Radio-frequency atomic magnetometer for defect detection and object surveillance

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Instruments based on radio-frequency inductive technologies (Magnetic Induction Tomography) create an exciting alternative to standard defect detection and object surveillance methods, e.g. ultrasound, infra-red or visible imaging. The rf atomic magnetometer brings superior sensitivity to inductive measurements, in addition to a range of functionalities; the ability for vectorial rf field measurement, a high bandwidth when operated in the self-oscillating (spin maser) mode, and tunability over a wide frequency range without compromising performance.

The inductive response of an object to an oscillating magnetic field reveals information about its electrical conductivity and magnetic permeability. We demonstrate that it is possible to determine the object's composition by measuring the angular, frequency, and spatial dependence of the inductive response. Identification is performed by referencing the object's response to that from materials with mutually exclusive properties such as copper (high electric conductivity, negligible magnetic permeability) and ferrite (opposite). This technique uses the difference in object response generated by eddy currents and magnetisation. Possible applications of the technique in security screening devices are discussed.

Additionally, we will explore the benefits of combining properties of the atomic magnetometer (e.g. the presence of an insensitive axis with the ability of vector field measurement and the symmetry of the primary radio-frequency field) to enhance this inductive imaging technique in both the free running (external drive for the radio-frequency field) and in the spin maser mode.

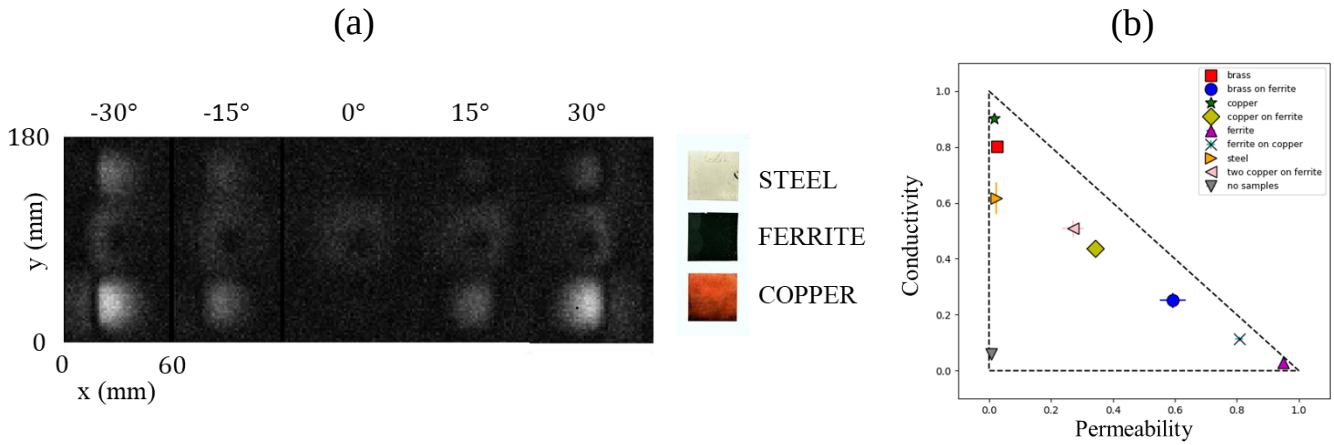

Figure 1: (a) Images of three different material types recorded via Magnetic Induction Tomography indicating a different angular response. (b) Determination of material type by analysing angular scans using machine learning techniques.