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Monitoring infrastructure stability in alpine permafrost

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The retreat of permafrost is a highly important issue in many arctic and alpine regions. Especially infrastructures such as buildings, power lines or cable car pylons are affected by the consequences of permafrost degradation. Thawing of ground ice can destabilize the ground and result in settling or tilting of infrastructure.
Parts of the cable car infrastructure of the Gemsstock skiing resort in Andermatt (Swiss Alps) are built in alpine permafrost. Thawing permafrost could potentially cause tilting of building walls and therefore affect rope guidance and structure stability. The infrastructure is therefore carefully monitored at regular intervals. Wall inclinations are measured manually at selected points of interest using fixed benchmarks. This is a time-consuming task which requires bulky measurement tools, manual recordings and manual post-processing of the data.
We present a first concept for a new monitoring system for infrastructure located in permafrost areas. The system is currently being tested at Gemsstock where eleven points of interest have been selected. At these points located on a pylon and inside the top station of the cable car, plastic markers have been installed as benchmarks. The measurement system consists of a small handheld computer with a user friendly software interface and a high precision inertia orientation sensor. The orientation sensor is a small box which directly monitors inclination angles in three perpendicular directions. It is placed at the markers and a measurement is started from the computer user interface. The three measured angles are directly transmitted and displayed on the handheld. In addition, the inclination deviations in comparison to a reference measurement are visualized in a time series plot. The position of the cable car cabins, which might affect the inclinations, can be recorded via pre-defined buttons on the interface. The combination of the simple setup and short measurement times of only a few seconds allows immediate on-site visualization and analysis of the results. Critical situations can be identified directly and possible measurement errors can be assessed by a repeated measurement. Post processing and in-office analysis is therefore dispensable.
First tests of the system have shown that inclination monitoring is simplified and accelerated in comparison to the previously used method. Nevertheless, we also recorded that external factors like the position and the movement of the cable cars have a discernable effect on the wall inclinations. The first tests also indicate that initial challenges of the system, including repeatability and stability issues might affect the accuracy of the measurements. These disturbing factors need to be quantified before the system can be used in an operational manner by practitioners.