学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Study on Monitoring System for Forest Fires Based on Wireless Sensor Networks
（センサネットワークを用いた森林火災監視システムに関する研究）

Indonesia has been suffered from forest fires. The recent fires in logger-over forest, peatland, and plantation should be classified into one of human-made disasters. In recent years, fires in Indonesia occurred mainly in peatland area and become one of international serious issues due to haze and CO2 emission. One strategy to detection and monitor peat-forest fires in Central Kalimantan, Indonesia is to use a WSNs technology, which contains miniature sensor nodes to collect environmental data such as temperature, relative humidity, light and barometric pressure, and to transmit more accurate information to fire-fighter and remote monitor. In this study, in order to get real-time monitoring data of peat-forest fires, we develop the integration system of the WSN data used for the ground sensing with video surveillance data obtained from an unmanned aerial vehicle (UAV), which is used for ground verification of satellite data in large peat forest areas. In data processing of WSN in collaboration with UAV work, the most important issue is to allow quick responses in order to minimize the scale of the peat-forest fires.

We develop a forest-fire monitoring system using wireless sensor network and the UAV. This system allows us to detect small fires which cannot be detected by the satellite especially under the dense smoke conditions. The developed system uses WSN containing the smart sensors to collect environment data such as temperature, humidity, and barometric pressure, and to deliver useful information to fire-fighter or remote monitors. When the WSN finds the symptoms of wild fires, UAV flies to the potential fire for verification. It is found that artificial small fires can be detected by the present system.

In WSN deployment, sensor nodes randomly placed into the target area. In forest, reliable communication in a dense or sparse environment is very important. Wireless sensor nodes must be able to effectively communicate data back to the base station. While battery power is limited and may not be rechargeable, wireless sensor nodes however can be equipped with a secondary power source such as solar cells. In any case, it is important for sensor nodes to save energy as much as possible.

For monitoring and detect using WSN technology, energy can be conserved with multi-hop optimal routing, short transmission range, in-network data aggregation, eliminating data redundancy, minimizing delays, and using low duty-cycle. To maximize the lifetime of the energy-constrained WSNs, communication protocols such as LEACH and HEED have been developed in which the cluster heads are autonomously selected to share the energy loss in the sensor nodes. In this study, we develop optimization method for WSNs which have long lifetime. To save the communication energy, the routers are optimally deployed to minimize the communication distances between the router nodes and sensors. The sensors are assumed to be randomly deployed to have wide coverage. We use genetic algorithm and simulated annealing for the optimization. We take the obstacles due to elevation differ-

ences into consideration in the optimization. Moreover, we consider the attenuation of electromagnetic waves in the forest. To compute the attenuation constant, we compute homogenized permittivity from the measured complex permittivity of tree trunks and basal area. It is shown that the horizontally polarized electromagnetic waves has smaller attenuation than the vertically polarized waves. We can know the necessary number of routers to have complete connections of sensors from the optimization results. Moreover, we can make optimal design of WSN topology for any vegetation and topography using the present method.