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Transport infrastructure monitoring: A ground based optical displacement monitoring system, field tests on a bridge, the Musmeci's bridge in Potenza, Italy.

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A gound based optical displacement monitoring system, "NIODIM", is being developed by Norsk Elektro Optikk in the framework of the activities of the European project "Integrated System for Transport Infrastructure surveillance and Monitoring by Electromagnetic Sensing" (ISTIMES), funded in the 7th Framework Programme (FP7/2007-2013). The optical displacement monitoring system has now participated in two real life field campaigns one in Switzerland and one in Italy. The latter, the tests in Potenza, Italy, will be presented in the following.

The NIODIM system has undergone some development during the last year to adopt it for use in a somewhat higher frequency domain by changing the camera sensor part. This to make it more useful for monitoring of structures with oscillation frequencies tens of Hz. The original system was intended to a large extent to monitor land slides, quick clay and rock slides and similar phenomena typically having a relatively slow time response. The system has been significantly speeded up from the original 12 Hz. Current tests have been performed at a frame rate of 64 Hz i.e. the camera part and data processing unit have been running on 64Hz. In connection with the tests in Italy the data processing has been upgraded to include sub-pixel resolution i.e. the measurement results are no longer limited by pixel borders or single pixels.

The main part of the NIODIM system is a camera capable of operating at a sufficiently high frame rate. This camera will typically be mounted on firm ground and will depict and monitor a reference point, typically a light emitting diode, LED, which will be mounted on the object susceptible to move. A processing unit will acquire the images from the camera part and find the position of the LED in the image and compare that to threshold values and if required raise a warning or an alarm. The NIODIM system can either be a standalone system or be an integrated part of the overall ISTIMES system, the ISTIMES system being a decision support system.

Field trials as part of the ISTIMES project took place in Potenza, Italy, for a week in July 2011. The test target was Musmeci's bridge, a bridge with a design where aesthetic values have been just as important as traditional civil engineering aspects. Several technologies and techniques were tested at the same part of the bridge to allow for data correlation between different sensors. The camera and processing parts of the optical displacement monitoring system were mounted on a concrete wall at the one end of the bridge while the LED reference points were mounted on the bridge approximately 40 metres away.

The tests at the Musmeci's bridge are successful and verifying some of the findings from the tests in Switzerland. However, we learned a lesson with regards to temporary mounting of the reference points using glossy stainless steel parts. A short period early in the morning, when illuminated by the sun, these stainless steel parts were just as bright as the LED reference point leading to potential noise in the measurements. Due to availability of the raw data this could be fixed later doing post processing on the stored data.

One of the findings was that we have relatively large time of day variation that appear to be periodic with a cycle time of about 24 hours, at least with similar weather conditions. These displacements appear to be in the order of 10 mm and is probably due to thermal effects. Several shorter displacements have also been registered with amplitudes of a couple of mm and duration around 10 seconds. These shorter displacement peaks appear to be caused by heavy vehicles passing by on the bridge. The introduction of the processing using sub-pixel resolution looks very promising and appears to give a significant improvement of the actual resolution of the system.

Even thought the measurements in the field are successfully completed we have noted larger slowly moving displacements than originally expected. This combined with shorter lasting peaks could lead to measurements above pre-set thresholds and could further on lead to a raised alarm. Such an alarm will most likely be regarded as a false alarm caused by the superposition of the long time constant thermal displacement and the short time constant peak possibly due to a vehicle. These results have made us re-think our system for handling warnings and alarms based on measurements done. There must be different thresholds for slow events and for quick event and the combination thereof. After taking into consideration the lessons learned our optical displacement monitoring system has potential of being a reliable and robust system solving the problem it was intended to solve.

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