ABSTRACT

Recent advances in data gathering and analysis, through sensors, are opening up new avenues for smart building technology. Smart buildings have brought structures and technology together. During their lifetime, structural buildings are prone to several kinds of damages. These damages will lead to deterioration of the entire building. Manual inspection is time-consuming in structures like bridges, which runs for several miles and the labor burdens are extremely more. Timely rehabilitation of the buildings is essential to save both human lives and assets. Structural Health Monitoring (SHM) has the capability to monitor and anticipate the events that may affect the health of the buildings. The health of the building is periodically monitored or when events like the earthquake, fire, etc., occurs. In the proposed research work, sensors measure the physical parameters, such as, temperature, corrosion, etc. which induce cracking, in the structural element, namely, column and transmit this information to the Remote Monitoring System (RMS) through the Cluster Heads (CH) for analysis. During the data transmission, congestion occurrence is avoided by selection of optimal CH using a soft computing approach of Biogeography-Based Krill Herd (BBKH) by considering the distance between the nodes, fairness index of the flows and the buffer occupancy level of CH. From the information collected at the RMS, the severity level of the cracks is classified into fine, moderate and severe crack by using the soft computing approach, namely, Fuzzy Cognitive Map (FCM). Based on the severity level, maintenance is initiated by the structural engineers.

The structural element, column is chosen for study, as the column has to bear the complete load from the upper layers and transfer the load to the structures below it. Hence, it is better to avoid column cracks. If column cracks are not attended, the entire building will collapse and the loss of human life and property would be high. Wireless Sensor Nodes (WSN) are deployed in the

buildings to collect the information about several physical parameters which induces crack formation in columns. The sensors consume energy for data transmission. As sensor nodes are battery powered, once deployed they cannot be recharged or replaced throughout their lifetime. Hence, energy efficiency is an important criterion to be considered.

Different physical parameters are measured at different intervals of time. Temperature, which causes cracks, is measured throughout the day. Corrosion and chloride attack in buildings are measured once in thirty days. In a particular location of the column, if the measured value is more than the threshold value, it is transmitted by the sensor nodes for making decisions, instead of transmitting all the sensed data. By this, the energy expenditure by the sensor nodes could be reduced. If the threshold level is reached, the rate of monitoring is increased to gather more data to make accurate decisions about the building condition. Hence, increased packet flow is noticed. Due to the sudden burst of threshold based data transmission from a particular location where a damage, such as corrosion has initiated, congestion is possible in that part of the sensor network. Mitigation of congestion occurrence during data transmission is essential, as uncontrolled congestion will lead to packet drop, followed by retransmission of lost packets. Retransmission increases the energy usage. The proposed research work employs BBKH for improving the lifetime of the sensor network by transmitting only the threshold-based data and mitigating the congestion occurrence during data forwarding by selecting optimal CH.

As the distance between the nodes increases, the energy consumed for data transmission also increases. In this proposed module, apart from congestion mitigation, the distance between the sensor nodes is also considered as a factor to further improve the energy efficiency of the nodes. Using the soft computing approach BBKH, clusters are formed by selecting optimal CH, such that the distance between the different sensor nodes and the remote monitoring system are less. Due to the reduced distance traveled by the data together with congestion mitigation technique, the energy consumption of the sensor nodes is reduced and the network lifetime is hence increased.

Data transmitted by different sensor nodes is aggregated at the CH and then transmitted to RMS. At the remote monitoring system, a soft computing approach, namely, Fuzzy Cognitive Map (FCM) is used to categorize the crack severity level based on the values received from the sensor nodes. Using FCM, the factors causing cracks and the influence of each factor on crack formation is modeled by collecting the expert knowledge. By using the FCM model formed, the severity level of the cracks is predicted. To improve the learning capabilities of FCM further, the supervised learning approach, namely, Data Driven Non-Linear Hebbian Learning (DD-NHL) and the unsupervised method, namely, Non-Linear Hebbian Learning (NHL) is used to classify the severity level of cracks. The results of DD-NHL are compared with classical machine learning algorithms. The proposed module helps structural engineers to know the severity level of the cracks, so that they can initiate the rehabilitation at the right time, in order to avoid structural collapse.