Guided waves based reference-free structural health monitoring using fiber Bragg grating sensors (REF-FREE)
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). In recent years optical fibre sensors have been used for GW receiving. 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.

Traditionally the damage is detected by comparing the measurements with the measurements carried out when the structure is healthy. But the healthy measurements are not always available or are measured at completely different environmental conditions and hence cannot be compare. In order to overcome this, a method which does not need the healthy measurements is needed and is the main aim of the proposed project. Three different approaches will be used to achieve this aim. Firstly, a new kind of sensor which allows separation of the two different waves will be used. The separation of the two modes has the potential to allow reference-free damage detection. The other approach is by comparing measurements conducted at the same time. The measurements will be all adjusted to be measured in similar conditions (such as distance from the sensor, angle of the sensor) and then compared with each other. If one of the signals contains damage information it will be different from the other measurements. The difference between the measurements can be measured and used for damage detection without information on the healthy structure. The third approach will be through using a very special feature of the optical fiber sensors called self-referencing. This ability allows the sensor to compare the information of the waves from two locations at the same time. If the condition at the two locations is same, the results will be similar. If the conditions at two points is different the measurements will show the difference which can be used to detect the damage. The three methods work in parallel. In order to make their best possible use they need to be combined in a proper way. Also the quality of the results obtained by the new method can be further improved by placing the sensors at the correct locations. The correct location is determined by the results from the three approaches.

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.