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Smart sensors to detect movements of cobbles and large woody debris dams. Insights from lab experiments.

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An increase in population pressure and severe storms under climate change have greatly impacted landslide and flood hazards globally. At the same time, recent advances in Wireless Sensor Network (WSN) and Internet of Things (IoT) technologies, microelectronics and machine learning offer new opportunities to effectively monitor stability of boulder and woody debris on landslides and in flood-prone rivers. In this framework, smart sensors embedded in elements within the landslide body and the river catchment can be potentially used for monitoring purposes and for developing early warning systems. This is because they are small, light-weight, and able to collect different environmental data with low battery consumption and communicate to a server through a wireless connection. However, their reliability still needs to be evaluated. As data from field sites could be fragmented, laboratory experiments are essential to validate sensor data and see their potential in a controlled environment. In the present study, dedicated laboratory experiments were designed to assess the ability of a tag equipped with an accelerometer, a gyroscope, and a magnetometer to detect movements in two different settings. In the first experimental campaign, the tag was installed inside a cobble of 10.0 cm diameter within a borehole of 4.0 cm diameter. The experiments consisted in letting the cobble fall on an experimental table composed of an inclined plane of 1.5 m, followed by a horizontal one of 2.0 m. The inclined plane can be tilted at different angles (18˚- 55˚) and different types of movement have been generated by letting the cobble roll, bounce, or slide. Sliding was generated by embedding the cobble within a layer of sand. The position of the cobble travelling down the slope was derived from camera videos by a tracking algorithm developed within the study. In the second experimental campaign, a simplified analogue model of a woody debris dam was built from a single hollowed dowel with a length of 40 cm and a diameter of 3.8 cm. The sensor tag is installed in the woody dowel within a 2.5 cm longitudinal borehole. Two metal rigs are mounted at both

sides of the woody dowel to allow different modes of movement. Specifically, the woody dowel is allowed to move either horizontally or vertically within a range of 20-30 mm, whereas it is always free to complete full rotations. The woody dowel is mounted on a frame within a 20 m long and 0.6 m wide flume. In these two experimental settings, combining data from the accelerometer, gyroscope and magnetometer it was possible to detect movements and differentiate between different type of motions both in a woody dowel and in the cobble under different initial conditions. Data were analysed to understand which type of information could be retrieved. This gives important insights for the assessment of the feasibility and effectiveness of the use of smart sensors in the detection of movements in woody logs within dams and boulders embedded in landslides, thus providing indications for the development of early warning systems using this innovative technology.