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Bill Spencer received his Ph.D. in theoretical and applied mechanics from the University of Illinois at Urbana-Champaign in 1985. He worked on the faculty at the University of Notre Dame for 17 years before returning to the University of Illinois at Urbana-Champaign, where he currently holds the Nathan M. and Anne M. Newmark Endowed Chair in Civil Engineering and is the Director of the Newmark Structural Engineering Laboratory. His research has been primarily in the areas of smart structures, stochastic fatigue, stochastic computational mechanics, and natural hazard mitigation. He was the first to study and design magnetorheological (MR) fluid dampers for protection of structures against earthquakes and strong winds, overcoming the inherent limitations of existing passive energy dissipation systems, as well as power-dependent active control systems, which are in common use today. His most recent research on structural health monitoring systems and smart wireless sensors integrates advanced computing tools with smart sensors, to provide a functional platform with self-interrogation capabilities. He led the Jindo Bridge monitoring project in South Korea, which constitutes the world's largest deployment of wireless smart sensors to monitor civil infrastructure to date. He is a Fellow of ASCE, a Foreign Member of the Polish Academy of Sciences, the North American Editor in Chief of Smart Structures and Systems, and the president of the Asia-Pacific Network of Centers for Research in Smart Structures Technology.

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Bio-Inspired Smart Sensor Networks for Adaptive Emergency Response

One of the most urgent and important challenges confronting society today is that of addressing the vulnerability of our civil infrastructure to mega disasters. In 2007, there were 414 reported natural disasters globally, affecting 211 million people, killing 16,847, and leading to over $74.9 billion (USD) in damage (CRED, 2008). These staggering numbers highlight the social and economic costs that society must bear, costs that can be reduced by more effective response and recovery efforts.

The recent disasters such as Hurricane Katrina and the Haiti Earthquake have brought real-time images of destruction into our homes like we have never seen before. Technology has succeeded in bringing global attention to these tragedies leading to fundraising efforts focused on relief and recovery and policy changes designed to mitigate future tragedies. However, in terms of saving lives, the first few hours after an event are the most critical. In these times, technology has in a sense failed to achieve its potential. During the Haiti earthquake, CNN reported that many victims were texting relatives on mobile devices, but not being located or rescued by authorities. Indeed the world is inundated with a vast array of sensors and networking in the form of mobile phones. There is at least one mobile phone subscription for every two people in the world. That is to say in a mega city during a mega disaster, the distressed would likely have access to a mobile phone. This preexisting telecommunications infrastructure can be adapted to form a decentralized and flexible communication network in the event of a mega disaster. Moreover, biological principles can be employed to cope with problems that frequently exist in the chaotic and inhospitable environment of disaster relief operations.

Mobile phones currently possess capabilities to sense (neurons) and communicate (synapses). Sensed information paralleling biological systems such as sound, video, motion detection, and GPS are currently standard capabilities of “smart” phones. If the

user themselves are responsive, such sensory input is extended to the extent of which a human can perceive. These mobile phones are capable of traditional long distance communication via cell towers, with the potential of short distance communication through ad-hoc networking. Through efficient acquisition and processing of data followed by distribution of task-relevant commands, mobile phones could provide a decentralized means by which to relay critical information to rescuers and survivors. Disaster-enabled mobile phones could be a part of survivor status assessments, survivor and hazard locating, rescue efforts for trapped victims, and controlled evacuations. Such an innovative extension and use of existing technology will require interdisciplinary cooperative efforts between civil engineering, computer scientists, sociologists, and neurobiologists.

User oriented solutions cannot be implemented without engaging the public in awareness and education campaigns. In prototyping a mobile phone assisted response and rescue plan, challenges for establishing the communication framework and methods for engaging the residents of these mega cities must be outlined. Professionals, including police, firemen, hospital workers, and government workers must be trained to use this technology as a tool alongside their normal response and rescue activities. Moreover, these professionals should be an integral part of creating the system such that their needs in a mega disaster are met. At the same time, we must remember that mega disasters are infrequent and chaotic. In this regard, such a system should remain as simple as possible from the user's perspective.

Pushes to include IT innovations in disaster management before, during, and after mega disasters has been the focus of considerable research. However, the hierarchical nature of many approaches is too inflexible to address the unpredictable and evolving needs of the distressed. Currently, real-time information is reported through voice communication with centralized emergency call stations. This centralized system is adequate for isolated emergencies, however quickly becomes overloaded during wide-spread disasters.

A dense network of smart sensors operating under decentralized networking protocol holds much promise as a flexible and efficient response and recovery tool. Utilizing the existing capabilities of mobile phones, this framework is much closer to fruition than otherwise possible.

References

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