-optimal staticsink deployment, the nodes close to the sink will drain their energy faster.

B. Wireless Sensor

Another approach is to extend thenodeneural sensor network structure using mobile/wireless. In several aspects, this similar to using a static sink-however, using somestatic sensor requires global communication to collect additional all data at a single end point [11]. In the context to overcome the shortcomings of the static sinks, the use of wireless sensors...
been proposed [12]. Wireless sensor can participate in various types of mobility patterns in the sensor field, such as random mobility, predictable/fixed road mobility, or controlled mobility, which has consequences for energy efficiency and data collection strategies.

C. Robotics Sensor Networks

Robotics sensor networks are physical agents that move and interact continuously while embedded in a dynamic environment. As one of the key techniques in the applications of mobile robots, autonomous navigation endows a robot with the capability of reaching expected positions without collisions for executing various tasks, e.g., transportation, surveillance, or exploration. Since the motion performance can strongly affect the task performance, reliable navigation architecture very necessary.

A typical autonomous robot must manage a large array of sensory information to determine its environment. Each sensor provides some input about the world around the robot; that input being incorporated into a knowledge base. From this knowledge base, appropriate rules about actions taken in response to input are generated. These rules allow the robot, to interact with its surroundings in a way that hopefully achieves some goal. However, creating and maintaining these rules, as well as gathering new data for the knowledge base poses significant challenges [13].

Currently RSNs have been widely applied to surveillance or monitoring scenarios. However, only few researchers discuss how to exploit mobility to reduce monitoring cost and if the sensing locations are far apart. Integration mobility in sensor network have been intensively studied in [14]. Other alternative is to use multi mobile robots as data mules to gather the data from the sensors. This approach has indicates two major benefits: The energy require for communication is minimized because the robots can move close to the sensors. This can improve the life-time of the stationary sensors significantly. Second, the robots can collect additional data along the way.

RSNs can be used and act as high-performance mobile node because robots equipped with various sensors and communication capabilities. If a robot can manipulate sensor nodes, that robot can change the range and topology of its SNs according to the communication conditions, sensing and adapting to the environmental situation. RSNs is expected to exhibit robustness superior to that of conventional SNs composed of fixed sensor nodes when sensing environments with remarkably adverse wireless communication conditions and wide ranges. Some research groups have begun to design robotics sensor network and have made some prototypes [9],[15],[16].

Nowadays, innovation of research advances all ow robots to generate the RSNs in low cost and the smaller size [17]. Fortherobot, a common goal is no easy task. This is caused by the constraintsthat come with a reduction in size, cheap sensors, sensor ranges from small, limited computing power, less memory and imprecise movement. Thus, a developed control algorithm for low RSNs raises interesting work. Inexpensive robots usually do not have long-distance communications skills and do not have global information such as the position and heading [8],[17-19].

III. PROPOSED ARCHITECTURE OF ROBOTIC SENSOR NETWORKS (RSNs)

The complete system architecture of a robotics sensor network includes a group of static sensor nodes and mobile sensor nodes, a base station, upper communication network infrastructures and clients as shown in Figure 1. The robots sensors node is in fact an enhanced sensor node. It not only has all the capabilities of the static sensor node, but also realizes mobility by adding a robotic base and a driver board. A base station is used to bridge the sensor network to another network or platform, such as internet.

![Fig 1. Proposed Architecture of Robotic Sensor Networks](image-url)

The proposed architecture can be divided into three layers: nodes layer, web server layer and clients’ layer. The nodes layer consists of all the sensor nodes that can be either static or mobile node. The server layer includes a personal computer or a single board computer for sensors data base. The clients’ layer includes local clients and remote clients.

In the RSNs architecture use multiple channels for wireless control with data processing in two directions for downloading and uploading. Robot Sensor Networks adopted a meanstoreduce the number of sensors needed to reach certain areas, which cannot be recovered by the sensor node. Each sensor node communicate with each other and cooperate to gather data from the environment around, such as temperature, air pressure, humidity and several other air quality parameters. For this purpose, a node is equipped with a sensor equipment used to detect ambient air quality and communication equipment. How to communicate between the sensors is a key issue. In RSNs applications, sensors should have the appropriate hardware modules, so that the sensors have the dimensions of the in processor, memory or wireless. In the future,
the devices of the clients’ layer can be any smart terminals, such as PCs, PDAs, Pocket PCs and smart phones. The data base layer and the client layer communicate with each other and they form a typical example of Internet. Furthermore, smartphones and tablets with Android OS use their components to acquire contexts about air quality monitoring.

IV. CONCLUSION AND FUTURE WORK

This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.

In the future ofthese systems can implement the visual behavior for navigating RSNs in real time. Many interesting future extension is feasible with our current set-up, among others are future these systems can be used in smart cities; the environmental data will provide useful information to citizens. For example, air quality, transportation information, emergency services, and so on. Citizens can access this information via the internet. Future is a vision-based system for environmental classification. This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.

In the future of these systems can implement the visual behavior for navigating RSNs in real time. Many interesting future extension is feasible with our current set-up, among others are future these systems can be used in smart cities; the environmental data will provide useful information to citizens. For example, air quality, transportation information, emergency services, and so on. Citizens can access this information via the internet. Future is a vision-based system for environmental classification. This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.

In the future of these systems can implement the visual behavior for navigating RSNs in real time. Many interesting future extension is feasible with our current set-up, among others are future these systems can be used in smart cities; the environmental data will provide useful information to citizens. For example, air quality, transportation information, emergency services, and so on. Citizens can access this information via the internet. Future is a vision-based system for environmental classification. This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.

In the future of these systems can implement the visual behavior for navigating RSNs in real time. Many interesting future extension is feasible with our current set-up, among others are future these systems can be used in smart cities; the environmental data will provide useful information to citizens. For example, air quality, transportation information, emergency services, and so on. Citizens can access this information via the internet. Future is a vision-based system for environmental classification. This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.

In the future of these systems can implement the visual behavior for navigating RSNs in real time. Many interesting future extension is feasible with our current set-up, among others are future these systems can be used in smart cities; the environmental data will provide useful information to citizens. For example, air quality, transportation information, emergency services, and so on. Citizens can access this information via the internet. Future is a vision-based system for environmental classification. This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.

In the future of these systems can implement the visual behavior for navigating RSNs in real time. Many interesting future extension is feasible with our current set-up, among others are future these systems can be used in smart cities; the environmental data will provide useful information to citizens. For example, air quality, transportation information, emergency services, and so on. Citizens can access this information via the internet. Future is a vision-based system for environmental classification. This paper proposes a new robotic sensor networks architecture. Initial results of RSNS architecture for monitoring environment with mobile platform is presented. Some of the mobile robot was set up as a robotic sensor node as pollution monitoring robot prototype. In the proposed architecture, RSNs node gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. Each sensor node communicate each other and cooperateto gathering data from the environment around, such as temperature, air pressure, humidity and severelother airquality parameters.