Predicting landslides with light

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Optical fiber sensors are used around the world to monitor the condition of difficult-to-access segments of infrastructure—such as the underbellies of bridges, the exterior walls of tunnels, the feet of dams, long pipelines and railways in remote rural areas.

Now, a team of researchers in Italy are expanding the reach of optical fiber sensors "to the hills" by embedding them in shallow trenches within slopes to detect and monitor both large landslides and slow slope movements. The team will present their research at The Optical Society's (OSA) 98th Annual Meeting, Frontiers in Optics, being held Oct. 19-23 in Tucson, Arizona, USA.

As major disasters around the world this year have shown, landslides can be stark examples of nature at her most unforgiving. Within seconds, a major landslide can completely erase houses and structures that have stood for years, and the catastrophic toll they inflict on communities is felt not just in that destructive loss of property but in the devastating loss of life. The 1999 Vargus tragedy in Venezuela, for instance, killed tens of thousands of people and erased whole towns from the map without warning.

The motivation for an early warning technology, like the one the Italian team has devised, is to find a way to mitigate such losses —just as hurricane tracking can prompt coastal evacuations and save lives.

Predicting Landslides by Detecting Land Strains

Landslides are failures of a rock or soil mass, and are always preceded by various types of "pre-failure" strains—known technically as elastic, plastic and viscous volumetric and shear strains. While the magnitude of these pre-failure strains depends on the rock or soil involved—ranging from fractured rock debris and pyroclastic flows to fine-grained soils—they are measurable. This new technology can detect small shifts in soil slopes, and thus can detect the onset of landslides. Usually, electrical sensors have been used for monitoring landslides, but these sensors are easily damaged. Optical fiber sensors are more robust, economical and sensitive. This is where the new technology could make a difference.

"Distributed optical fiber sensors can act as a 'nervous system' of slopes by measuring the tensile strain of the soil they're embedded within," explained Professor Luigi Zeni, who is in the Department of Industrial & Information Engineering at the Second University of Naples.

Taking it a step further, Zeni and his colleagues worked out a way of combining several types of optical fiber sensors into a plastic tube that twists and moves under the forces of pre-failure strains. Researchers are then able to monitor the movement and bending of the optical fiber remotely to determine if a landslide is imminent.

The use of novel fiber optic sensors "allows us to overcome some limitations of traditional inclinometers, because fiber-based ones have no moving parts and can withstand larger soil deformations," Zeni said. "These sensors can be used to cover very large areas—several square kilometers—and interrogated in a time-continuous way to pinpoint any critical zones."

The findings clearly demonstrate the potential of distributed optical fiber sensors as an entirely new tool to monitor areas subject to landslide risk, Zeni said, and to develop early warning systems based on geo-

indicators—early deformations—of slope failures.

More information: Presentation FTu2B.4, "Distributed Fiber Optic Sensing Techniques for Soil Slope Monitoring," takes place Tuesday, Oct. 21 at 11:30 a.m. MDT at the Arizona Ballroom, Salon 9 at the JW Marriott Tucson Starr Pass Resort in Tucson.

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