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Personnel Detection Technology

a sensor networking approach

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Larus Technologies Corporation

Abstract

Personnel detection deals with the prevention, detection and response to unauthorized persons from crossing an established perimeter. It is required in a variety of military and civilian situations. In this white paper, we present the drawbacks of the current technology-based solutions and how we plan to alleviate them. A replacement technology is introduced to the current trip wire-based techniques while a system-of-systems solution is presented to the larger problem of Territorial Security.

Personnel Detection

Detecting unauthorized persons crossing a perimeter is a security concern of individual, corporate, and international scope. State-of-the-art perimeter-security solutions use physical barriers and mechanical sensors (such as trip wires) to detect personnel intrusions. These procedures are effective in a limited scenario, where a few entrance points are constrained by well-delineated physical boundaries, however, are very inefficient when it comes to reuse and full coverage.

The idea of electronic trip wires involves the use of sensors such as infrared, laser, imaging, magnetic and seismic sensors, to detect intrusions and notify the remote operator for the deployment of a faster and more accurate response mechanism. These electronic trip wires can be interconnected to form a network that can fuse individual and disparate data streams in real-time, issuing alerts when intrusions are detected.

Larus Technologies proposes a novel, real-time personnel detection technology solution that meets requirements which seek to replace the mechanical trip wires utilized in protecting perimeters.

Requirements Definition

Currently, a group of trip wires positioned around a remote node are used to detect personnel. Theses mechanical sensors suffer from two major drawbacks: their one time use and their lack of 360 degree coverage (see Figure 1). Once a trip wire is triggered, it has to be replaced and/or reset manually. An electronic replacement is required which does not suffer from such limitations. This replacement would also completely cover the periphery of the node as opposed to trip wires which have a limited peripheral coverage.

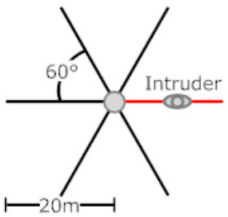

Figure 1. Current personnel detection technology

Larus Core Capabilities

Larus Technologies delivers innovative solutions for end to end multi-sensor systems; from sensor networking products that enhance the data collection from networks of diverse sensors, to a fusion engine that synthesizes data from multiple sources, resulting in intelligent and actionable information. Larus Technologies has developed solutions to make sense of the overwhelming data collected by sensor networks by allowing the user to seamlessly handle the collected data within a more uniform and integrated operating environment.

Our flagship product, Larus Total::Insight™, provides a complete end to end intelligent surveillance solution, from enhancing the collection of data from in situ sensors with our LISA Networking products, to the synthesis of data through our fusion engine, to providing actionable intelligence to client decision support and command and control systems.

The Larus Intelligent Sensor and Actuator (LISA) is an 'add-on' product for sensors, data sources and actuators and their supporting networks. The LISA Network (LISANet), is a proprietary network solution that enables the networking of peripherals, including sensors, actuators, motors, custom peripherals, communication hardware, etc. Additional **Total::Insight™** and LISA product details are available at **http://www.larus.com**.

Proposed Technology Solution

Larus Technologies has developed a personnel detection system using a system of remote, wireless, battery operated nodes forming a sensor and actuator network (SANET). The system contains nodes which are deployed around a Critical Infrastructure (CI) to outline a Virtual Fence (VF) as can be seen in Figure 2. The system is equipped with various devices in order to detect intrusions of the VF, motion and fire in the vicinity of the nodes, as well as sound alarms in certain events.

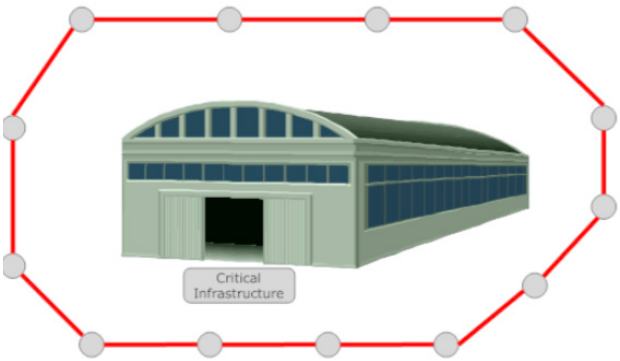

Figure 2. Virtual Fence protecting a critical infrastructure.

The sensor suite equipped on these nodes is suitable for the requirements set out for replacing mechanical trip wires. Passive Infrared (PIR) sensors are used to detect the presence of personnel, which is a suitable replacement for trip wires.

PIR sensors measure infrared light radiating from objects in its field of view. Apparent motion is detected when a warm body, such as a person, passes through the field of view of the sensor. They are low power sensors; hence, they can be left on at all times and can be reused without manual intervention or resetting. They have wide areas of coverage, so 360 degree coverage of a node can be attained by using a group of them.

Five PIR sensors would be placed around the periphery the enclosure with equal spacing between each. The PIR sensors have a horizontal detection angle of 110 degrees. This allows for full 360 degree coverage with 38 degree overlaps between the detection areas. The personnel localization resolution of the resulting system thus is 38 degrees. PIR sensors with a range of 10 meters are available. The coverage area of the system and the localization of an intruder can be seen in Figure 3.

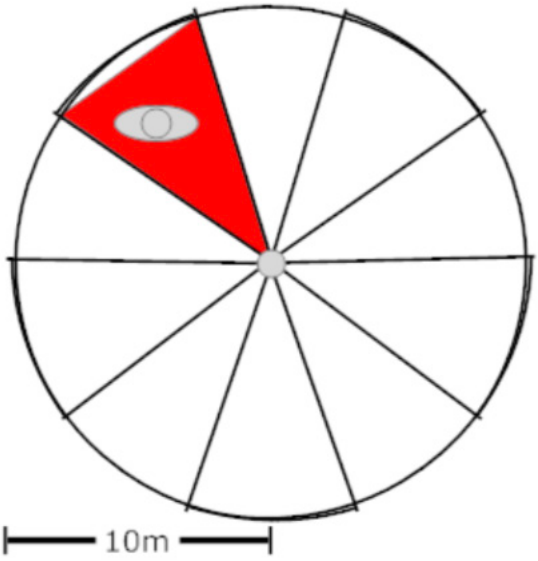

Figure 3. PIR based system detecting and localizing an intruder

PIR sensors are enough to detect the presence of a person within 10 meters of a node. In addition, other sensors on the node can be used to reduce the level of false positives. Imaging, acoustic and magnetic sensors can be employed to sense the environment in the event of motion being detected. These sensors can also help in the detection and classification of other objects of interest, such as vehicles. Acoustic sensors can pick up signatures of vehicles or personnel as they pass near the nodes. If vehicle detection

is required, magnetic sensors can be used to detect vehicles passing within 15 meters of a node. Vehicles contain ferrous materials that disturb the earth's magnetic field; this distortion can be measured by the magnetic sensor to detect a passing vehicle, as shown in Figure 4.

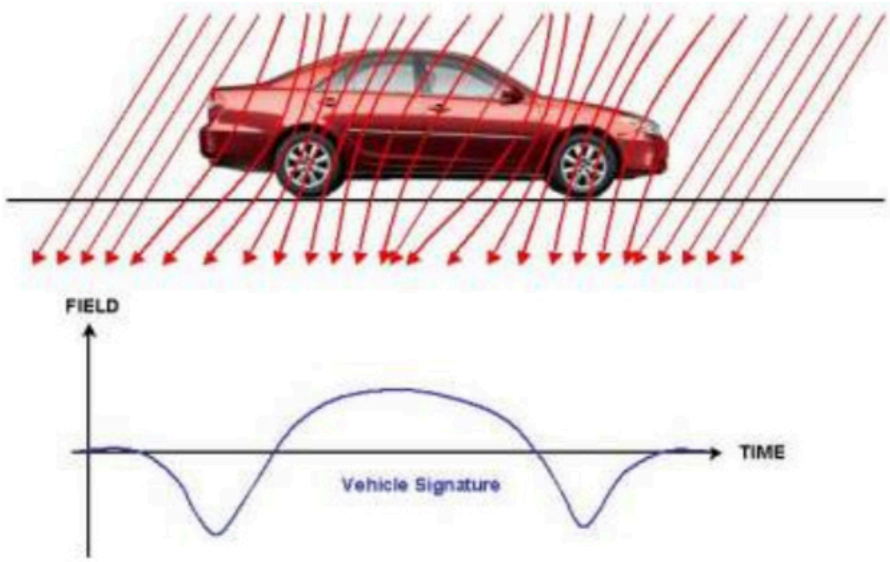

Figure 4. Vehicle detection using magnetic sensors
image source

An imaging sensor can also be used to take snapshots of the environment in the vicinity of detected motion. On board image processing would detect an object of interest and may be able to classify it as either a vehicle or a person. Optionally, these images may be transmitted to a remote operator or control unit. These secondary sensors require higher power and more processing. Given the power constraints of the system, they could only be turned on for brief periods of time. They can be integrated by cueing them in the event of motion detection by the PIR sensors. Hence, the power consumption of the detector would be based on the level of activity in the environment.

System-of-Systems Solution

The proposed personnel detection technology solution can replace the existing trip wire-based solution. It is a low power system and can operate continuously. There is no need for manual intervention upon detections. The system's personnel detection coverage is 360 degrees, with a localization resolution of 38 degrees up to 10 meters from the node. The system produces a low level of false positives by utilizing secondary sensors to aid in the classification of objects of interest. The components can be distributed as shown in Figure 5.

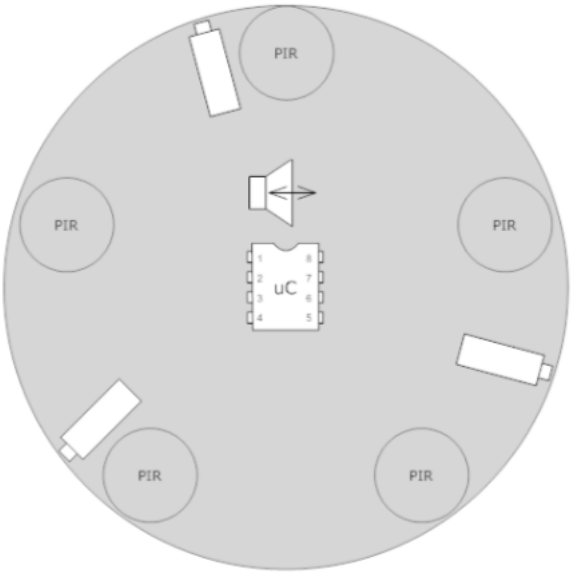

Figure 5. System component distribution

Larus Technologies has developed a complete Territorial Security system that includes the detection of personnel, as well as vehicles and other objects of interest. The latter consists of a network of detectors and backend servers that perform data fusion from multiple nodes to detect, classify and track personnel, vehicles and other intruding entities. Figure 6 shows the components of that system.

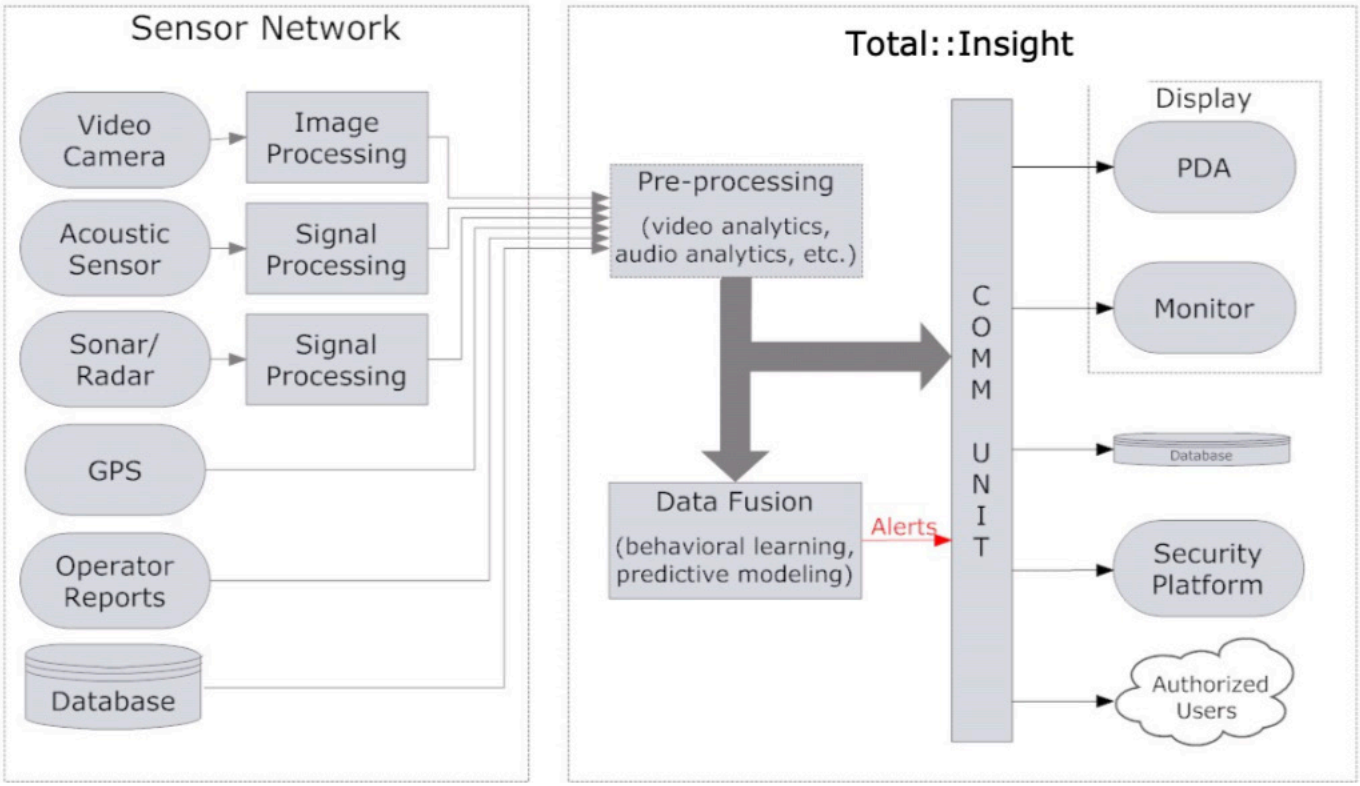

Figure 6. Data flow within system-of-systems solution

Using a network of personnel/vehicle detectors the system is able to gather and provide the user with aggregated information. Fusing data from multiple nodes helps better classify an object of interest. It also provides different threat severity levels associated with the detected object.

One of the advantages of using such a system is the in-network processing characteristic. For example, utilizing multiple detectors, an object can be tracked as it moves past various nodes. An object's speed and direction can be calculated by detecting its signature on multiple nodes, and by using the nodes' positions, the system can track the object and relay this information to the user. This is more useful than just having messages sent to the user each time a node detects an object.

If an object is detected by a node, the system can cue nearby nodes in order to anticipate the object and acquire information about it. For example, a nearby node can start taking images in the direction of the node where the object was detected, without first having to wait for the detection of motion near its node. Optionally, the nodes themselves may be made mobile. In certain applications, it may be desirable to have the nodes move to a new position on command. This way the nodes can be reused and do not need to be left in the field. Our flagship product, **Total::Insight**, provides a complete end to end intelligent surveillance solution, from enhancing the collection of data from in situ sensors with our LISA Sensor Networking products, to the synthesis of data through our propriety **Total::Insight** fusion engine, to provide actionable intelligence to client decision support and command and control systems.

Total::Insight runs a closed-loop decision-support system (DSS) that takes in the data source inputs, extracts the required information from their raw data streams and, according to the user's decision, proceeds to perform a plan of action through effectuation of the environment. As the latter has now changed, the data consumption phase starts another run through the DSS loop. A customized solution, **Total::Insight** for Territorial Security, presents the following features:

- Motion detection This feature consists of detecting the presence of motion near a critical infrastructure
- Intrusion detection This feature consists of detecting an intrusion within a protected perimeter. An intrusion is defined as an object entering a protected perimeter without permission
- Fire/smoke detection This feature consists of detecting the presence of fire or smoke near a critical infrastructure, or within a restricted access zone or public setting
- Object localization This feature consists of determining the global location of an object
- Object tracking This feature consists of tracking individuals or other moving objects inside a protected perimeter

- Object classification This feature consists of categorizing an object as either human, car, animal, etc.

Furthermore, the raw data is mined for patterns that represent information, with the set of patterns representing the knowledge attained by the system. This combination of data mining and fusion alleviates the strain on the operator by reducing the influx of information to a manageable level.

Fielded Applications

At Larus Technologies, we have designed and fabricated sensor nodes for use in various applications, the latest of which is a Virtual Fence system used for Territorial Security. Prototypes of the system have been fabricated and deployed as virtual gates and virtual fences around a critical infrastructure to monitor for events of interest such as intrusions of the virtual fence line and classifications of the intruding entities. The nodes were designed to be low power, maintenance free and exhibit a long operational life, with a low false positive rate and a high reliability. As indicated above, the system currently is in the prototype demonstration phase, where they are being evaluated in a relevant environment. We have achieved a classification accuracy of 71% on previously unseen data while using a multi-output classifier that can inspect its input and provide probabilities of membership for its multiple classes (e.g. car, human, bird, bicycle, etc.).

Conclusions

Current personnel detection technologies suffer from two major drawbacks: their one time use and their lack of 360 degree coverage. In this white paper, a replacement technology in the form of electronic trip wires was presented. The Larus product lines and expertise areas provide a suitable solution to the original problem, as well as a system-of-systems solution to the larger problem of Territorial Security. The latter consists of a network of detectors and backend servers that perform data fusion from multiple nodes to detect, classify and track personnel, vehicles and other intruding objects.

About Larus

Through our culture of innovation and research, Larus Technologies has developed the next generation of embedded technology for developers of mission-critical C4ISR Systems and Security Systems.

With a solid foundation pioneering high level information fusion (HLIF) for the ever-changing defense and security industries, Larus is perfectly positioned to help Original Equipment Manufacturers (OEMs) make a world of difference. Working at the higher levels of the US Department of Defense's Joint Director of Laboratories (JDL) information fusion model, our technology not only delivers more knowledge, its adaptive learning algorithms deliver more accurate and more predictive information—faster.

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