# DISPLACEMENT MEASUREMENT ON BUILDING MODEL WITH COMPUTER VISION

**Nuh Muhammed PİŞKİN[1]-M.Serdar AVCI[2]-Emre ERCAN[3]*-Ayhan NUHOĞLU[4]**

*Ege University, Faculty of Engineering, Department of Civil Engineering, Izmir/ Turkey, nmpiskin@gmail.com*

[2] *Ege University, Faculty of Engineering, Department of Civil Engineering, Izmir/Turkey, mserdaravci@gmail.com @ege.edu.tr*

[3] *Ege University, Faculty of Engineering, Department of Civil Engineering, Izmir/Turkey, emre.ercan@gmail.com*

[4] *Ege University, Faculty of Engineering, Department of Civil Engineering, Izmir/Turkey, ayhan.nuhoglu@ege.edu.tr*

**Abstract:** Computer vision is widely used in the solution of many engineering problems in recent years. Displacement measurement of structural elements are difficult to measure in civil engineering. In order to measure these displacements in a more practical and sound way, object tracking algorithm were developed. As an application, displacement at the peak of a model structure was measured by displacement meter and also the displacement of the point was measured through the video image by a computer algorithm of the same structure. In addition, experiments are repeated with different quality videos. The results were compared and the effect of video quality and other parameters on displacement measurement were investigated.

**Keywords:** Computer Vision, Displacement, Object Tracking, Structural Health Monitoring

## Introduction

With the developing technology, structures with different characteristics emerge. The displacement of these structures under load is very important for the healthy use of the structure.

To monitor displacements occurring in the existing systems, acceleration and displacement meters should be placed at each point. Due to the different architectural features of the buildings, the installation of the devices is difficult. For these reasons, displacements need to be measured by image-based systems. In order to develop such systems, deficiencies and defects of the system must be tested. (Feng and Feng, 2018).

In this study, the displacements formed at the top of the model under vibration applied on a 19 storey building model were recorded. In addition, the same experiment was performed with video recordings at different resolutions. At the end of the study, error rates between actual displacements and image based displacement measurements were compared.

## Method

### Object Tracking and Displacement Measurement

Object tracking is to identify the object within the tracked area by tracking algorithms and monitor that object from the video frames. By having information about the movement direction and position of the monitored object, parameters such as displacement, speed and acceleration can be accessed. The unit of the displacement which is found is pixel. Therefore, in order to achieve the actual displacement, the actual length of an edge of the tracked area must be known. The metric value corresponding to one pixel is calculated from the ratio between the actual length and the length in pixels of this edge. With the obtained ratio, displacement values were converted to metric system.

### Experimental Study

The displacements of a 19 storey model structure under vibration were investigated. As a result of the investigations, a potentiometric displacement meter was placed at the top end of the structure where maximum displacement is predicted (Figure 1.). A reference object is also placed at the same point. The width of the reference body is set to 4 cm. Then, for the follow-up, the square was placed on a square reference object with an edge of 4 cm.

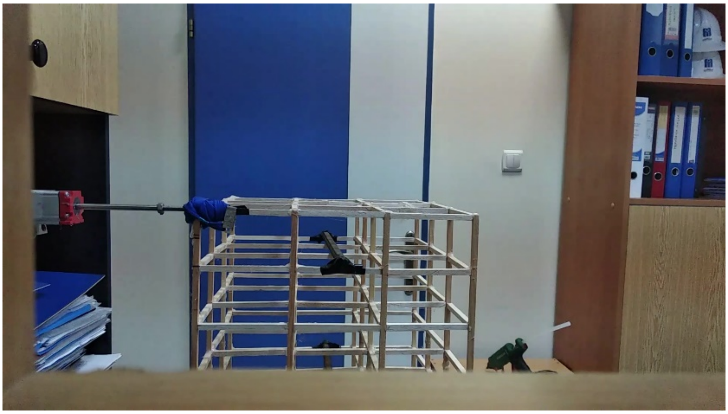


**Figure 1.** Displacement Meter Connection and Tracking Point

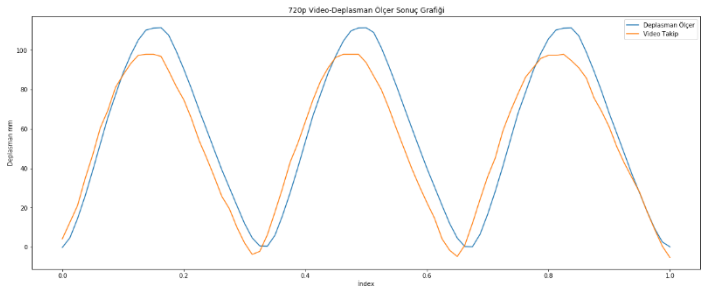
Sinusoidal vibrations were given to the structure model and displacements were created at the reference point. The displacements were recorded with 720p, 1080p, 2k format video recordings and potentiometric displacement meter.

**Application and Findings**

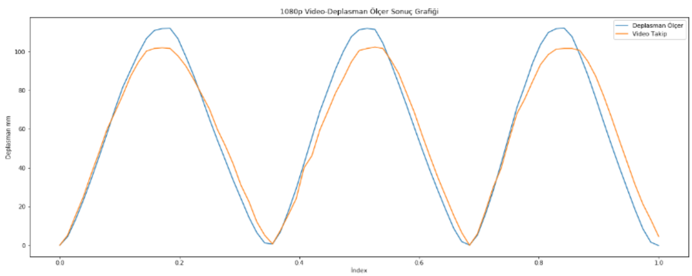
The potentiometric displacement meter can record up to 8 data per second while videos record at 30 FPS (30 data / second). In order to put these two data in the same time interval, the video data was marked with the time tag and brought to the same time interval with the potentiometric data. Then the error between the potentiometric displacement meter data and the displacements obtained from the videos was calculated. Figure 2 shows the displacement result graphs taken from the potentimetric displacement meter and videos. In Table 1, the errors between the displacement values obtained from the 2k, 1080p, 720p video formats and the actual displacements are given.

**Table 1.** Error values between potentiometric and video displacements

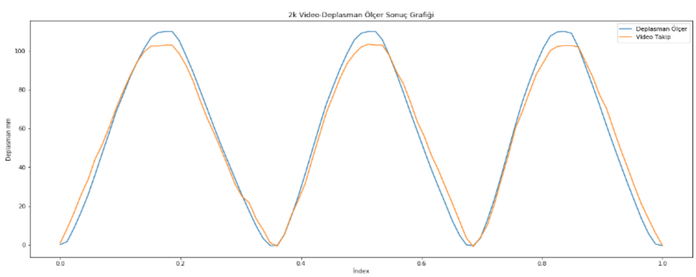
| Unit mm | 2k Video | 1080p Video | 720P Video |
|---|---|---|---|
| R2 Score | %97.6 | % 94.9 | % 91.73 |
| Square Mean Error | 5.3 | 7.6 | 10.21 |
| Absolute Mean Error | 4.6 | 6.44 | 8.64 |




a)




b)




c)

**Figure 2**. Different format video-displacement meter results graphs a) 720p, b) 1080p, c) 2k

## Conclusion and Suggestions

### Result

In this study, the effect of image quality on image based displacement measurements was investigated and the potential of image based displacement measurements in displacement measurement was investigated. The performance of image-based displacement measurement has been seen to be adequate and consistent, and it has been found to have great advantages over standard methods in terms of cost and usability when considering the setup processing.

**Suggestions**

Setting the video resolution according to the computer which is used

It is important for the accuracy of the results that the selected reference length is clearly visible. To be sensitive in determining initial condititations,

It is suggested that the researches in this field will be further expanded and different tracking algorithms will contribute to the development of precise measurements.

## References


Feng, D., and Feng, M. Q., 2017, Identification of Structural Stiffness and Excitation Forces In Time Domain Using Noncontact Vision-Based Displacement Measurement, Journal of Sound and Vibration, 406: 15–28 pp.

Gündoğan, M., 2012, Çelik Model Köprünün Yapı Sağlığının Gözlenmesi, Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 97 s.

Gazar E., 2018, Object Tracking with OpenCV, https://ehsangazar.com/object-tracking-with-opencv-fd18ccdd7369 , (Erişim Tarihi: 4 Nisan 2019).

Kim, S. W., and Kim, N. S., 2011, Multi-point Displacement Response Measurement of Civil Infrastructures Using Digital Image Processing, Procedia Engineering, 14: 195–203 pp.