# Potential Use of New Techniques for Building Structural Health Monitoring in a High Seismic Environment

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## Introduction

During my stay at the Earthquake Research Institute (ERI) I worked at Kusunoki Laboratory. My research focused on the evaluation and implementation of strategies for structural health monitoring (SHM) using the existing acceleration data and expanding it with new technologies based on computer vision (CV) and drones (UAV). Special attention was give to the combination of video and accelerometer information, use of web or drone cameras for deformation determination, in a particular selection of the minimum number of visual tracking points/sensors to identify and locate damage, drift estimation in building structures, use of residual displacement as an indicator of severe damage, detecting minor damage under the effect of varying ambient conditions. As part of this work, I continue developing a reference book on computer vision methods in civil structural health monitoring.

## Computer Vision for Response Monitoring

Videos records during real earthquakes or laboratory tests are common and in general they are obtained with a relatively low investment. On the contrary standard sensors (accelerometers, strain gages, displacement meters) require considerable planning and have limitations due to cost and wiring, among others. Nevertheless, standard sensors are in general more precise. The combination of both is an excellent option. We could use the full field view obtained from a video with the high precision and localized benefit of a dedicated sensor. Computer vision has been applied in other fields of knowledge and it is now starting to be used more intensively in the evaluation of the seismic response of structures.

Key aspect of my research was to determine the best techniques and the limitation of computer vision in real problems. For this two investigations were developed: analysis of seismic response of planar small scale structure in a control laboratory environment, monitor with standard video camaras and sensors. In this case the information of the videos and sensor was available from the beginning. Full field response values were determined using targetless tracking techniques. Identify global displacements were converted to relative displacement, interstory drift and total acceleration. With these response values, nonlinear structural response was identified, including the determination of window linear equivalent modal properties and residual drift to determine level of damage. In this case the determined response shows excellent results.

To further validate the methodology a blind test was developed. Videos from an E Defense large scale test on an 8 story structure were analysis without any information on the actual recorded response, Figure *1*. The computer vision derived response data was later sent to Professor Koichi Kusunoki and Dr. Trevor Yeow so they can be validated with traditional sensor data.

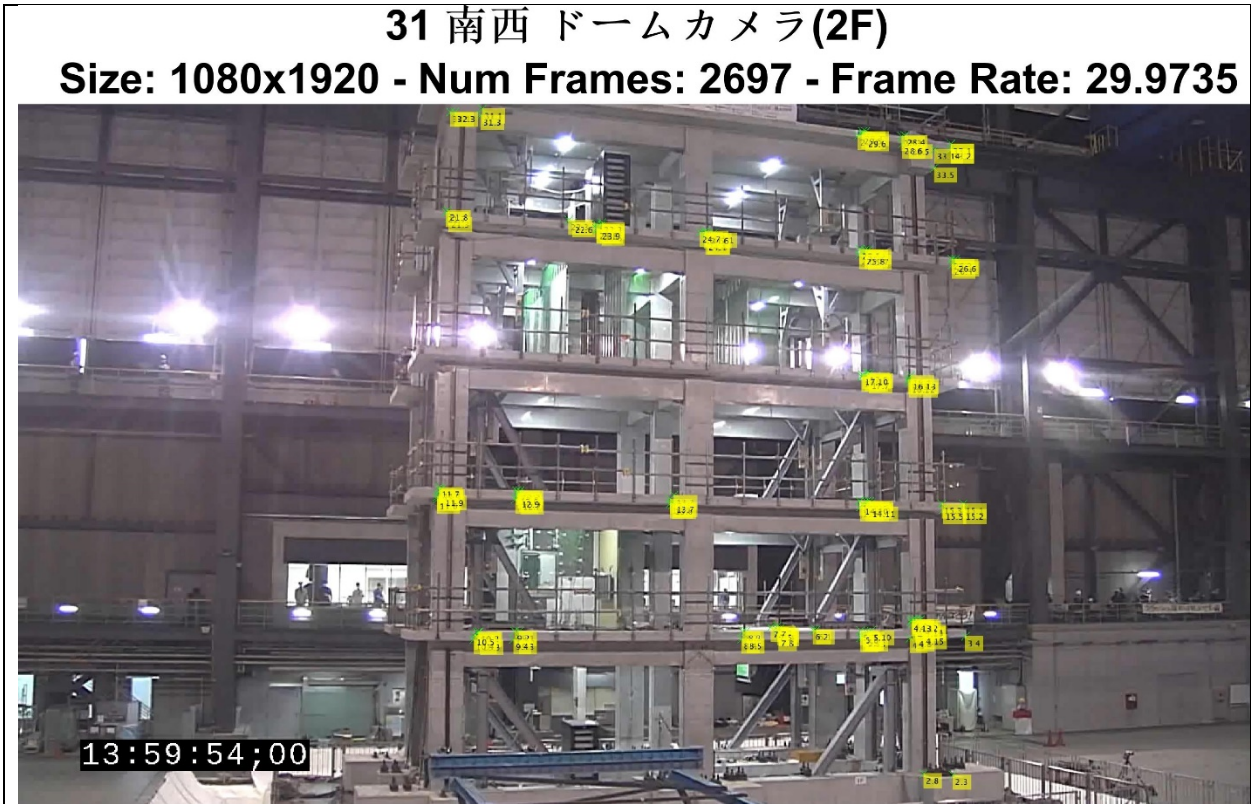


Figure 1 Detected Features for Tracking using Computer Vision.

The results were impressive with minimum difference between traditional sensor and CV, indicating the importance that CV can have in SSHM, Figure 2.

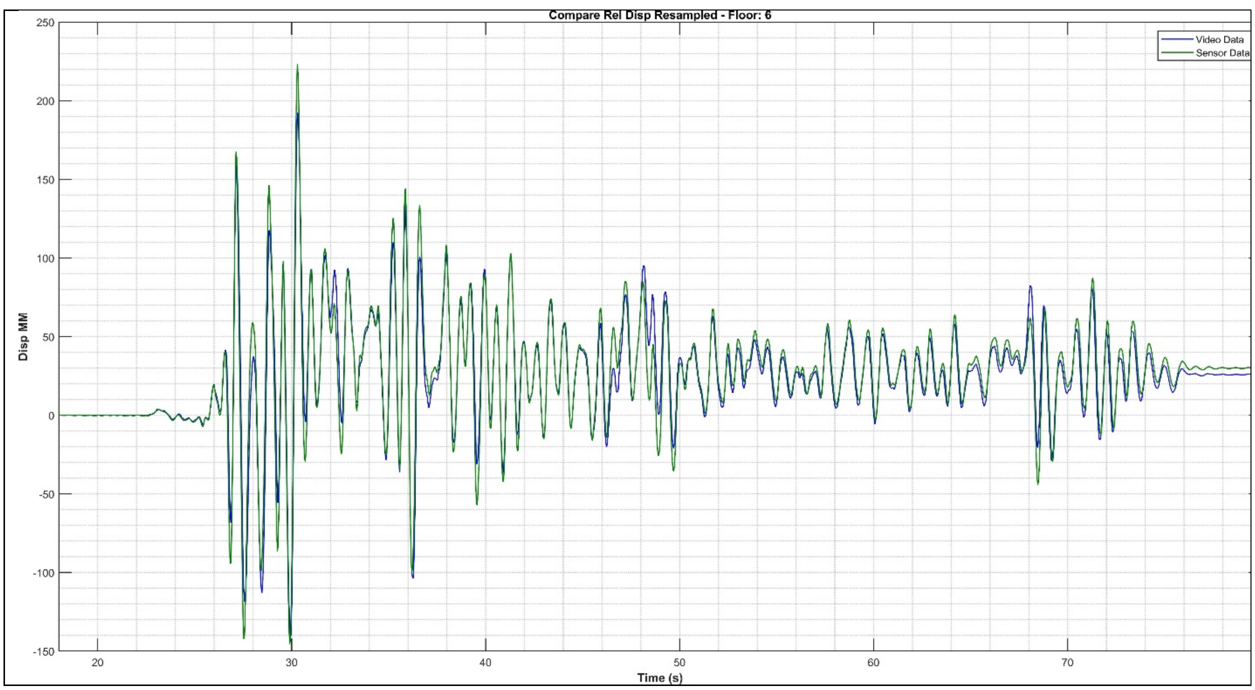

Figure 2 Relative to base displacements derived from videos and recorded displacement.

## Computer Vision Introductory Curse.

Due to the excellent results, I prepared course notes and taught a 15-hour course on Computer Visions for Structural Engineers. The course allows the student to understand the key tools and limitations of the techniques. Students were able to develop their own software for tracking the response of civil structures. The opportunity allows me to further deepen my knowledge on computer vision and the best procedures to teach these methods to our students.


## Acknowledgement

I am thankful to the University of Tokyo and the Earthquake Research Institute, particularly to Professor Kusunoki and staff at International Office for providing an interesting opportunity to do research in mutual areas of interest. Also, I would like to thank Dr. Trevor Yeow and the students that with their discussions allowed me to further improve my work.


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