APPLICATION OF SENSOR BASED CIVIONICS TECHNOLOGIES TO HARD INFRASTRUCTURE FOR ASSESSMENT, STRUCTURAL INTEGRITY AND HEALTH MONITORING

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Abstract

A sensor is a device which detects or measures a physical property and records, indicates or otherwise responds to it. Civionics is a special field of study which is a combination of Civil and Electronics. Hard Infrastructures corresponds to all types of infrastructures like- Buildings, Bridges, Industries, and Heritage Infrastructure etc. Some absolutes of structure defines as long as structures will keep on getting build, failures will keep occurring and it will keep the forensics busy for a long time. Some of primary causes of structural failure includes deferred maintenance, overloading, design flaws, material failures or combination of above. This fear of failure will put stakeholders to take action and one such action is application of sensor based civionics technologies.

Key Words : Civionics, Sensor, Laser Scanning, Accelerometer, Inclinator/tilt meter, Shock, Digitization

1. Introduction

Hard Infrastructures are critical to any country's economy as it is directly proportional to its growth. Economic growth depends on quantitative growth of its hard infrastructure but maintenance is a big question till date. Designers and stakeholder's have to think about the maintenance program from the very inception. However, there has been a paradigm shift from regular maintenance to Condition Based Maintenance. Condition based Maintenance is a concept which encompasses that in a continuous growing market productivity plays a key role to stay competitive for any industry[1]. Productivity can be availed through availability and availability can be increased through efficient maintenance practices. CBM or Predictive Maintenance is such a concept which primarily uses sensing technologies like Non-Destructive Technologies [2], Visual Inspection and Performance Data to assess the structural present condition [3]. Availability was a concern earlier but now technology has changed such a way that there are numerous availability but awareness is less.

2. Problems Usually Faced

Infrastructures faces a lot of problems technically many of which can be solved using state of art sensing technologies. Usually the typical problems faced are as follows:

1. Unavailability of As-Built Drawings
2. Inaccessibility to Areas
3. Visualization Problems
4. Typical problems like vibrations, tilt, shock, deflections, settlement, and corrosion.

5. Structural Components Identification and Quantification.

6. Continuous Performance and Parameter Monitoring in Infrastructures.

In this paper we shall be discussing some case studies where these problems were there and solutions were provided using sensing technologies which not only solved the problem but created awareness amongst the stakeholders and provided them with an informed decision making approach to take critical decisions.

3. Some Select Typical Case Studies

1. Unavailability of As-Built Drawings:

Hard Infrastructure is a part of growing economy henceforth are liable for continuous changes. These changes are made in terms of strengthening, extensions, construction of new levels etc. Sometimes these changes are documented but many a times not. These changes are crucial to the structural integrity of the structure. Traditional methods of preparing as- built is highly laborious and lacks efficiency. But there are technologies available which can reduce the labour drastically and can create as built drawings that too in 3D in the least possible time.

Case Study 1:

Problem Statement: Industry having complex piping system doesn't have any as built drawings of the piping section and building section.

Solution Suggested: An As-Built survey of the pipe rack and building was suggested using a precise 3D Laser

Scanner. This scanner was mounted on a tripod stand and the laser scanner was programmed to scan the area with an accuracy of 8mm. The scanner creates a point cloud of the scanned area using the LASER and thus a mesh model is created. This mesh is further processed to form a CAD Drawing. This process takes very short time and is very precise.

Fig. 1 : CAD Drawing of Building Section made from data acquired from 3D Laser Scanner

Fig. 2 : Point Cloud Data from 3D Laser Scanner and processing of point cloud data to CAD Data

4. Inaccessibility to Areas

Structures are of various types and styles. But each structure has some critical components and some of which are not accessible and cannot be viewed using naked eye or with any accessories. Some of the best examples of inaccessible areas like tall chimneys, underneath of slabs etc. Though these areas can be accessed using scaffoldings, cradles, ropes etc. but it comes with great cost henceforth not a good medium for regular maintenance programmes and inspections. These problems are being faced everywhere but due lack of availability of technology it was left unattended and even if attended came at a big cost.

Case Study 2

Problem Statement : 120 Meter tall Chimney with no monkey ladder and no means to view the top of the chimney and conditions of wind cutters. Stakeholder's noticed some concrete pieces were falling from chimney top and were unsure of the source.

Inspection Method Used by Stakeholder : They were using binoculars and high optical zoom cameras but still not able to find out the condition of the top.

Solution Provided : Unmanned aerial vehicle with high resolution camera was suggested for the survey and necessary permissions were taken out. The unmanned aerial vehicle was used to reach to the top of the surface and survey the condition. During the flight the unmanned aerial vehicle was taking videos and pictures of critical areas of the chimney and condition of wind cutters.

Fig. 3 : Images taken from Unmanned Aerial Vehicle.

Case Study 3

Problem Statement : A treatment plant where the concrete members are in continuous touch with acidic medium and visual observation of underneath of concrete members is not possible.

Usual Method of Inspection : Visual Inspection but no such medium to reach the underneath the surface.

Solution Provided: Visual Observation by Low Level Unmanned Aerial Vehicle.

Unmanned Aerial Vehicle was used to fly through congested areas of the treatment plant where accessibility was not possible. The unmanned Aerial Vehicle captured shots of the underneath of the slab and walkway section. A close up inspection was also made to assess the condition of the concrete.

Fig. 4 : Underneath of Slab and Walkway Sections captured by Unmanned Aerial Vehicle.

5. Visualization Problems

Structures being an amalgamation of various different kinds of combination of structural components, sometimes it becomes difficult to visualize the aesthetics and different aspects of design. Once such areas where these problems are usually faced are by the Landscape Architects. Working with the ideas and vision of the stakeholder's it is a laborious job to abide by those demands. Visualization is basically a field which enhances the value addition aspect of any design or ideas in terms of structural integrity, design calculations, aesthetics etc. Any construction/ repair/rehabilitation activity comes with great complications and with different views of different experts where conflict zones are high. This is where visualization plays a great role and solves the problem. There are various visualization technologies available out of which one of the most trustworthy is a 3D LASER SCANNING. This can be used for a variety of purposes like topographical surveys, construction progress monitoring, as-built design creation, condition surveys of buildings etc.

Case Study 1

Problem Statement : A heritage property is being converted to a Hotel where landscaping Architects are finding it difficult to align with the idea of the stakeholder.

A statue was to be erected in a particular place but they were unable to decide what size of the statue would best fit. Stakeholder has given them the selection of the statue which is basically a 3 ft statue. This statue needs to be enlarged in dimensions and they were finding it difficult to visualize the best fit size of the statue.

Solution Provided : 3D Laser Scanning of the statues was suggested and upon building the mesh model from point cloud data the mesh model to be scaled to preferred dimensions and visualize the same with the topography of the location.

Fig. 5 : Statue to be digitalized and scaled for visualization

Fig. 6 : 3D Scanned and Modelled Data for Visualization

After Post-processing works the modelled data was scaled to various dimensions and visualized with the topography of the location which made the job of the Landscaping Architect easier.

6. Paradigm Shift Towards Predictive Maintenance

Recent years there has been a paradigm shift towards predictive maintenance. Predictive Maintenance basically applies technologies to gather information about the infrastructure in terms of various structural parameters which are continuously monitored using sensing technologies and these collected data are analysed and interpreted to know about the structural performance and hence optimize activities which saves a considerable amount of expenses and efforts. Predictive Maintenance in a nutshell seems to be very interesting and easy but comes with many complications and difficulties. One such difficulty is awareness among the stakeholders. The when, how, why comes in every aspect of predictive maintenance programmes. From why to move towards predictive Maintenance to selection of technologies to data interpretation and usage of data to take decision. The basic difference amongst the industry opinions is whether to go for predictive maintenance or not and if we go what shall we get out of it. Here one thing should be noted very carefully that any predictive maintenance programmes does not yield instant results, but in due course of time the amount of value addition it yields is very high and creates a huge impact to the economy. Hard Infrastructure are under continuous usage and hence prone to various loading conditions from various sources. Monitoring these loading conditions on a real time basis yields great benefits as it adds voice to the structure and the structure can speak for itself. It is basically like putting sensory organs to the structure.

Fig. 7 : Analogy between Human Sensory system and Sensory System to Structures.

Typical Problems faced by Structures : Some of the typical problems faced by structures are vibrations, tilt, deflections, settlement, corrosion, stress, strain etc. As said earlier, as long as structures will be kept on building problems will surface along with it. These problems are evident in most of the structures which includes both new construction and old buildings. Some of these problems are of continuous nature and slowly degrades the structure and this degradation results in costly repairs. Most of the times these problems are conquered with existing solutions but a system to monitor these problems on a regular basis helps to estimate the performance of the solutions applied and hence guarantees the integrity of the structures.

Monitoring Types: Basically monitoring are of two types Short Term Monitoring and Long Term Monitoring. Short term monitoring is basically applied when the problems faced is of temporary nature and can be corrected using corrective actions. Long terms monitoring is suggested when the problem is of repetitive nature and the structure is subjected to continuous loading. However, a long term monitoring is highly suggested as gives a real time view of structural performance and also provides an informed decision making platform for taking decisions related to any structural activity.

Typical Architecture of a Monitoring System

Fig. 8 : Typical Architecture of a Monitoring System

7. Benefits of A Monitoring System

There are numerous advantages of a monitoring system, some of major advantages are like integrated solutions, increased safety of people, nature and property, Extending the lifetime of ageing structures, reduced maintenance costs, quick access to structures records and safety information, discovers deficiencies in real time and increases safety and most importantly increases knowledge about the structure which proves fruitful for future endeavours.

8. Conclusions

Monitoring is not a new field, it was existent from a long time but the recent advancements in electronics and sensor technologies made it more feasible and cost effective solution for the structural needs. These value addition services are one stop solution to many a problems related to infrastructure. One single technology has a variety of usage and hence are multipurpose in nature. Civionics has earmarked a major advancement in the field of Non Destructive Testing as well. Awareness is one critical aspect which needs to be focussed on.

References

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