TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. SEISMIC WALLPAPER WITH FIBER OPTIC SENSOR FOR CIVIL ENGINEERING

Naturally occurring disasters, such as earthquakes and floods, can crack buildings and force them to fail. The waves from earthquake are so strong that masonry buildings easily fail with the force and pressure. In addition, these waves also have a bad effect on newly constructed buildings. There is a need for a device that can resist cracks and prevent collapse of the walls and at the same time monitor the reason behind building failure.

To address the above challenge, researchers from various universities and companies funded by the European Commission have developed thin seismic wallpaper with fiber optic sensors to increase resistance to cracking and collapsing and monitor the health of the walls.

The seismic wallpaper is a thin woven material made of plastic and glass fibers. The fiber optic sensor is weaved into the wallpaper. The signal from the laser is used by the fiber optic sensor to monitor the health of the wall. The sensor helps to figure out the cracks in the wall and the reason for the building failure. The seismic wallpaper with the fiber optic sensor is glued to the wall to increase resistance to cracking and collapsing and monitor the walls. Regardless of the direction of the earthquake wave, the wallpaper can support buildings. The sensors in the wallpaper will make the new structures more resistant to earthquakes. This kind of textile can be used to strengthen embankments and prevent floods and landslides.

The seismic wallpaper was first deployed at the European Centre for Training and Research in Earthquake Engineering in Pavia, Italy, for testing purposes. The researchers created a building with the help of the seismic wallpaper and shook the building with the help of external forces. The building cracked but remained intact. The external force was not able to break the building. These wallpapers are very useful in masonry buildings, which can crack and collapse very quickly during earthquakes.

The project Polyfunctional Technical Textiles against Natural Hazards (POLYTECT) was funded by the European Commission. The amount invested was €10,153,058 (equivalent to $11,574,486 at the current exchange rate). The project was supported by 12 countries and 30 partners. The project has been completed and the product is now being used in industrial settings. The seismic wallpaper is commercially available in several countries, including Italy and Germany. The seismic wallpaper has opportunities to get a good response from the civil engineering industry.

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2. VIBRATION CONTROL AND MONITORING PLATFORM FOR STRUCTURES

In different types of machines, vibrations are a daily occurrence. Vibrations can also be seen in trains, aircraft, bridges, and so on. The vibration causes wear and tear, which often leads to structural failure. There is a need for a device that can monitor the vibrations in different structures and understand the underlying causes. In addition, the device should be easy to use and deploy and should overcome the barriers of complex wiring.

To address the above challenge, a team of researchers has developed a self-powered wireless vibration control and monitoring platform. The European Commission funded project is called WIBRATE.

The self-powered wireless vibration control and monitoring platform consists of different sensors, which can be fitted in structures, such as trains, petrochemical plants, and civil engineering structures in minutes. Smart sensors in trains capture the vibration data when the train is in motion. In addition, the software algorithm collects and analyzes the data from the sensor and looks for signs, such as wear and tear and further stores the detection data in the central database wirelessly to further compare the data in the future to predict the health of the structure. As the system is wireless, the technology further reduces the cost of accidents and maintenance without the need for complex retrofit wiring and batteries. Train operators are kept updated with real-time information on the health status of the train.

Southeastern Railways, UK was the first to deploy the sensors on a number of trains. With the deployment of wireless vibration control and monitoring platforms, Southeastern Railways has significantly reduced maintenance and operational costs. In addition, the system also helps to identify premature failures, which improves safety for travelers. The sensor system monitors the wear and tear of axles and wheels on trains. The researchers have also identified that the sensor system can be deployed in train tracks to get real-time information on tracks and secure routes. This technology is being adopted by train operators in a number of countries in Europe including Germany, Italy, Ireland, Sweden, and Spain.

The WIBRATE project was supported by the European Commission under the 7th Framework Program. In total, €2.85 million (equivalent to $3.25 million at the current exchange rate) was invested by the European commission. The WIBRATE project was supported by seven partners from different countries--the University of Twente, Universita Della Svizzera Italiana, Honeywell (India), Fiat's Research Centre in Italy, LMS International (Belgium), Inertia Technology (The Netherlands), and Perpetuum (UK). The wireless vibration control and monitoring platform was first deployed in Southeastern Railway. The system has received impressive feedback from the first deployment. It is expected to be further deployed in rail networks across Europe. According to the European Commission, monitoring and control revenue will grow to €143 billion (equivalent to $162.11 billion with current exchange rate) by 2020.

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3. WIRELESS SENSOR NETWORK TO MONITOR LARGE INFRASTRUCTURES

Structures can be affected by different natural and unnatural calamities such as earthquake, landslides, construction defects or any kind of terrorist activities. These events can result in collapse of structures such as buildings, bridges, and dams among others; this can sometimes tragically result in death. In addition, the structure can also collapse because of factors, such as aging, accidents or other changes. There is a need to address the challenge of safeguarding infrastructures, particularly those structures that are intensively used by the public such as historic monuments and bridges. There is a need to monitor these structures in real time and take appropriate action before it is too late.

To address the above challenge, researchers from various universities have worked together under the European Commission project GENESI (Green sEnsor NEtworks for Structural monItoring) to develop a wireless sensor system to monitor large infrastructures and their safety. The wireless sensor network is designed with energy harvesting, low-power capability and wake-up radio capabilities, which is further able to support infrastructures by providing reliable monitoring, for very long periods of time in an energy neutral way. In addition, the project has developed tools to support deployments of wireless sensor network, data sampling, data processing and outlier detection techniques to increase reliability and reduce energy consumption. The main aim of GENESI is to provide structural health monitoring for the construction site over the entire lifetime, that is, from the development stage to completion and post completion stage. The wireless sensor network is designed to be installed in a new structure during the construction phase. To detect long-term changes in the structure, the wireless sensor network will remain in its place to monitor parameters, such as ageing, accidents or other changes. This will help the experts to compare past performance, which will further help to predict the future of the structure.

Two construction sites, the Pont de la Poya Bridge in Fribourg, Switzerland and B1 metro line in Rome, have validated the wireless sensor network technology. In the metro, the sensors were deployed next to the tunnel boring machine to measure and monitor parameters, such as temperature, deformation in real time and strain. After processing of data, it is communicated to the offsite location via 3G and Internet, and professionals check and analyze the data. The wireless sensor network is quicker, cheaper, and simpler to deploy than traditional cable connected sensor systems. In the Pont de la Poya Bridge construction site, the sensor was used to monitor and measure parameters, such as bearing displacement, temperature, wind, pull on the pylon, and water levels. Thus, the wireless sensor network was validated by these two construction sites.

The project was funded by the European Commission under the 7th Framework Programme. The project commenced in April 2010 and was successfully completed in August 2013. In total EUR 2 million (equivalent to $2.28 million at the current exchange rate) was invested by the European Commission. The project was supported by seven partners from four different countries. The seven different partners are University of Rome La Sapienza, University of Twente, University of Bologna, STMicroelectronics, Tyndall, Solexperts and Tre Esse Engineering. The wireless sensor system to monitor large infrastructure was first deployed in Rome's metro and a Swiss road bridge. The wireless sensor system has been very successful at both sites. A spin off company from GENESI called WSENSE is expected to deploy the wireless sensor network in Italy to monitor public heritage sites.

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4. RECENT PATENTS IN THE FIELD OF STRUCTURAL HEALTH MONITORING IN AIRCRAFT

While monitoring and diagnostics has been crucial for increasing safety and reliability in rotating machinery, structural health monitoring with visual inspection has historically been the most widely used type of inspection.

The various market drivers that have enabled research and development activities across structural health monitoring in aircraft are weight reduction, cost reduction, simplified systems, safety, and environmental concerns, through life management, availability improvement and reliable prognostics. The other trends driving the market are lighter structures, increasing use of composites instead of metal, development of smaller airframes, increasing use of electrical drives and actuators, more compact engines and smart wings.

The possibility of continuous monitoring of structures by low-power integrated sensor networks instead of scheduled inspections at intervals will enable the discovery of damage at a much earlier stage and help damage detection and evolution. This can have a strong economic impact and improve the safety of the structure. It can also lead to the development of new methodologies in design and engineering. Cost of preventive maintenance is a key driver for condition-based maintenance in aircraft. In satellites and aircraft, the complex wiring is a major driver for the development of wireless sensor networks. In addition, difficult to inspect areas are the innovation hotspots in aircraft where the majority of research and development activities are focused.

The key stakeholders who will benefit from the research and development activities for structural health monitoring in aircraft are aircraft manufacturers, fleet operators, designers, insurance companies, government and tax payers.

Some of the participants investing in R&D of structural health monitoring in aircraft are Rigas Technical University LV, Fundación Centro de Tecnologías Aeronáuticas ES, Insensor AS DK, ASCO Industries N.V. BE, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V. DE, Universität Leipzig DE, Universidad Del País Vasco / Euskal Herriko Unibertsitatea ES, Vrije Universiteit Brussel BE, Lufthansa Technik AG among others.

A recent patent in aircraft structural health monitoring, Modal Acoustic Aircraft Weight System, (US20150034395), assigned to The Boeing Company, includes a sensor that may provide information on the weight bearing structure of an aircraft when a force is applied to the structure.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
MODAL ACOUSTIC AIRCRAFT WEIGHT SYSTEM	05.02.2015; US20150034395	The Boeing Company	Smith Paul R.	A method includes receiving characteristic information from a sensor. The characteristic information may be representative of a characteristic of a weight bearing structure of an aircraft when a force is applied to the weight bearing structure. The method includes determining a weight of the aircraft based on the characteristic information.

AIRCRAFT INCLUDING A SYSTEM FOR MEASURING PRESSURE, AND AN ASSOCIATED METHOD	13.11.2014; WO/2014/180870	Airbus Operations (SAS)	DOS-REIS Michel	The invention relates to an aircraft (10) having a system for measuring a static reference pressure in flight, which system comprises: a pressure sensor (22) connected to the rear portion of the aircraft by a cable (16) and associated with a pressure intake (24) that is located, in flight, in an undisturbed zone downstream from the aircraft, the pressure signal (22) being suitable firstly for measuring a pressure coming from the pressure intake (24) and secondly for transmitting a signal representative of the measured pressure, e.g. an electric signal, to the aircraft; and a system (34) on board the aircraft, which system is suitable for determining a pressure measurement firstly from the transmitted signal and secondly from a position of the pressure sensor (22) relative to the aircraft (10). Pressure is measured dynamically while the aircraft is climbing or descending.
INERTING DEVICE, TANK AND AIRCRAFT PROVIDED WITH SUCH A DEVICE, AND CORRESPONDING METHOD	21.01.2015; EP2825463	L AIR LIQUIDE SOCIÉTÉ ANONYME POUR L ETUDE ET L EXPL DES PROCÉDÉS GEORGES CLAUDE	TIGER XAVIER	The invention relates to an inerting device for a pressurized aircraft fuel tank, i.e. for a tank provided with a main vessel (2) and a separate overflow space (3), the device including a generator (1) of nitrogen-enriched gas, a circuit (4, 5) for transferring the nitrogen-enriched gas produced by the generator (1), the transfer circuit (4, 5) including an upstream end connected to the generator (1), a first downstream end (4) which can be coupled to the main vessel (2) and a second downstream end (5) which can be coupled to the overflow space (3), the device including a sensor array (6, 7) for measuring information representative of the pressure differential (P3-Pa) between the interior of the overflow space (3) and the exterior of the tank, the device further including an electronic logic (8) receiving the measurements from the sensor array (6, 7), the electronic logic (8) being connected to the generator (1) and/or to the transfer circuit (4, 5), and being designed to control the supply of a nitrogen-enriched gas flow to the second downstream end (5) when the pressure differential (P3-Pa) between the interior of the overflow space and the exterior drops below a predetermined threshold S.
AIRCRAFT TIRE PRESSURE SENSOR RESONANT LOOP LINK	08.01.2015; US20150008759	ELDEC CORPORATION	Lamping Jeff	The aircraft tire pressure resonant loop link assembly electromagnetically couples a magnetic field between a wheel axle electromagnetic adapter transformer primary coil and a tire pressure sensor receiver coil for powering a tire pressure sensor, and includes a pair of spaced apart electrically conductive connecting arms, a single electrically conductive primary loop electrically connected to first ends of the connecting arms mounted adjacent to a secondary tire pressure sensor coil, and a circuit including a resonant tuning capacitor and a secondary coil with one or more electrically conductive loops at second ends of the connecting arms. The tire pressure sensor coil pair includes a transformer core, and secondary resonant coil pair also includes a transformer core
SYSTEM AND METHOD FOR DETECTING AN ON GROUND CONDITION OF AN AIRCRAFT	08.01.2015; US20150012195	Goodrich Corporation	Georgin Marc	Systems and methods for detecting an on ground condition of an aircraft are disclosed. A weight on wheel system may determine that an aircraft is on the ground. Wheel speed sensors may measure the speed of the aircraft wheels. Axle reference speeds may be calculated for each landing gear based on the speed of the aircraft wheels. A brake control unit may determine that the axle reference speed for each axle of the landing gears is above an on ground threshold speed,

				and the brake control unit may allow braking to be applied.
METHOD FOR DETECTING A FAILURE OF AT LEAST ONE SENSOR ONBOARD AN AIRCRAFT IMPLEMENTING WIND DETECTION, AND ASSOCIATED SYSTEM	01.01.2015; US20150006021	DASSAULT AVIATION	AVIATION D'ARBONNEAU Francois-Xavier	A method for detecting a failure of at least one sensor onboard an aircraft implementing wind detection is provided. The method includes measuring an airspeed of the aircraft; measuring a geographical speed of the aircraft; determining an instantaneous wind vector, based on the measured airspeed and geographical speed; establishing an instantaneous wind variation vector, based on the determined instantaneous wind vector; projecting the instantaneous wind variation vector on the direction of the vector of an air or geographical speed of the aircraft; and determining the presence of a failure based on the obtained projection.
CONTROL DEVICE, CONTROL SYSTEM, AND CONTROL METHOD OF AIRCRAFT	31.12.2014; WO/2014/205885	SZ DJI TECHNOLOGY CO.,LTD	WANG, Tao	Disclosed are a control device, a control system, and a control method of an aircraft. The control device comprises a first control rod. The movement of the first control rod in a first movement direction controls the motion of the aircraft in a first motion direction, and after the external force applied on the first control rod in the first movement direction is removed, the first control rod automatically returns to a predetermined position in the first movement direction. When the first control rod automatically returns to the predetermined position, the aircraft maintains a flying state in the first motion direction, and the flying state is maintained depending on a control signal received by the aircraft that is generated when the external force applied on the first control rod in the first motion direction changes and a state signal that is measured by a state measurement sensor carried by the aircraft.

Exhibit 1 lists some of the patents related to structural health monitoring in aircraft.

Picture Credit: Frost & Sullivan

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