

Internet of Things for Natural Hazards and Warnings

Abstract

Natural hazards pose a significant threat to ensuring community safety. Information is needed to help stakeholders understand the triggers and processes that drive these hazards. Just as important are data to alert stakeholders to any local changes in environmental factors that could indicate a potential problem. Internet of Things provides the means to collect real-time data on environmental conditions such as temperature, humidity, pressure, seismic activity, water levels and ground movement. These data can be combined and analysed to inform decisions that may help reduce any risks to environment, infrastructure or society.

Key points

- IoT connects objects, things and machines. Devices send and receive real-time information, can learn and take action with minimal human intervention.
- IoT is used for a variety of applications. IoT provides an opportunity to collect real-time data on environmental conditions such as temperature, humidity, pressure, seismic activity, water levels, and ground movement.
- Installation of IoT systems can be scalable, easily deployable, enable remote access to data and, importantly, require low operational and maintenance costs.

What is the Internet of Things?

The Internet of Things (IoT) is a technology that connects objects, things and machines by allowing them to use the Internet to communicate information with each other and with other systems. As well as enabling devices to send and receive real-time information, it can also learn and take actions with minimal human intervention, forming semi-autonomous systems.

IoT systems in everyday life

Some of the most adopted IoT technologies are smart watches or other wearable devices that monitor heart rate, sleep and exercise. As well as monitoring known symptoms associated with health conditions, these can alert the wearer once certain thresholds have been exceeded. For example, a series of nights with broken sleep associated with periods of higher-than-average heart rate can result in an alert to rest and relax.

Other examples can be found in technologies set up and interconnected in the home. Smart heating systems allow a series of sensors to automatically adjust the temperature in different rooms according to the homeowner's requirements. Blinds know when to open and close themselves. Lighting can change according to your TV viewing habits. Security systems can alert your mobile phone if someone unexpected is in the house but not if it spots a pet. Tracking habits over time, these systems can anticipate how homeowners use the technology and adjust accordingly.

IoT systems are also used to monitor key indicators in other organisational sectors such as air quality, movement and vibrations in structures like tunnels and bridges, logistics and supply chains and for optimising irrigation.

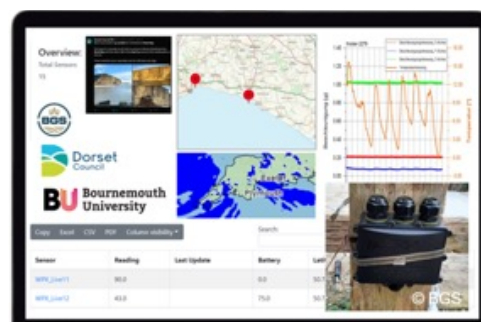
IoT for natural hazards

More recently, researchers are using IoT technol-

ogies to help monitor natural hazards including landslides, flooding, drought, storms, heatwaves and forest fires.

Traditional monitoring methods can be limited. Data collection can be restricted by how often the site can be manually accessed and the variation of accuracy and precision of data; financial costs can also limit what is possible to install and maintain.

IoT provides an opportunity to collect real-time data on environmental conditions such as temperature, humidity, pressure, seismic activity, water levels, and ground movement. Installation of IoT systems can be scalable, easily deployable, enable remote access to data and, importantly, require low operational and maintenance costs.



In locations where rainfall-induced landslides are triggered by a combination of wet antecedent conditions, snow melting and/or intense rainfall, IoT deployment can support the identification of threshold values exceedance for early warning purposes. In communities outside of strategic regional flood warnings IoT can help with flood detection, collecting information on water levels and precipitation.

Data communication

IoT technologies enable us to develop end-to-end systems that sense and collect data from the environment. This is transmitted over the Internet to

other digital systems for storage and further processing. IoT systems achieve this by using a variety of networks – cellular, satellite or specialised IoT networks – each one with its own characteristics. This variety gives scientists and engineers the ability to tailor the design of IoT systems to the specific needs of each application, whether it is monitoring the natural environment, digital health, smart power grids, or other. With the use of technologies, such as Artificial Intelligence, information can be extracted from collected data and then be presented on human-friendly dashboards, accessible via computers or smartphones. This provides scientists with seamless access to data over time, enabling them to focus on new information and eventually produce new knowledge.

Example 1: The case study in Eidsvoll, Norway¹, presents an operational IoT-based system to forecast the stability of a slope. A prototype early warning system was developed by combining weather forecasts, real-time environmental monitoring and artificial intelligence. A web platform automatically collects and analyses data, issuing warnings when stability is low. The system forecasts slope stability up to three days in advance. This initiative showcases the role of technology, data analysis, and cross-disciplinary collaboration in enhancing disaster preparedness and protecting communities from landslides.



Example 2: The case study in the Catalan Pyrenees² illustrates the use of IoT technologies to monitor natural hazards in remote, mountainous terrain. A network of sensors collects real-time data on rainfall, temperature, humidity and soil moisture. The goal was to extend and complement the data provided by official weather stations, filling critical territorial gaps in monitoring coverage. Sensor data are transmitted automatically via a LoRaWAN network to a cloud platform, where it

is processed and visualised through custom dashboards. Local authorities and emergency managers can monitor evolving environmental conditions and receive early warnings when thresholds are exceeded. The system operates with low energy consumption and minimal maintenance, supported by solar panels and robust design. This initiative demonstrates how IoT and purpose-built communication infrastructure can enhance resilience in remote areas.



Challenges

Installing sensors to monitor natural hazards is challenging. The initial installation may be physically demanding and involve steep slopes, unstable ground or water bodies e.g. rivers, sea. The sensors need to communicate over a reliable network and maintain power to do so. Beyond this, the natural environment brings with it temperature extremes, storms, plants, insects and animals, people and, if coastal, salt. All of these can impact the data being collected, battery life, corrode the devices or subject them to damage and even theft.

What is happening in The HuT

In The HuT project, knowledge sharing across the demonstrator projects is amplifying the learning across the project partners. Several demonstrator projects are now developing or improving real-time monitoring systems exploring the possibility to move towards Internet of Things technology for early warning purposes. These low cost, low maintenance systems allow for continuous real-time data collection on a range of environmental conditions relevant to the hazards being monitored. Analysis of these data identifies trends and patterns to establish thresholds that, once exceeded, can automatically provide warnings to stakeholders and/or users.

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Learn more about The HuT project:

<https://thehut-nexus.eu>



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References

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- ² Val d'Aran Region DEM <https://thehut-nexus.eu/territory/val-daran-region/>