StUdy of fibre oPtic sEnsor aRrays for structuraL heAlth moniToring based on guIded waVEs (SUPERLATIVE)

Description for the general public

A stone dropped in water leads to ripples (small waves) on the water surface which move in the shape of a circle with the location where the stone was dropped in the center. These ripples continue along the surface of the water and reduce in strength before disappearing completely. If the ripples encounter a branch or edge of pond on their path, some of the waves get reflected and for another circular shape with the discontinuity at the center going radially outwards. Similar phenomenon can be generated in solid plates but on a smaller scale. Similar patterns are seen of the propagating waves. The reflections of the waves from the discontinuities can be measured and processed in order to determine the location of the discontinuities. Although in water the branch or edge of the pond are harmless discontinuities in structures the discontinuities may be cracks or other damage in the structure. A small crack or damage in an airplane wing may lead to catastrophic accident hence it is of utmost importance to check the structure regularly for cracks, detect the crack and locate them so that they can be fixed.

For this purpose airplanes and other critical structures are instrumented with sensors. The sensors convey the condition of the structure regularly. The assessment of the condition of the structure using the travelling waves is known as guided waves (GW) based structural health monitoring (SHM). Traditionally the sensors for generating and measuring these waves has been using piezo-ceramic sensors. They are special materials which convert electrical signal to mechanical signal or mechanical signal to electrical signal. These sensors need additional wires and may not be use in conditions of lightning without protection. Also the additional wires add weight to the system. In recent years optical fibre sensors have been used for the same purpose. The optical fibres are sensors as thin as hair and are very light. They do not need additional wires and hence are easy to deploy. The fibres can be considered as pipes for light. They can be made be made selectively reflective on only some frequencies and by studying the reflected waves they can be used as sensors.

The fibres are attached to the structure at few locations with glue or tape. When the wave in the structure encounters the glue/tape, part of the wave is reflected (like from the branch in water), and part of the wave continues along the structure while some is transferred to the fibre and transmitted in both directions (forward and backward) along the fibre. Although this effect of transmitting the wave is useful for measurement of the waves, it is also a problem for processing the data from the sensors as the waves measured may be from any location where the fibre is attached to the structure. Also the portion of the wave incident which gets transferred to the fibre is dependent on the angle of the fibre with the incident wave (directionality). Hence for processing the information from the fibre sensors this phenomena needs to be taken into consideration. Also the amount of energy that is transferred from the sample to the fibre also is dependent on the type of glue, length of the gluing area as well as the sample and fibre material. The study of this phenomena and to incorporate this effect in the processing of damage detection is the main aim of the project. The studies will be done through experiments as well as computer simulations.

The knowledge gained from these studies will be used for processing and developing a method for damage detection with fibre optic sensors. The existing techniques for the processing of the wave data will be improved for the specific application. The compensation of the effects will be done through innovative setups of the sensors as well as through use of signal processing tools.

Once the damage detection technique is developed, in order to improve the performance of the method even further the locations of the sensor placement will be optimized. For the decision on the best locations for the sensor placement the directional nature of the fibre optic sensors as well as other restrictions imposed by the use of sensors need to be considered. The implementation of the optimization algorithm needs special attention so that the real conditions for the sensor placement in location and orientation are realistically represented.

The work within the project is on the methodology level and may find applications in several applications including airplanes, wind turbines, automobiles etc. and make these inventions of everyday use safer and more reliable.