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Development of a road bridge digital twin for simulating traffic loadings

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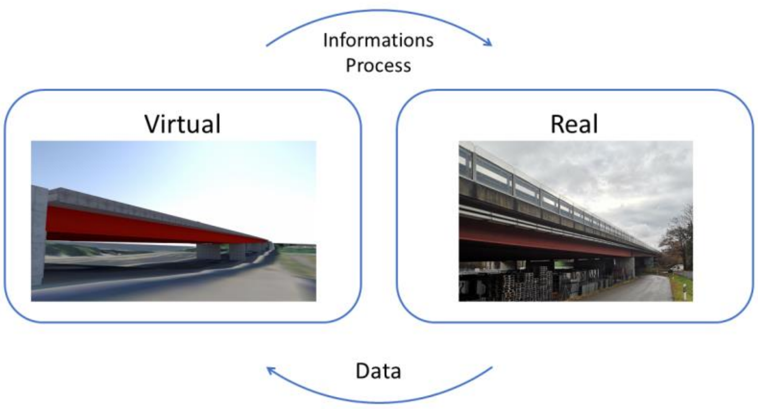
ABSTRACT

The bridge over the Venoge, built in 1966 and extended in 1997, is a composite bridge located on the highway between Lausanne and Geneva. The aim of this project was to develop a digital twin of this bridge, which consists of a digital representation of the real structure with a connection to the real structure through an efficient data transfer pipeline. The project will contribute to understanding the steps and challenges required to have a numerical model as close as possible to reality and what are the most important parameters to consider. To obtain this digital twin, a BIM model of the bridge was built and then, using measured displacement and visual inspections of the bridge, the BIM model was transformed into a digital twin.

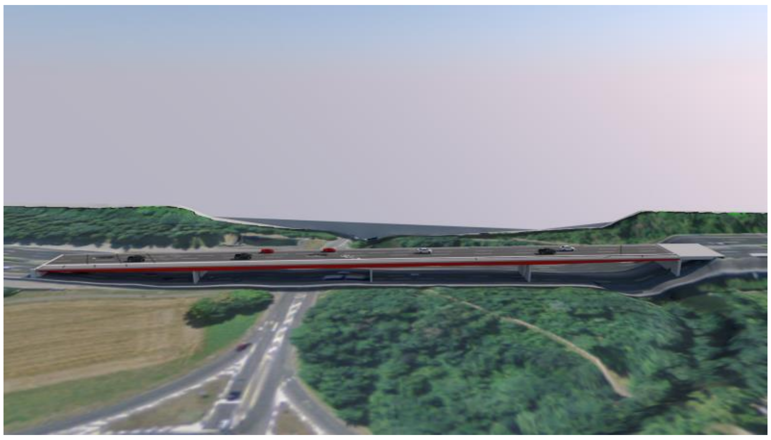
DIGITAL TWIN

A digital twin can be described as a realistic representation of existing assets, which can be a continuous process that refines that representation on an ongoing basis. It should be composed of three elements : a physical system in a real environment, a digital system in a virtual environment and data/information pipeline connecting the two parts. This model can help the maintenance process to fix and predict potential problems that may arise.



BIM MODEL

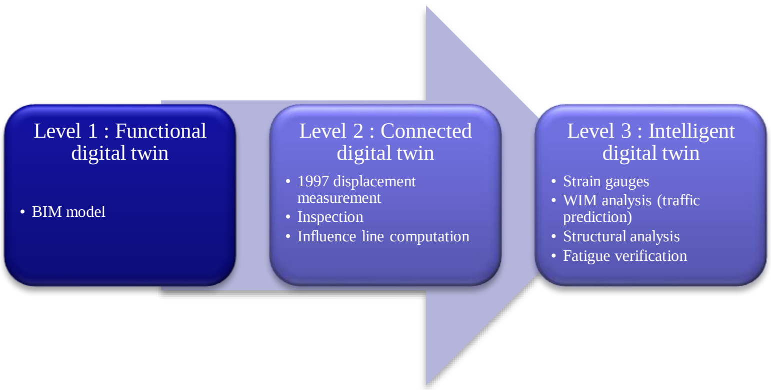
To build a digital twin, it is first necessary to have a BIM model that represents, as closely as possible, the geometrical aspects of the bridge. The model was done using Allplan Bridge, a BIM software extension specially made for bridges, which allows all BIM functions for bridges. The model was then imported into a BIM software to add some architectural aspects.



FROM BIM TO Digital Twin

The BIM model was then updated using displacement measurements from previous load case experimentation. This was done to calibrate the model to make its behaviour to be as resemblant as possible to the physical system. It was found that the increase in concrete strength with age as well as the properties of the steel-concrete composite connection are the most critical parameters in order to reproduce the behaviour of the real bridge.

A visual inspection was completed to allow the updating of some geometrical details and to improve the similarity with the real bridge. Finally, a fatigue verification procedure was proposed where actual traffic data from nearby WIM stations (Denges) was used to make predictions of future worst-case scenarios that can be implement in the digital twin to obtain maximum stresses and stress ranges.



CONCLUSION

In this master thesis, the level 1 of the digital twin was achieved by implementing the BIM model, to be as realistic as possible to the geometry of the real bridge. Then, using data from the bridge itself, such as the 1997 displacement, it was possible to calibrate and update the model to be as close as possible to its actual behavior. A visual inspection was also done to update some geometrical details, to improve the resemblance with the real bridge. This level 2 could provide some results such as lines of influence.

This connected digital twin realized in this project is a good platform for future work, which will consist in reaching level 3 and becoming an intelligent digital twin.