Grand Challenge Research on Bio-inspired Sensor Technology for Civil Infrastructure Application – Early Warning for Geologic Hazard Events

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To date, the diversity and resourcefulness of biological sensing are enormous and remain largely unexplored for civil infrastructure applications. One of the natural hazards as a major threat to civil infrastructures failures is landslides and earthquakes. Field evidence has shown that geologic hazard events such as landslide, volcano eruption, avalanche and possibly earthquakes can radiate infrasonic waves. In particular, landslides constitute a major geologic hazard because they are widespread, occur in all 50 states and U.S. territories, and cause $1-2 billion in damages and more than 25 fatalities on average each year (see http://landslides.usgs.gov/). Expansion of urban and recreational developments into hillside areas leads to more people that are threatened by landslides each year. Figure 1-(a) shows a landslide in Laguna Beach, CA that occurred in 2005. Landslides commonly occur in connection with other major natural disasters such as earthquakes, volcanoes, wildfires, and floods. Figure 1-(b) shows a picture of the landslide that buried part of the Beichuan town after the M8.0 Great Sichuan earthquake in 2008. Early detection of imminent landslides is thus important to the reduction of casualty and economic losses in areas prone to such geohazardous event.

(a) Laguna Beach, CA, 2005 (from USGS) (b) Beichuan County, 2008 M8.0 Sichuan Earthquake

Fig. 1. Landslide events around the world

Sensors have been used for detection and measurement of various kinds of data and quantities such as temperature, strain, pressure, and other dynamic force and response measurements. However, there currently is no sensor available for early detection of landslides. Biological organisms can sense a multitude of stimuli using highly evolved, often novel structures with unique innervations schemes. For example, insects sense a multifaceted array of stimuli including: moisture, gas/fluid flow, vibrations, pressure, and chemicals, to name a few (*e.g.* pit vipers use extremely sensitive infrared/thermal detection to locate prey, and beetles employ their infrared detection system to locate suitable breeding grounds).

Sensitivity to infrasound signal may the ability of certain animal species in early detection of geologic hazards. For example, cephalopods such as an octopus underwater can hear a volcano before it erupts. As observed in the Stromboli volcano eruption, all octopus in the neighboring water area, left before its eruption. It is speculated that this tremendous survival skill of the octopus is due to its ultra-sensitive hearing in the infrasound range because volcano produces infrasound before its eruption. It is also observed that octopus knows to push off fast before large rocks start dropping in the water. The octopus does not swim fast so it needs a bit of early warning. Similar behavior may be also observed in other animals. Understanding these ingenious biological designs could lead to the development of new sensor technology for early warning of landslides and other geologic hazard events.