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LABORATOIRE ÉLECTRONIQUE, SYSTÈMES DE COMMUNICATION ET MICROSYSTÈMES

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Traffic/load sensors and data-driven structural health monitoring

Machine learning algorithms are nowadays available to exploit the huge amount of data continuously acquired through sensor networks, and to solve inverse problems. Challenging engineering issues, like structural health monitoring (SHM) or load identification, are currently linked to Big Data, consisting of structural vibration recordings shaped as multivariate time series. The aforementioned algorithms should therefore allow an effective dimensionality reduction, to retain the informative content of data, and infer correlations within and across time series. Within this framework, AutoEncoders may employ inception modules and residual learning, and a latent representation specifically adapted to tackle identification tasks.
Besides issues linked to the architecture of the neural network, the setting of the network hyperparameters and the fine tuning of the network weights, the quality of the dataset upon which the SMH algorithms provides the classification or inference task is a crux. This is basically linked to the fact that deceptive information is linked to load and environmental variability. The possibility offered by hybrid model-based and data-driven approaches or by the so-called physic-informed neural networks can be exploited to bring into the SHM monitoring additional information collected, e.g. through load sensors used to monitor/measure the traffic loads on an infrastructure.
We aim to develop a traffic/load sensor to be buried inside or under the road pavement, able to sustain the heavy loads featured by the installation process and to also all the seasonal temperature and humidity variations. It has to provide meaningful information concerning the traffic load and must bring information into the network with a minimum power consumption. Eventually, energy harvesting exploiting the structural vibrations and also the oscillations in the load amplitude, can be foreseen to extend the sensor lifetime.

The research proposed will be carried out within the International Associated Laboratory (LIA) SensIN-CT which brings together Université G. Eiffel and Politecnico Milano. It will be supervised by a team common to the two universities. On the French side, it is plan to develop battery-less RFID (Radio-Frequency Identification) tags including temperature and humidity sensors in the road pavement. The objective is to interrogate a set of RFID tags buried in the road with hand held readers. The two technological outcomes for the design are 1/ the electromagnetic characterization of the road pavement (bitumen) to estimate the attenuation of radio waves and the detuning of the tag antenna 2/ the proper design of the antenna with respect to this knowledge and an estimation of the maximum depth of the tags inside the road for a correct reading. The skills required are a minimum of background in electromagnetics (wave propagation) et and in basic electronics.

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