APPLICATION OF FORWARD ERROR CORRECTION (FEC) CODES IN WIRELESS ACOUSTIC EMISSION STRUCTURAL HEALTH MONITORING ON RAILWAY INFRASTRUCTURES

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Recently, the transport industry has moved away from metal parts in vehicle bodies, rather employing composite materials due to their properties such as increased strenght, higher stiffness and reduced weight. However, these materials – similarly to metal materials – must be monitored to ensure they are not subject to extreme fatigue or that failures are not imminent. In this context, Structural Health Monitoring (SHM) has been extensively used in the railway industry, with applications ranging from railway infrastructures to carbody shells.

SHM is a technique aiming able to monitor infrastructure and provide predictions regarding fatigue life. SHM acts by sending waves from sources ranging from acoustic, thermal, or electromagnetic, among others. These methods comprise different implementations and sensors, and it is, therefore, crucial to study them and have a deep understanding of their functions.

Within CARBODIN, SHM is analysed in relation to its abilities to identify potential cracks or disjoint parts.

An excellent method for performing SHM is acoustic emission (AE), which can be utilised for real-time damage detection via monitoring. AE is essentially the generation of elastic waves due to the release of energy from a localised source within a material composing a structure. Among the main features of AE, it is possible to identify the capability of real-time monitoring, the high sensitivity in sensing, its global monitoring abilities, its capability of source location, the high sensitivity to any mechanism that produces stress waves, and its passive nature, since the energy from the source is encapsulated.

SHM using AE could comprise monitoring the entire state of a structure using an array of sensors and assessing their parameters. Moreover, monitoring of a single location in a structure can be conducted, such as the growth of a crack in a specific part of the structure, using one or a plethora of sensors. For the correct SHM of the carbody, the acquisition of data from AE sensors is of utmost importance since the data is continuous and need to be transferred to a dedicated server.

Wireless communications have emerged in the field of the SHM and AE in order to transmit and forward the data to a terminal computer. In particular, wireless sensor networks (WSN)s and their successors, namely the Internet of Things (IoT), have been assigned a vital role in the next generation of SHM.

In addition, thanks to 5G, a large volume of data can be exchanged with low latency at a low energy cost. However, errors in the transmission due to noisy channels may still be experienced, and because of these the SHM system may result in the wrong detection of a potential defect in a railway infrastructure with dangerous consequences, such as derailment.

To avoid this outcome, methods for adequately dealing with these errors need to be established, such as Forward Error Correction (FEC) codes. Through FEC codes, the data sender adds an Error-Correcting Code (ECC) to the original data, allowing the receiver to detect and correct a limited number of errors in a noisy channel. In this paper, the authors suggest the use of the wireless FEC codes applied to a number of deployed AE devices on a 5G network, in order to perform correction at the transmissions.

After describing the application of FEC codes, the researchers investigated the new POLAR codes and compared this method with the Reed-Solomon (RS) codes.

After a comparative analysis based on metrics such as the Bit-Error Rate (BER), Frame-Error-Rate (FER), and throughput, the researchers conclude that the POLAR codes produce smaller BER and FER with the increase of the signal-to-noise ratio (SNR) value in simulation and higher throughput, which makes them better for the application in SHM of train car bodies. These findings are promising as they set the basis for future research on SHM, opening the way to the possibility of detecting defects – and improve railway safety – through innovative systems.

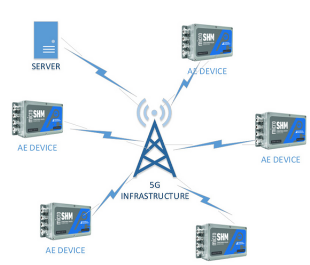

Fig. 1. Telecommunication configuration.

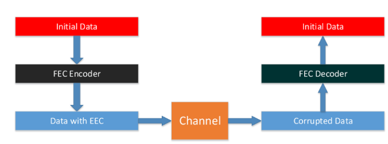

Fig. 2. FEC scheme

Link to the entire paper.

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