ABSTRACT

A Visual Sensor Network (VSN) is a distributed system which is formed by combining many camera sensor nodes. The main components of a node are image sensor, embedded processor, wireless transceiver and energy supply. The major difference between a VSN and an ordinary sensor network is that a VSN generates two dimensional image data. VSNs can be deployed in many application areas like environmental monitoring, surveillance, traffic monitoring and industrial automation. In comparison to scalar sensor networks, the VSNs generate large amount of data. Therefore, they require more resources to process and communicate this data.

This research focuses on the modelling, optimization and design of VSNs for sky surveillance applications. A taxonomy is developed to facilitate the design and classification of surveillance systems. It is based on behavioural, implementation, and actuation models. A number of surveillance systems were studied and analyzed on the basis of this taxonomy. The analysis proves the robustness of taxonomy. The taxonomy can be used as a tool for optimizing the design of surveillance systems which can results in reduced design efforts, implementation cost, and development time. An example case study of monitoring the eagles in wind parks is analyzed by using this taxonomy and solution space is explored to design a volumetric surveillance system for collision avoidance of eagles with wind mills.

To implement the VSN for eagle surveillance system, two solutions are considered. In the first option, a VSN is designed to monitor a wind park area by considering it as a single entity. In the second option, the wind park area is divided into two areas: an outer ring area and the inner area. A VSN in the form of a tighter guard ring is designed for the surveillance of outer area and a relaxed VSN is designed for inner area. A VSN can be implemented by homogeneous design or heterogeneous design. The homogeneous VSN uses similar camera nodes while the heterogeneous VSN uses different types of nodes for different altitude layers.

The design phases of a VSN model are presented which can be deployed to provide the surveillance solution for an area. The model explores a number of VSN design parameters like camera sensors type and its properties, optics, lower and higher monitoring altitudes, distance between monitoring nodes. When all these parameters are combined together in an optimized way they form a VSN which is able to fulfil a particular objective. The objective can be to detect, monitor or track an object. The VSN designed here is applied to monitor the movement of large objects in a wide area, such as eagles in the sky. The area to be covered is increased by increasing or decreasing the higher or lower monitoring altitudes, respectively. As the surveillance area is increased, the implementation cost of a VSN is also increased. However, the desired objective is opposite to that. The aim is to increase the surveillance area at a decreased implementation cost. To fulfil this objective, optimization

techniques were developed which result in a heterogeneous VSN design. The techniques were applied to a particular case study. The analysis and evaluation of the results showed about 87% reduction in the implementation cost. The VSN models and optimization techniques are experimentally verified with actual cameras and optics.