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Low Energy Consumption Sensor Node Leaping Mechanism

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According to USGS, we suffer from the earthquake of the scale of magnitude 3 to more, average 5,110 times for a year in Japan. It is the same as that of the earthquake has occurred about 14 times for a day. The biggest earthquake is the Tohoku earthquake occurred in May, 2011 in Japan. Its scale of magnitude was 9.0. This is a scale of the fourth largest earthquakes in the world since 2004. The earthquake caused the damage such as seismic sea wave, liquefaction phenomenon and building collapse. The number of the dead and missing person has gone up to about 20,000 people in total. So the establishment of disaster prevention and the life rescue system to such a city type disaster are very aspired.

With recent advances in electronics and communication technologies, there has been increasing interest in wireless sensor networks in a variety of applications such as environmental or habitat monitoring. One of the most important issues that can be raised in such applications is how to cover an area as large as possible while maintaining network connectivity. Since sensor nodes can be scattered in an area from an aircraft, their self-relocation strategies must accompany initial node distribution to enhance network connectivity and area coverage. Regarding the self-relocation issue, most researches done to date have focused on developing scalable distributed algorithms for computing target locations, but the nodes were unrealistically assumed to have unlimited energy resources. In practice, energy consumption caused by node movement accounts for a significant portion of battery lifetime. Considering such practical limitations, in this work, we attempt to propose a new omni-direction mobility design that can minimize node energy consumption.

Recently, node mobility has been gaining increasing attention. To extend the lifetime of a heterogeneous mobile sensor network, a mobile relay strategy is proposed, enabling mobile sensors to help relieve static sensors with burden by high network traffic. To minimize energy consumption for surveillance and data transmission, a minimal energy path planning method is presented. Meanwhile, various prototypes have been developed for mobile sensor networks such as omni-ball, evacuation robot, jumping robot and so on. Specifically, there exist some notable leaping mechanisms inspired by spring-tail, locust, or flea to move at a low energetic cost and jump relatively large obstacles. In spite of impressive leaping performance, their complicated structure and bulky size are difficult to be used for tiny wireless sensor nodes.

The main purpose of this work is to present our design of a new instantaneous mobility mechanism well suited for tiny wireless sensor nodes. Toward enhancing coverage and connectivity from initial random distributions of sensor nodes, we propose a novel one-time-use spring-powered leaping mechanism that utilizes the ground reaction force generated when selectively releasing multiple actuators mounted underneath individual sensor nodes. One significant advantage is to minimize the amount of energy required for relocation and deployment by the proposed robotic leaper. It is the most important aspect from a practical point of view is how to control the leaping distance and direction in order to improve the capability of fixed sensor networks.

This paper presents the design, performance analysis, and preliminary implementation of a one-time-use leaping mechanism for energy-saving sensor node relocation, resulting in larger coverage and higher connectivity in wireless sensor networks. It is known to be challenging and difficult to achieve controllable mobility management for energy-constrained sensor nodes that ensures an autonomous, robust, and dependable relocation even in adverse environmental conditions. It is important to develop a simple yet efficient omni-directional mobility system with the minimum amount of energy required. We propose a new leaping actuating system that utilizes the ground reaction force generated when releasing selectively multiple pre-compressed springs mounted underneath the sensor node. In this paper, we investigate through simulations and experiments the technical features of our working prototype whose distance and direction are finitely controllable.