Advanced Self-Powered ‘Dragon egg’ Sensor Units

Research area: Monitoring

PI: Professor Tom Scott, University of Bristol

Partners: Sensor Driven Ltd**,** University of Cambridge, University of Sheffield, National Centre for Nuclear Robotics

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Contact details: t.b.scott@bristol.ac.uk

The Challenge

Volcanoes are inherently unpredictable, therefore it is notoriously difficult to record their behaviour into reliable analytical models – instead, real-time data of volcanic activity is essential for providing early warning of an imminent eruption.

Such data is often best acquired immediately next to a volcano’s active vent but it is understandably difficult and very dangerous for humans to get sensors so close. The payoff from such sensors would be significant, delivering better prediction and warning of eruptions, which in turn would provide rescue services with advanced warning and additional time to coordinate evacuation of endangered residents living in the nearby area.

Such an extreme, hazardous environment is as unforgiving to electronics as it is life, so tackling this problem necessitates the development of highly specialised sensor pods that can withstand the harsh conditions around the heart of a volcano.

The Solution

The “dragon eggs” being developed at the University of Bristol are autonomous, intelligent sensor pods designed to monitor volcanic activity. They are being equipped with a range of state-of-the-art sensors for temperature, humidity, vibrations, and numerous toxic gases, and are being designed to be able to operate in the extreme conditions of a volcano without requiring maintenance.

These sensor pods are the result of an intense cross-faculty collaboration and incorporate remarkable new technologies invented and developed at the University of Bristol. Among these, the self-energising event detectors called “sensor-driven” detectors are a vital part of this new device, as they allow "dragon eggs" to remain dormant for prolonged periods of time to preserve power, until volcanic activity is detected and the dragon egg “hatches” into a full featured remote monitoring station with a wireless transceiver.

Designed by the Electrical Energy Management and the Digital Health research groups, the detectors have the lowest stand-by power consumption in the world.

The sensor units with UAV ready for deployment

They can be activated by pulses as low as 5 picojoules (about 50,000 times less than the energy of a single flying mosquito). Therefore, sensor-driven detectors do not require battery power and instead use a fraction of the energy contained in the sensor signals.

Due to the extreme conditions near the crater, the "dragon eggs" are designed to be deployed by flying Unmanned Aerial Vehicles (UAVs). Using a lightweight yet fast drop-off mechanism, a small drone with high agility can be used for the deployment missions, minimising the time spent in the danger zone and limiting the exposure to highly corrosive volcanic gases. The eggs are placed on the slope of the volcano and they are designed to hatch when the sensor-driven module detects vibrations caused by volcanic tremors. Thanks to this detection circuit, the eggs can remain in service for many months without depleting their energy resources.

With a powerful wireless transmitter, the dragon eggs can report data to a base station with a satellite uplink at a safe distance of up to 10km, away from the dangers of the volcano. The Sensor Driven technology is key to maximising the life span of each individual egg. The eggs synergise together as an intelligent low power sensor network with a star topology, which enables the network to continue operation even after several eggs have been engulfed in lava and flames.

The Impact

These detectors have been licenced to and further developed by tech start-up Sensor Driven Ltd, and have already been deployed in the Stromboli volcano in Italy, marking the first attempt to use such a technology for monitoring an active volcano.

Combining the cross-disciplinary expertise and technologies from several complimentary grants working together has enabled the team to deliver results on a much shorter timeline and smaller budget than would usually be possible.

The researchers envisage numerous applications for the technology they are developing, including remote monitoring of glaciers, geological faults and nuclear waste storage sites.