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Robotic Probe Positioning System for Structural Health Monitoring

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Structural health Monitoring (SHM) is a very critical component for sustainable civil and mechanical structures in modern urban settings. The sky-scrappers and huge bridges in modern metropolis today are essential aspects of the prosperity and development of a country but at the same time they present a great challenge in terms of maintaining and sustaining the structures in a good health. Due to the complex designs of these structures, it is typically very dangerous to do SHM tasks through human personnel. Deployment of a monitoring team with various forms of equipment and scaffolding accompanied with their hoisting machines becomes extremely exorbitant for the maintenance and planning of the structures causing unnecessary cost-spill on other areas of the available budget. For most of the metallic structures, a fast method of scanning an area more closely is the Magnetic Flux Leakage (MFL) based defect detection. The MFL is considered the most economical approach for inspecting the metallic structures. Traditionally a hand-held device is used for performing the MFL inspection. In this paper, an autonomous MFL inspection robot has been presented which is small, flexible and remotely accessible. The robot is constructed with an Aluminum chassis, driven by two servomotors and holds a stack of very powerful Neodymium magnets to produce the required magnetic circuit. As the robot moves on a metallic surface, the magnetic circuit produces a layered magnetic field just under the scanning probe. The probe is composed of several Hall-effect sensors to detect any leakage in the magnetic circuit, which happens due to abnormality in the surface, thus detecting an anomaly. In this paper, a coordinated robotic inspection system has been proposed that utilizes a set of drones with one positioning robotic crawler platform with additional load

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hoisting capabilities that are utilized in order to position a specific defect-locating probe on the building under scan. Proposed methodology can play a vital role in SHM since it is capable of scanning a specific area and transmit back the results in a shorter time with a very safe mode of operation. This method is more reliable as compared to fixed sensors that focus a particular area of the structure only. Design for SHM robot involves intelligent integration of navigation system comprising of crucial parts that act as its backbone and assist the robot to work autonomously. These parts include GPS module, compass, range sensor, Infrared (IR) sensor along with MFL probe and winch setup and powerful PMDC Servo Motor controller (MC 160) used to drive two (2) powerful motors. The MC160 brushed Motor Controller proves to be a perfect platform for controlling Brushed DC motors. The controller consists of two power drivers in addition to OSMC connector for a third power driver (winch motor control). All these things add extra degrees of freedom to the robotic system for SHM. Novelty of the methodology is that the robot's program logic is not fixed. It is flexible in terms of path following. It has ability to detect an obstacle while it is on its way to scan the building. It not only detects obstacle but also changes its course and automatically adopts new route to the target destination. Such an autonomous robotic system can play a vital role in Structural Health Monitoring (SHM) in contrast to manual inspection eliminating the need of physical presence of human in severe weather conditions. The presented methodology is condition based in contrast to schedule-based approach. Core scan is easily done and robot is reconfigurable in a sense that it automatically changes its course to adopt to rough terrain and avoids obstacles on its way. Easy deployment makes robot an excellent choice for SHM with minimum cost and enhanced flexibility. Proposed robotic system can perform a coarse level of scan of a tall building using drones and the probe deployment robots (PDR). The drones provide a rough estimate of the location of possible defect or abnormality and PDR inspects the anomaly more closely. In addition, the coarse information about a possible defect can also help in deploying other means of inspection in a much lower cost since the whole structure needs not to be inspected.