Technische Universität München

News Release

Munich, 04/07/2010

Technology from TUM researchers makes continuous monitoring of endangered alpine regions possible

Monitoring System Warns of Slippery Slopes

As a consequence of climatic changes, the number of avalanche threats has been increasing in the Alps and other alpine regions, with fatal consequences for people and infrastructures. Continuous monitoring of every endangered area has been lacking until now due to high costs and manpower requirements. Geological researchers in Munich have now developed an inexpensive system, which with the help of several technologies can continuously monitor slopes, assess changes, and provide early warnings to communities potentially affected by landslides. The scientists themselves hope to improve their understanding of these natural phenomena by means of long-term measurements.

Doren in the Bregenzerwald, February 2007: a slope 650 meters long breaks, resulting in a massive slide into the valley below. The nearest residential buildings are very close to the 70-meter-high rim. This barely avoided catastrophe is not the only incident. Geologists have been monitoring increasingly unstable masses of earth over the past few years in the Alps and other Alpine regions, which have slipped down slopes and on slid unchecked down valleys to more stable substrates. The scientists are primarily looking at heavy rainfall and snowmelt caused by climatie change, which in turn has caused the substrate to soften and has increased the weight on it.

Identifying potentially dangerous mountain slopes is not difficult. Many of them have been unstable for centuries, and the remains of previous slides indicate prior disasters. In addition, geological records that reveal slopes at risk are available in Alpine countries. However, it has not been possible until recently to monitor any unsettled masses continuously. In order to detect movements, experts had to insert probes into drilled pockets and measure marked points on the surface. Permanently installing such devices is, however, normally too expensive to consider. Scientists can only do their inspections at intervals using this technique and gain limited insight about the events inside the slope.

Researchers at the Technische Universität München (TUM) and the Universitaet der Bundeswehr Muenchen have now made decisive progress in the development of geo-sensors and combined them with monitoring software into an early warning system that is both flexible and inexpensive to deploy. They can also drill into the ground at several locations. "We simply fill the drill pockets with basic coaxial cable, such as one uses for antenna cables, for example," says Professor Kurosch Thuro, Engineering Geology Chair at TUM. The scientists use a very simple but effective mechanism; if the surface mass of earth starts to slip, the cable will be crushed at the transfer point against the unmoving stratum. A small transmission device on the surface records this event and forwards the information. In addition, the Engineering Geodata Department at the Bundeswehruniversität (Prof. Otto Heunecke) distributes sensors, whose position can be determined by means of GPS, over the

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slope. Here also, the challenge lies in achieving precision measurements in the millimeter range using ready-made, inexpensive components for recording even the smallest movements.

As the third step, the scientists are using a new-generation measuring device, the so-called video-tachometer, which uses a laser scanner and camera. Where one once had to set up artificial reflectors to measure the direction, distance and height of a target object, today the devices recognize natural target objects, such as stones or tree stumps, for example. Scientists have now programmed the manufacturer's prototypes so that each can detect the movements of a number of target objects. The tachometer charts the structure of a cliff, for example, re-measures it at periodic intervals, and records the changes while doing so. "If we don't have to set up reflectors, we will save even more money," says Professor Thomas A. Wunderlich, Chair of Geodesy at TUM, "And we do not have any more concerns about grazing cattle running over them."

With these three components, the scientists create a granular network of monitoring points across the slope. The data is collected at a central data base. The brain of the system assesses the data together with additional parameters, which include the weather data most importantly. The researchers tested their development at Sudelfeld in the Upper Bavarian town of Oberaudorf for three and half years. A hillside there is moving and threatens several mountain pastures and a federal highway. "Impressively, the data streams have shown us what is happening to the slope, how the precipitation and frost are affecting it and what is happening from a mechanical point of view," says Kurosch Thuro. "Now, we understand these movements much better."

The scientists can evaluate individual events much better for this reason. As the slope very quickly slid four millimeters in May 2010, they knew that this distance was exceptional and a source of great concern, even though it looked minimal for that area at first. Furthermore, the assessment of the data made issuing an early warning possible even before the slope had really moved. "Because we now know how the rainfall is affecting the area, we were able to determine a threshold," explains Thuro. If the ground water pressure exceeds a certain value, the system will trigger the alarm. "Then, there is a period of two and half days between the increased level and the movement of the slope."

Affected communities get an immediate benefit from the system, because they will get the data directly and will have it translated into comprehensible charts and explanations. After an early warning has been triggered, the responsible parties can barricade the slope, re-direct traffic, or evacuate buildings, as is appropriate for the level of danger.

In collaboration with two industrial partners, the researchers are now developing the system requested by the Bundesforschungsministerium (Federal Research Ministry) and the Deutsche Forschungsgemeinschaft (German Research Foundation) for marketability, using "Early Warning System for Alpine Slopes (alpEWAS)" as the project name. Interested parties have already made themselves known and a portion of the system is already being used in Doren. Professor Thuro expects significant progress not just for the users but also for science itself. "As the number of slopes that we can monitor continues to increase, we will understand even larger relationships between individual events and the alpine macro-climate."

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