State-Of-The-Art of Research on Distributed Optical Fibre Sensors

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Optical fibres offer the possibility to realize distributed sensing, which means that each point along the fibre can separately and selectively sense quantities such as temperature, strain, acoustics, and pressure, in total similarity to a real organic nerve. The fibre can therefore distinctively inform on the position of the stimulus and on its magnitude. This unique feature makes the optical fibre actually play two essential roles: linear sensing element transducing the quantity value into an optical modulation and transmission line to convey this optical information to the processing unit at the fibre end.

Distributed optical fibre sensors have today demonstrated their capability to measure quantities such as deformation and temperature over tens of km with an excellent accuracy, essentially thanks to the extreme transparency of the glass fibres. Using the most advanced nonlinear interactions, up to 1’000’000 distinct sensing points can be resolved along a single optical fibre, meaning that a quantity can be selectively measured each 10 cm over some 100km, or each millimetre over 1km. This makes the proposed concept of a fibre optic sensing nerve possible, either by monitoring a large distance, area or an entire facility remotely controlled from a safe place, or by densely innerving a tool or a structure to make it as selectively sensitive as the human skin.

We shall review the physical principles underlying the different distributed fibre sensing configurations, essentially based on the 3 natural scatterings present in silica fibres: Rayleigh, Raman and Brillouin scatterings. This will be illustrated by examples of real sensing and by some exemplary implementations. Focus will be placed on the fundamentals and the concepts, highlighting the crucial advantages and the perspectives for space applications.