PANOPTiS

Development of a Decision Support System for increasing the Resilience of Road Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools

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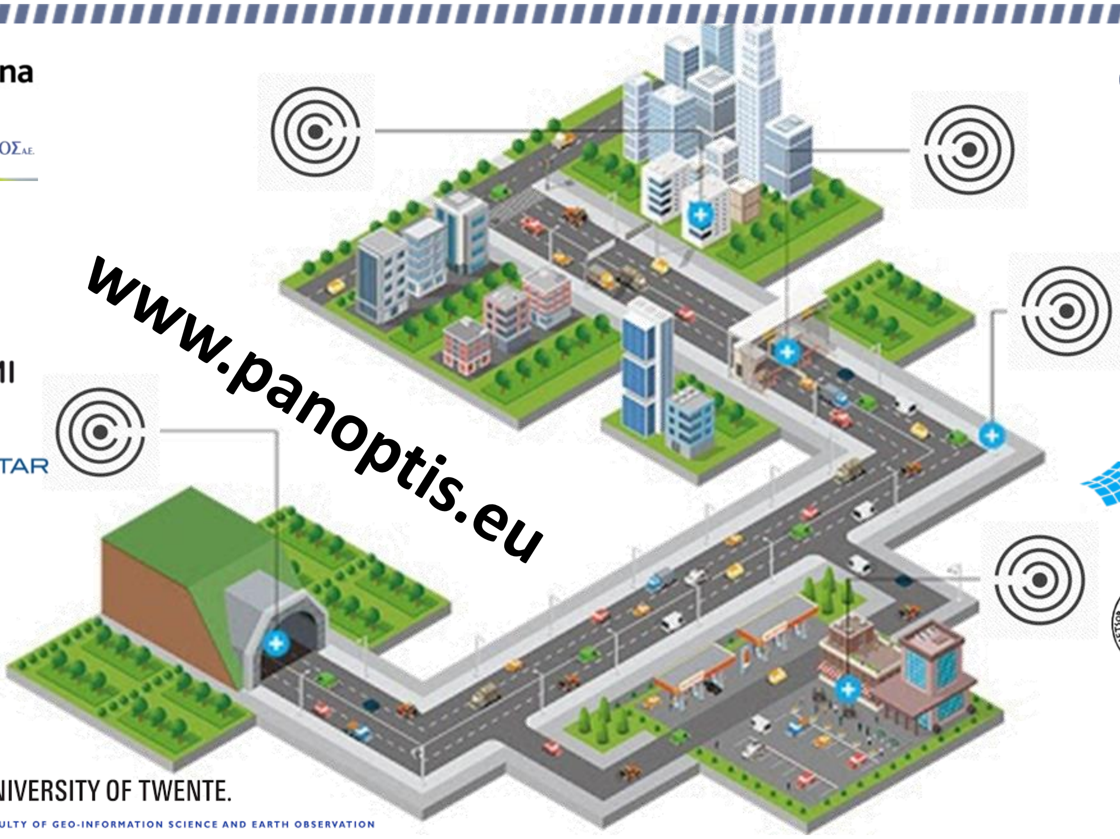

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PANOPTIS aims at increasing the resilience of the road infrastructures and ensuring reliable network availability under unfavorable conditions, such as extreme weather, landslides, and earthquakes. The main target is to combine downscaled climate change scenarios with simulation tools (structural/geotechnical) and actual data (from existing and novel sensors), so as to provide the operators with an integrated tool able to support more effective management of their infrastructures at planning, maintenance and operation level.

The road so far…

1. Earthquake & landslide vulnerability estimation.
2. Scene understanding via deep learning models.
3. UAV based inspection for anomaly detection on road surface.
4. Weather micro-climate models & extreme events analysis.

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Project Objectives

01. Utilize a multi-sensor fusion approach, including structure health monitoring, radar and weather sensors, airborne instruments, and external sources.

02. Quantifying the climatic, hydrological, and atmospheric stresses on the RI elements.

03. Multi-Hazard modelling which includes indirect climate change related hazards (i.e. flooding) as well as geo-hazards (i.e., earthquakes and landslides).

04. Tailored weather and precipitation forecasts for risk assessment across the RIs' "hot spots".

05. Structural and geotechnical safety risk assessment using specialized simulators.

06. Computer vision and Machine Learning damage diagnostic for diverse RI.

07. Design of a Holistic Resilience Assessment Platform.

08. Enhanced visualization interface and an Incident Management System.

PANOPTIS is being developed by a multi-disciplinary team, coordinated by AIRBUS DS SAS, in the EU's Horizon 2020 framework. The project was launched in May 2018 and will run for three and a half years (forty-two months), to allow enough time for the development and validation of the applied technologies.

A holistic approach

The road corridor is divided into three distinct monitoring levels: A) the road surface, B) adjacent RI objects and C) adjacent RI areas (see Fig. 1). PANOPTIS platform is capable to handle simultaneously all the above. Towards that direction, deep learning models are used to identify areas of interest or various hazards that may cause any type of disruption.

Weather impact is also considered by employing various simulation and forecasting techniques. All the available information and models' outcomes are easily accessible by the operators at the control center.

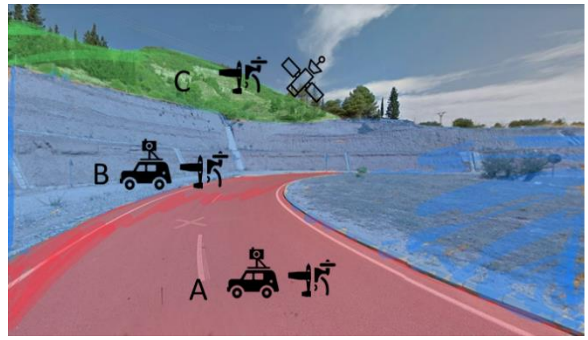

Figure 1. Different monitoring levels in the road corridor.

Deep Learning Tools

Reduction of natural disaster-related fatalities through preventive information, hazard awareness, and disaster relief is at the core of risk prevention and crisis management policies (see Fig. 2). PANOPTIS employs innovative computer vision methods and new sensing capabilities for damage diagnosis of RIs (e.g. tunnels and bridges), by making use of ground and UAVs respectively.

Figure 2. Detection of events that may affect the efficient movement of vehicles, through a transportation network.

Corrosion detection on metal constructions is a major challenge in civil engineering for quick, safe, and effective inspection. Deep learning can be used for pixel-level detection. Towards that direction, PANOPTIS employed pixel level detection mechanisms (see Fig. 3).

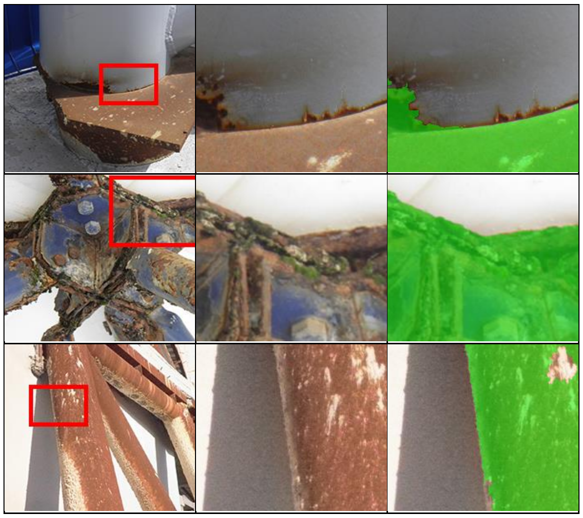

Figure 3. Illustrating the segmentation results for specific areas.

C. Provide low cost micro-climate stations which can be deployed at large numbers along the RI forming a dense grid of sensors to assist the provision of a detailed picture of the conditions.
D. Offer real-time information for monitoring and anticipating meteorological extreme events as well as data to other specialized modules.

Figure 5. Up: forecasted precipitation field for the A2 Highway, Spain.

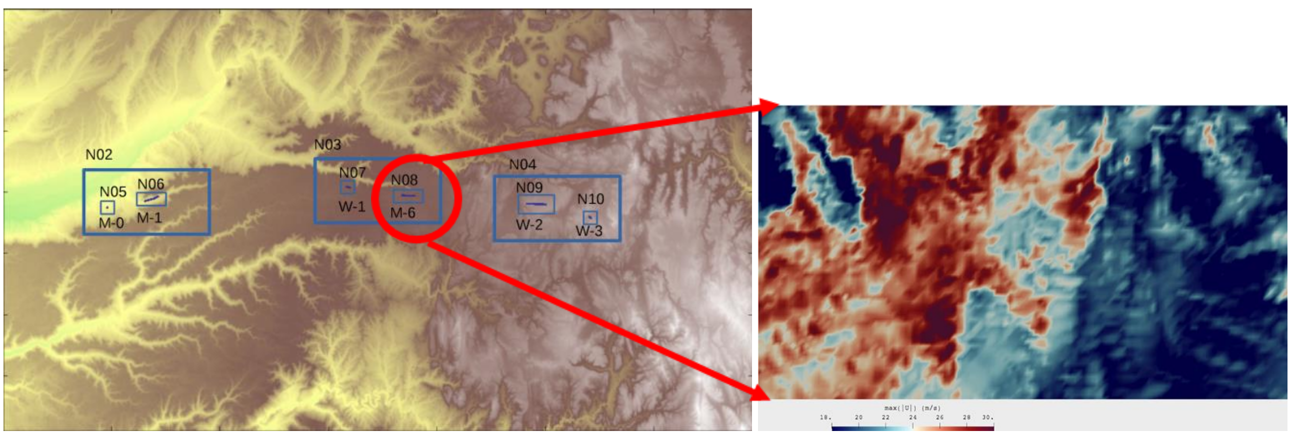

Figure 4. Left: Visualization of the nested domains that are modelled with higher resolution. Right: Visualization of the maximum gust distribution at 2 m height from nest region N06.

Weather monitoring & impact assessment

PANOPTIS project emphasize on weather impact analysis as preventive action towards increased infrastructures resilience. The following outcomes summarize the work done so far:

A. Describe the severity analysis of climate impacts performed for the PANOPTIS pilot sites in Spain and Greece
B. Generate a reference database of average and extreme indicators of high representativity of potential impacts (atmospheric hazards) for the selected study regions at the areas of interest.

Vulnerability

Lightweight steel structures, such as sign bridges and toll booths, are susceptible to wind loads, because of their small weight and significant exposed surface. Simulation models consider such probabilities and inform the operators.

A section of the Egnatia Motorway, located in the Northern part of Greece, was used as a test case. The specific area is subject to high exposure of the structures - bridges and geotechnical works (high embankments, big cuts) - and prone to catastrophic seismic events, high annual precipitations that affect active landslide areas, traffic overloading, and geotechnical movements (landslide, settlements, rock-falls).

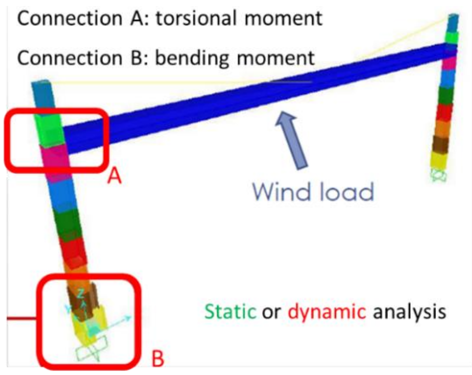

Figure 6. Load analysis for a steel traffic sign.

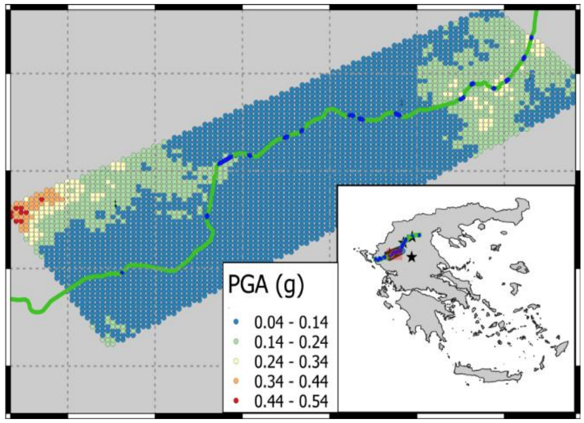

Figure 7. All potential ground motion fields are generated by considering both distributed seismicity and seismicity on faults, for a section of Egnatia Odos highway

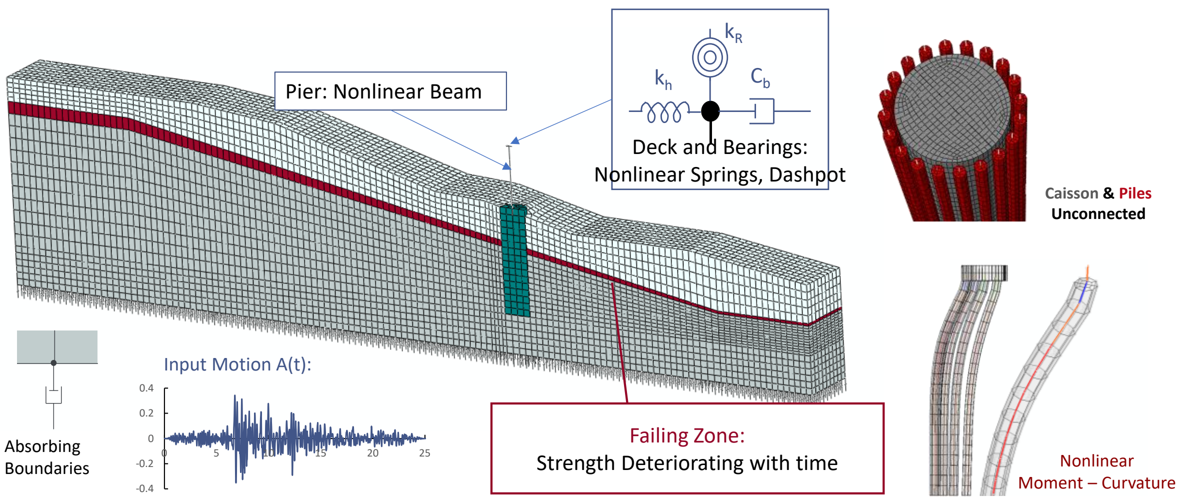

Figure 8. A 3D model simulation for one among the bridge's foundation pillars.

Bridge G1 is located in mountainous terrain a few kilometers east of the town of Metsovo in Northern Greece. The structure consists of two twin T-girder bridges with average span 37 m and significant pier height, reaching up to 25 m.

The underlying geology includes soft rock formations (flysch and ophiolite). The problem is the shallow surface layer, which consists of weathered cohesive material. Significant landslide movements have been recorded affecting mainly the 5^{th} row of piers, approximately in the middle of the bridge.

The seismic hazard is considered in conjunction with landslide displacements due to rainfall, as the region is prone to moderate seismicity.

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