Human, animal or tree? A sensor-based system to classify movement in forests

A research project at the Indian Institute of Science (IISc) has come up with a sensor-based platform that can pick up movements and make out whether they were caused by a human or animal intruder, or simply by vegetative movement in the background. The platform is made of Passive Infra-Red (PIR) sensors, and the operating principle is based on techniques of signal processing. This work is part of a project jointly funded by the Department of Electronics and Information Technology under a Indo-US Pervasive Communications and Computing Collaboration (PC3) initiative. Apart from IISc, this project also involves researchers from the Indian Institute of Information Technology, Allahabad & the Wildlife Institute of India, Dehradun, from the Indian side and Ohio State & Cornell Universities on the US side.

In forested areas, it is often important to detect intrusions by humans to prevent illegal activities such as poaching, for which sensors need to be deployed. PIR sensors induce a current flow whenever there is a change in the radiation incident on the sensor. Such a change can happen due to any movement within the sensor's field of view. But it is often difficult to ascertain whether the movement is by human beings or animals, or is simply a movement of the vegetation due to wind. This research project attempts to make this classification. At IISc, the research is a collaborative effort between researchers belonging to the Electrical Communication Engineering (ECE) and Electronic Systems Engineering Departments (DESE) at IISc. It involves graduate students and project assistants from both departments, under the guidance of Professors P. Vijay Kumar (PI), Anurag Kumar (Co-PI and Director, IISc) and Dr. T.V. Prabhakar.

The system is mounted in the form of a tower, and consists of 8 sensors. The corresponding electronics and the packaging was designed and developed at DESE. The sensors are arranged in such a way so as to differentiate between translation movement by intruders, and oscillations of the vegetation. The system focusses on animals such as dogs, wolves, leopards and tigers, which are of lesser height in comparison with a human being. By estimating the height of the intruder, the system can distinguish between human and animal. So effectively, for every detected signal the system needs to do two rounds of classification: first to differentiate between vegetation and non-vegetation, and then between human and animal.

Data can be classified into different categories by various algorithms. But for that, the data must be represented mathematically. Such a representation is called “feature vector”. In this case, the data i.e. the radiation signal, is first converted into a feature vector by using a mathematical operation called “Chirplet Decomposition”. In addition, classification algorithms perform well only after they have been provided with enough examples of data, where the classification is known. In other words, they have to use a large number of sensor signals along with the information of what caused
the signal - a human, an animal or simply, vegetative movement. Ideally, such examples should come directly from the sensor observations themselves. But since such data is hard to come by in large quantities, the researchers at IISc used animation-based techniques to simulate the received signal. They created realistic animations of humans and various animals, and simulated their movements to estimate the signals generated by the sensors. Features are identified using simulated data provided to the classification algorithm. Some actual data was collected from sensors deployed in forests inside the IISc campus, caused by intrusions or movements in the trees nearby. The performance was validated on this real data. These sensor signals were correctly classified by the algorithms with very high accuracy. This validates the efficacy of these sensor systems, and indicates that it has potential for deployment in forests.

It is envisaged that the sensor networks will typically be deployed along forest trails. A second key outcome of the research project is the development of algorithms for the deployment of wireless relays as a deployment agent walks from a base station (e.g., a watch tower in the forest) to the sensor placement location. The problem is one of sequential decision making, and here the research team has resorted to the theory of Markov decision processes. At each potential relay placement location, say every 50 meters, the deployment agent makes measurements of link quality to one or more of the previously placed relays, and then decides where to place a relay. A variety of optimal measurement based algorithms that involve either a single pass or allows back-tracking have been developed. The algorithms were tested via deployment trials that were conducted within the forested area of IISc (Jubilee Gardens) and the Wildlife Institute of India. The results obtained showed a low packet loss indicating the efficacy of the algorithm in forested settings.

About the team:

**From Electrical Communication Engineering Department:**
Prof. Vijay Kumar (Principal Investigator)
Prof. Anurag Kumar (Co-Principal Investigator and Director, IISc)

Ajit Prabhu, V. S. Ashath, Christo K. Thomas, A. Praneeth, Raviteja Upadrashta, Siddhant Raman, Tarun Choubisa, Tony Gracious and S. Vikas (students under Prof. P. Vijay Kumar).
Abhishek Sinha, Anu Krishna, Arpan Chattopadhyay and Avishek Ghosh (students under Prof. Anurag Kumar).

**From the Department of Electronic System Design:**
Dr. T. V. Prabhakar (Senior Scientific Officer)
Mr. Ashwath Narayan Singh (Junior Scientific Assistant) and Mr. Chalapathi Rao (Principal Research Scientist)
Hari Prasad Gokul R., Madhuri S. Iyer and Sripad Kowshik (work under Dr. T.V. Prabhakar).