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Monitoring industrial facilities using principles of integration of fiber classifier and local sensor networks

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Increased complexity of the engineering structures, higher human impact on the natural environment inevitably lead to the growing number of natural emergencies and technogenic disasters. One of the most effective ways to solve this problem is to create a system for continuous monitoring of the potentially dangerous objects. Analysis of changes in the structures, ground and communications allows proper assessment of possible emergencies at any time point.

As a part of this work, we have discussed the experience of creating the integrated monitoring systems used to control the hazardous industrial facilities with significant extent. These objects include railways, pipelines, communications systems, bridges and tunnels.

In the recent years, in order to conduct monitoring of the extended objects, method based on use of optical fiber has been widely used. This method relies on a property of high vibration sensitivity of infrared radiation propagating in the optical fiber. The fiber is placed next to the controlled object. A semiconductor low-power laser is used as a source of coherent radiation. This sensor can be considered in monitoring tasks as a spatially-continuous receiver of seismoacoustic signals. However, based on our experience, we are convinced that use of fiber optic sensor only does not provide the required functional completeness.

Practical tasks of industrial monitoring require a monitoring system to provide simultaneous solution of the following tasks: 1) monitoring the condition of the local areas, including structural elements, soils, and grounds; and 2) monitoring the condition of extended objects and classification of the external disturbances. The first task group is to be solved by applying a set of discrete sensors. The second group requires application of spatially-extended sensors which may include optical fiber. With these requirements in mind, studies aimed to integrate fiber classifier and local segments of sensor networks into a single system, have been conducted.

In this system, the optical fiber is used for solving the technological traffic monitoring problem, the condition of the railroad bed. The sensors included in the network allow monitoring the condition of structures designed to protect the railway from falling rocks and landslides. The integrated monitoring system provides for proper control over the road section up to forty kilometers long. The system’s structure includes fiber optic cable, a group of segments of the sensor network attached thereto, and a single control center that hosts the radiation source, the receiver of the reflected optical signals, and networks' control device. Number of the connected sensor networks is not restricted by the optical fiber which in this case acts as a parallel communication channel. The number of connected sensor networks has no restrictions imposed on the optical fiber, which in this case plays the role of a parallel link.

As a result of the conducted research, the architecture of integrated monitoring system was developed, fiber–optic classifier has been designed and tested, sensor networks including vibration, breakage, shock, decline sensors, have been created and tested. The study of algorithms for multimodal classifier for object condition monitoring was also performed. The study has confirmed feasibility of the predictive (adaptive) monitoring. This allows increasing frequency of information retrieval in the periods when observed structures experience the highest external impacts. Furthermore, measurement frequency control can also be performed depending on the seismic activity or due to the existing climatic factors. In natural conditions, assessment of an object’s condition can be done 1 - 2 times a day. In the face of ever increasing external perturbations, such assessment may be generated 1 - 2 times per minute and even more often. This may significantly increase the effectiveness of the monitoring system and, at the same time, reduce the operational costs thereof.