MOTION SENSING AND AGEING PREDECTION OF KUPONDOLE-THAPATHALI BAGMATI BRIDGE USING MACHINE LEARNING AND TIME SERIES ANALYSIS

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Student Research Symposium on Earthquake Risk and Resiliency in Kathmandu, iHub, January 3, 2020

Abstract

Motion sensing has been a really exciting topic with the availability of new hardware, networks, and multiple domains that has the potentiality to uncover various applications which would have been very difficult with traditional methods and calculations. Vibrations in bridges are one of those topics which we believe will help to estimate ageing of the bridge and alert the authority about the situation. This study aims to analyze the aging of Kupondole-Thapathali Bagmati River Bridge using accelerometry analysis through Machine Learning and Time Series Analysis. Moreover, the data collected will be very valuable for other research purposes like impacts of vehicle movement and city traffic analysis.

Introduction

There are two bridges at Thapathali, an old one and a new one. The old one was constructed in 1967 AD and the new was constructed in 1995 AD. The length of both the bridges is 184 m and have a width of 6 m. These bridges fall on the category of Beam Bridge (Fig. 1). A beam and slab or composite bridge are the ones where a reinforced concrete deck sits on the top of steel I-beam, and act compositely with them in bending. The reinforced the steel structure acts as a tension member.

The beam and slab construction is multi girder type. Generally, the span is short in Beam Bridge because, unlike truss bridges, they do not have built-in support. The only support is provided by the pier. Naturally, the bridge has its limited life span.

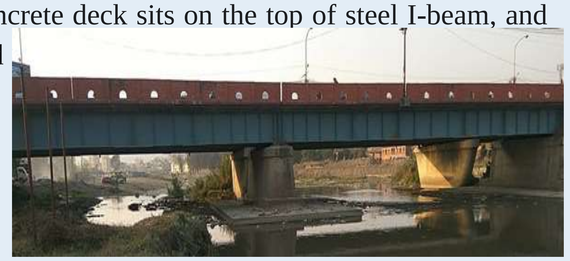

Fig. 1. A side-look of Kupondole-Thapathaly Bagmati River Bridge.

In addition. daily heavy vehicular movements challenge its life span. This study aims to analyze the aging of this bridge using accelerometry analysis coupled to Machine Learning.

Sensing Hardware Used

- Measurement dimension: Acceleration 3 axes, Angular velocity 3 axes, Magnetic field Angle 3 axes, Air pressure
- Range: Acceleration ±16g, Angular velocity ±2000°/s, Angle X/Z±180° Y±90°
- Stability: Acceleration -0.01g Angular velocity 0.05°/s
- Attitude measurement stability: 0.05°
- Output content: Acceleration, angular velocity, angle, magnetic field, port state, air pressure, height.
- Output frequency：0.1Hz--100Hz, default: 10Hz.
- Date interface: Serial TTL level Baud rate--115200
- Bluetooth transmission distance: >10m.
- Extended opening function: Analog input(0～VCC), digital input, digital output.
- Bluetooth4.0：Compatible Android/ IOS operating system.

Objective

The specific aim of this research to introduce a paradigm to predict the ageing, access serviceability conditions and verify the life expectancy that outlined in the structural design phase. Big Data interfaced assessments using IT instrumentations and implementing Deep Learning model to predict the ageing of one of the very busy and heavily loaded Kupondole-Thapathali Bagmati River Bridge (BRB) that connects the capital with another city named Lalitpur as a pilot experiment. Upon the success of such prediction analysis, other typical studies ca n be considered with some other typical bridges of the country.

Progress and Future Plan

Currently, we are testing multiple types of sensors in a multiple geometry under the bridge. Fig. 2 shows a one-day tine series of x-, y- and moving average plot of the bridge, depicting the heavy impact of vehicular movements especially during heavy traffic hours around 9-10LT. However, for now, the data collected is stored on SD card and is transferred to database manually after a certain time interval. After comparing outputs from multiple sensor types and multiple configurations, we will implement Bluetooth 5.0 network under the bridge that will help us stream the collected data in real-time directly to the server through the 4G network and perform real-time analysis on the cloud.

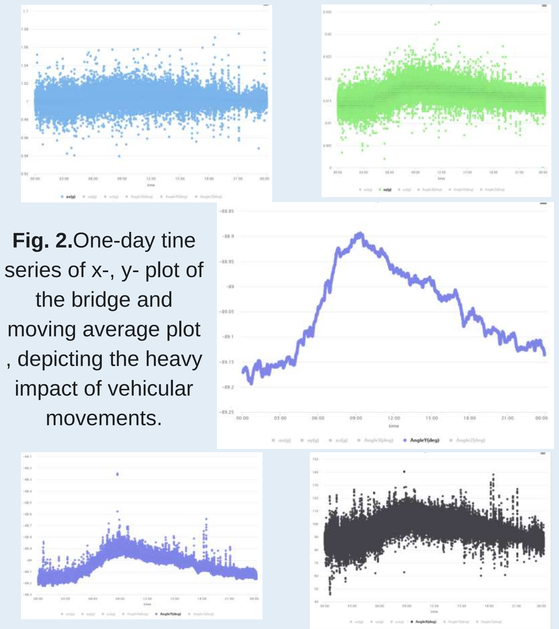

Fig. 2. One-day tine series of x-, y- plot of the bridge and moving average plot , depicting the heavy impact of vehicular movements.

Conclusions

This project, for the first time of its nature, introduces a new research paradigm of remote motion sensing for health monitoring of civil construction on public safety domain in Nepal. Preliminary data from a piloting study from BRB encourages us to move forward with aging analysis of such civil structures. Students from DoECE at IOE, Pulchowk Campus will collaborate to test network configurations and hardware types. One of such configuration will be Master/Slave configuration over Raspberry Pi Server with Bluetooth 5.0 and multiple Arduino BLE Kits. The data collected will create an opportunity to study vehicle mobility and its impact on the bridge as well as over other multiple domains which we are very open for collaborations.

Acknowledgments

The project teams gratefully acknowledge the support from Higher Education Reform Project - Tribhuvan University, Kirtipur for supporting the project with Research Grants.