Radio Frequency Tomography for Remote and Close-In Sensing

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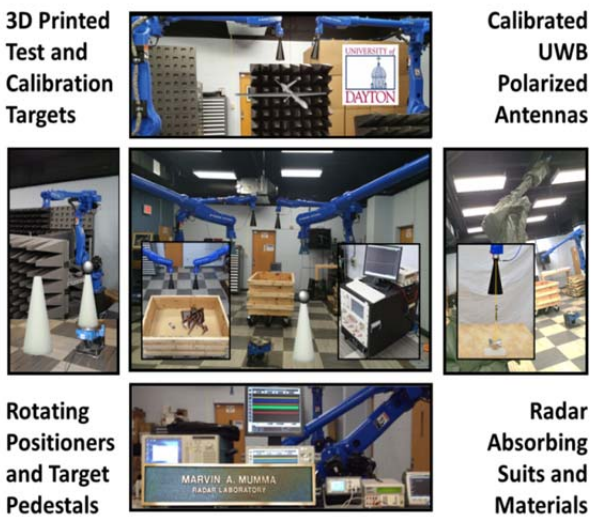
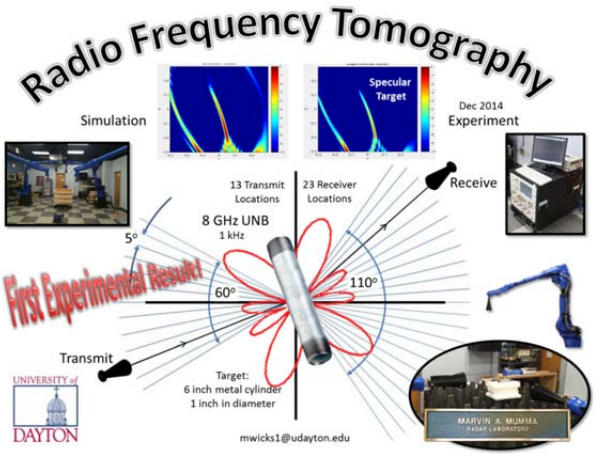
Close-in sensing via radio frequency tomography (RFT) has a variety of scientific applications. Most important among these is feature based object recognition. At a minimum, this may be accomplished via parameter estimation, material identification, kinematic analysis (of moving parts), or any combination thereof. Close proximity to targets under test will aid in feature extraction via automatic signal and image processing. With close-in sensing, the ability to observe objects from a variety of viewing angles enhances the quality and quantity of data available for analysis. Research in RFT in the MUMMA Radar Lab (MRL) is currently focused on MIMO communications/radar and RFT sensing at X-Band; with a frequency of operation centered at 10 GHz. This is ideally suited for applications to autonomous manufacturing (3D printing) as well as medical sensors and systems.



Our newly developed RFT test bed (picture to the left) in Kettering Laboratory employs several industrial robots for rapid reconfiguration of sensors and systems. As such, four robotic arms position transmit and receive antennas in close proximity to objects under test - which are placed on spinning turntables. This geometry permits real-time data collection in hours or minutes, as compared to days or weeks in traditional chamber facilities. Using custom configured electronic equipment, this unique RFT test bed permits pioneering research in algorithms and architectures, with broad commercial applications including civil and environmental engineering.



The initial goal of this research is tomographic imaging of test objects and the analysis of antennas and model targets. Our first RFT image, of an iron pipe in an open environment, is presented in the figure to the right. Our long term goal includes automatic assessment and quality control in autonomous manufacturing and 3D printing. With RFT, continuous sensing of products under print will ultimately permit automatic flaw detection, even deep within an object, as well as autonomous manufacturing with process correction, all in real time. This multispectral sensing approach will permit the hands-free production of the highest quality manufactured goods, especially important with the US emerging as a world leader in autonomous manufacturing.

Five technical papers are accepted for presentation by the MRL Team at the 2015 International Radar Conference in Washington DC, May 2015, on researched sponsored by the US Army, the Air Force Research Laboratory, the US Department of Energy, and the State of Ohio. Three doctoral students from the MRL Team have presented and passed their Part 2 Exams in the past month! Two SBIR Phase 2 subcontracts have recently been awarded based upon innovations developed in the MRL, and a third on windfarm technology is pending. All three SBIRs focus on mathematical algorithms developed using data analysis resulting from calibrated phenomenology measurements and experiments conducted in the MRL.