Inverse Problems Network Meeting 4

Thursday, 17th January 2019 - Friday, 18th January 2019

Mall Room, Level 8 of the School of Mathematics, University of Leeds

Abstract of Talk

INVERSE PROBLEMS IN MANUFACTURING, ROBOTICS, AND THE NUCLEAR INDUSTRY

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I will discuss an inverse problem whose input arises from an array of sensors, whose goal is to reconstruct a spatial map of some material property within a domain, and whose purpose is to reduce the uncertainty in some measurement. I will discuss two application areas that at first sight might appear to be unconnected but the underlying problem and the method of solution are in fact common. The first application area is in the nondestructive imaging and measurement of flaws in safety critical structures such as those found in the nuclear industry. Traditional imaging algorithms within ultrasonic non-destructive testing (the dominant sensing modality in this area by far) typically assume that the material being inspected is homogeneous. Often the medium is in fact spatially heterogeneous and this leads to poor detection, sizing and characterisation of defects. I will discuss our recent work which reconstructs the inhomogeneous wave speed maps of random media from ultrasonic phased array data. This is achieved via application of the reversible-jump Markov chain Monte Carlo method to a Fullwave Inversion methodology. The inverted maps are used in conjunction with an imaging algorithm to correct for deviations in the wave speed, and the reconstructed flaw images are then used to quantitatively assess the success of this methodology. I will also show how this approach can be used to optimise the design of a new component at the manufacturing stage such that it maximises the ability thereafter to test this component non-destructively for the presence of any flaws. In a second application area I will describe how modern manufacturing increasingly utilizes automated systems for component positioning and assembly. A vital aspect of autonomous precision manufacturing is large volume metrology (so a local GPS system for robots if you prefer). One popular approach uses light rays, which travel through the volume of air, to calculate the position of an object of interest. These optical-based metrology systems such as photogrammetry and laser tracking are crucial in improving the accuracy and quality associated with robotic assembly. In an industrial setting these positional measurement systems give rise to uncertainties which can in many instances be greater than the required tolerances. One source of this uncertainty is light refraction due (in part) to temperature fluctuations in the air. The inverse problem associated with using light-based sensor data to reconstruct the refractive index map in the spatial domain volume can then be tackled using a similar methodology as above. I will show how this reduces the measurement uncertainty and facilitates the use of these light based systems in assisting robotic manufacturing.