Theme 3-3: Quality and Non-Destructive Evaluation - 2023

Title	Name of the PI	List the Names of the Co-Is	Department	Abstract	Starting Date	Ending Date	Funding	Amount of Funding
Millimeter Wave Propagation Characterization in Common Building Material used in the U.A.E.	Dr. Amer Zakaria	Prof. Mahmoud H. Ismail and Prof. Sherif Yehia	ELE	Fifth-generation (5G) mobile radio systems are being explored by the wireless community to support the new and advanced applications that need faster data rates, lower latency, higher reliability, and availability, along with supporting a huge number of connected devices. This is motivated by the tremendous growth excepted in machine-to-machine type communications and their use in the Internet of Things (IoT). One of the enabling technologies for 5G is the use of higher frequency bands in the 30 to 60 GHz range, which is called the millimeter-wave (mmWave) range. However, for proper deployment of wireless systems using mmWaves, it is very important to have accurate estimates for the propagation losses of these signals through buildings to allow for predicting the coverage and performance of these systems. Within the proposed 5G frequency range, most of the work was done to characterize the propagation of signals through building materials such as glass, bricks, and plywood. Nevertheless, limited work was done to understand the propagation of signals through concrete walls with different specifications, which is the most common material used in buildings in the United Arab Emirates (UAE). Currently, in the UAE, in order to achieve sustainability, several supplementary cementitious materials (SCMs) (fly ash, silica fume, ground blast furnace slag (GGBS)) are being used in concrete mixes. Concrete mixes with SCMs achieve strength and durability requirements for the concrete industry in the UAE. In this project, the investigators plan to develop and implement an experimental setup to measure the propagation characteristics through various building materials commonly used in the UAE. These characteristics will be estimated indirectly by measuring the signals reflected off and transmitted through various materials. This project is interdisciplinary research between the Electrical and Civil Engineering Departments at AUS.	01/06/2018	31/05/2020	FRG	138125
Microwave-Based Vibration Monitoring Smart Robot	Nasser Qaddoumi	Amer Zakaria and Shayok Mukhopadhyay	ELE	The objective of this research was to design and build a system that measures vibrational frequencies in critical infrastructure. This was used to assess and evaluate the health of various machinery and structures, such as rotating turbines and structural health monitoring (SHM). The prototype was mounted on an autonomous robot. The system had a near-field microwave sensor, which was contactless, low-cost, and safe as it emitted non-ionizing low-power electromagnetic signals at high frequencies within the microwave range (1 GHz – 300 GHz). Such a system is novel in its type within the field of vibration monitoring, and therefore it has a high potential to get patented and published. In addition to the sensor, the system consisted of a robot base, a controlled mechanical arm, and a signal processing unit. This sensor had a relatively larger frequency detection range, in contrast to existing sensors that were utilized for these applications. Using vibration analysis, the sustainability of a mechanical machine was improved, ensuring that the machine lived up to its intended lifetime, which will help in minimizing sudden accidents.	16/11/2022	10/06/2023	URG	6000
Sonic IR edge and near-edge crack length estimation for aerospace applications	Bassam Abu-Nabah	Mohammad Hamdan	MCE	The Aviation sector in UAE represents 15% of its gross domestic product as of 2018. This industry employs approximately 250,000 direct hires and supports 225,000 indirect jobs. The rapid growth in this industry has forced aerospace engineers to develop rapid and robust crack detection techniques. Sonic infrared (IR) is a fatigue crack detection technique which has been gaining a rapid popularity in the aerospace industry for its potential wide area inspection capabilities. The multidisciplinary nature of this nondestructive evaluation technique makes it difficult to deliver a practical solution in estimating crack sizes. Even with the use of existing semi-analytical solutions and temperature-based digital imaging techniques, estimating the crack size with accuracy and robustness is still rather limited. Recently, a 2D heat diffusion model with an arbitrary heat source function along a crack line was proven feasible to assess surface crack lengths with a significant improvement in accuracy. This proposal mainly aims at delivering a new 2D heat diffusion model to address the edge effect and properly estimate the size of edge and near-edge cracks. The validity of the forward analytical solution of the heat diffusion model will be accomplished in close comparison with 2D and 3D finite element simulations using COMSOL. Upon theoretical and computational validation of the forward model, an inversion model will be established to assess edge and near-edge crack lengths with accuracy. Furthermore, this project targets building a sonic IR system capability and acquiring low-cycle fatigue cracked samples relevant to the aerospace industry to deliver an experimental validation to this proposed effort	01/06/2019	31/05/2021	FRG	130000
A novel two-dimensional eddy current thermography approach towards crack detection and mapping in metallic material	Bassam Abu-Nabah	Mohammad Hamdan	MCE	This effort aims at extending this ECT technology to a wider range following a two-dimensional (2D) approach while separating the electrometric coupling from the heat diffusion in a metallic component of interest. This requires establishing a realistic 2D heat diffusion model that lends itself for crack detection and mapping to the proposed 2D approach while covering the sample of interest with a single thermal image captured at a quasi-steady-state condition. This further promotes the proposed approach for wide-area ECT inspection technique without the need for scanning the sample. The theoretical model will be validated computationally and experimentally following finite element simulations using COMSOL and the detection of low-cycle fatigue (LCF) crack sizes relevant to the Aviation industry, respectively. Furthermore, this project targets advancing the in-house preliminary ECT system capability to cover a wider inspection frequency range and the acquisition of LCF cracked plates relevant to the aviation industry and in compliance with MIL-HDBK-1823A to experimentally validate the proposed 2D ECT technique. Once the experimental capability is established following the proposed approach, the forward theoretical model will be used to detect and map surface indications or cracks. This requires the development of an inversion and crack sizing algorithm to map the surface cracks with accuracy. Furthermore, this research effort will add a promising capability to the new NDT Lab at the American University of Sharjah with the aim of fostering a research collaboration in the near future with the growing aviation industry in UAE and the region at large.	01/06/2021	31/05/2024	FRG	148000
Plastic deformation assessment of Al2024 alloys using eddy current technology	Bassam Abu-Nabah	Undergraduate Students	MCE	Al2024 is commonly used in the aerospace industry where the demand for preventive maintenance has been growing as part of different life extension programs. This effort targets the use of eddy current technology as a nondestructive evaluation method to assess the alloy plastic deformation of the material at different stages before and after necking. The approach mainly relays on the relating the material electric conductivity changes at different plastic deformation levels from its intact state. This will be accompanied with analyzing the material microstructural changes using optical and scanning electron microscopy to further understand the material behavior at different stages.	01/12/2021	31/12/2022	URG	9920