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Conference Details

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Conference Title: SPIE Defense + Commercial Sensing

Communication Title: An adaptive ultrasound sensing system using a coiled low-finesse fiber-optic Fabry-Perot interferometer and phase generated carrier demodulation scheme

ABSTRACT

The diagnosis and prognosis of possible health problems of modern structures, such as buildings, bridges, long gas pipelines, large oil tanks, airplanes, ships, etc., have been receiving growing attention of researchers across almost all science and engineering disciplines. The structural health indicators include strain, temperature, fatigue, vibration, crack initiation and growth, to name just a few. Collection of these parameters is implemented by all kinds of sensors, mostly electronic sensors which, however, are not integration friendly for many structures. Optical fibers, which were initially invented for optical communication, have proven to be an alternative or in some cases the only tool for measuring these parameters.

In this talk, the development of a practically promising fiber-optic ultrasound sensor (FOUS), which aims at detecting the ultrasounds generated from crack initiation and growth in structures, will be presented. Although the investigation of FOUSs has been around for decades, there are no commercial products in the current market for structural health monitoring due to several technical challenges. A major challenge is the very large background strain or temperature drift that easily knocks the interrogation laser out of its sweet operation spot. To tackle this, we constructed a FOUS having periodic sweet spots and modulated the interrogation laser to form a series of sidebands, such that, at any time, there was always one laser line working around a sweet spot. Experiments were carried out to demonstrate the idea on a large aluminum plate which simulated an engineering structure, such as wings of an aircraft. Results suggested that the developed FOUS worked well in picking out the ultra-weak ultrasounds exerted on the large background strains while the aluminum plate underwent large deformations. The success of this FOUS is an innovative combination of laser modulation, sensor structure development, and signal demodulation. The proposed sensing system is expected to serve as a promising candidate toward practical applications.

COMMUNICATION OUTCOMES

As aforementioned in the ABSTRACT, development of a practically useful fiber-optic ultrasound sensing system is very challenging and commercially unsuccessful yet in the fiber-optic sensing community. Since the establishment more than ten years ago, the Han research lab has been dedicated to taking the challenges. Over the years, numerous ways have been tried to overcome the problems encountered in practice, and the bottlenecks of present techniques have been more and more clear. The work, which is planned to be presented in the conference, is a very practically promising idea recently proposed by us. We want to share this new development with the whole community. Presentation in the conference is one of the most timely and powerful ways to disseminate the work and make impacts to the field. The conference I will attend is a yearly leading global event of sensing, imaging, and photonics technologies. Thousands of peers will come from all over the world to exchange ideas and seek collaborations.

Attending the conference not only gives me the opportunity to broadcast our sensor, but also provides a precious opportunity to seek collaborations and exchange ideas with global colleagues. Back to a few years ago in this conference, one of the projects I have been working on was initiated after a discussion with one oceanographer from the U.S. Naval Research Laboratory (NRL). The fiber-optic temperature sensor we developed for NRL was very successful and outperformed the state-of-the-art commercial products NRL was using. Due to its success, the work received the prestigious Alan Berman Research Publication Award from NRL. We developed a patented underwater prototype and very successfully tested it in the field with NRL, which led to an ongoing effort to commercialize the sensor. Another example is that, we were struggling with finding new fabrication methods to enable the sensor working at elevated temperatures (over 1000 degrees Celsius). Then in the same conference held in 2016, I borrowed an idea from colleagues at Clemson University and came up with an innovative way to fabricate our temperature sensors. A fiber-optic 'incandescent lamp' was a result of this novel fabrication process, which was broadly covered by many media outlets, such as, Fox42 KPTM news, Laser Focus World, etc. Now, the method has become a standard for fabricating many different sensors in the lab. With these previous experiences, I firmly believe it will be highly beneficial in a similar way for me to attend the coming conference. The travel award will facilitate my presence at the conference, and I hope to get such a support.