The Application of Unattended Ground Sensors to Human Socio-Cultural Behavior Monitoring

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ABSTRACT

Textron Defense Systems has developed a wide range of unattended ground sensor (UGS) systems for the military and border patrol. These include T-UGS (Tactical UGS), U-UGS (Urban UGS), and most recently the new MicroObserver® multimodal UGS system. MicroObserver® is characterized by its best-in-class covertness, ease of deployment, negligible false alarm rate, and extremely long battery life (2+ years), yet with very low total cost of ownership. It uses advanced tracking and imaging algorithms to provide detection, classification and identification of both personnel and vehicles, and is proven in operational use to deliver reliable actionable intelligence to remote operators.

Traditional missions for UGS such as MicroObserver® include border surveillance, facility/base security, and tactical battlefield intelligence. In most cases, UGS are deployed in sparsely populated areas and the detection of targets of interest is relatively uncommon. However the persistent nature of UGS allows long term monitoring of human socio-cultural behaviors (HSCB) such as pervasive signatures related to human activity even in heavily populated locales such as towns, villages, and cities. Acoustic, seismic, magnetic, E-field, and even image signatures may be collected, processed, and transmitted for interpretation by a remote operator or automated system. Patterns of life may thus be monitored and important deviations detected and the causes inferred, alone or in combination with other intelligence channels such as HUMINT.

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1. INTRODUCTION

As specified in [1], the overall objective of applying Human Socio-Cultural Behavior (HSCB) research to military and counter-terrorism missions is the ability to track and forecast changes in entities (e.g., human behaviors), environments, and phenomena of interest along multiple dimensions, namely, time, space, social networks, behavior types, etc., through persistent sensing, modeling, and analysis. In this context, unattended ground sensor (UGS) systems must enable understanding of socio-cultural parameters of operational environment, detection of valid and relevant socio-cultural behavior signals and patterns from noise, and forecasting of behaviors in response to possible courses of action. This paper identifies and discusses the special features and capabilities needed in UGS to enable such HSCB mission needs and illustrates how the new Textron MicroObserver® modular sensor system [2] helps meet those needs. Finally, future UGS systems that may enable much more sophisticated HSCB applications are covered, such as those contemplated under the DARPA ADAPT (ADAPTable Sensor System) program.

2. SENSOR SYSTEM REQUIREMENTS FOR HSCB APPLICATION

In HSCB missions, sensors are used to procure a persistent capability to detect socio-cultural behavior signals of interest amidst complexity and noisy irrelevance, and to harvest data for analysis. This ISR capability as applied to HSCB is referred to as "social radar" [1]. Key system requirements for UGS pertinent to HSCB missions include covertness in heavily populated areas, robust sensor data storage and managing systems, tools enabling timely (near real-time) dynamic analysis, non-line-of-sight communications (NLOS), high detection rate, power management, special discrimination, data reduction, and sensor fusion algorithms for complex and signature rich environments.

2.1 Covertness

Real world environments are harsh. Thus, typical sensors for HSCB missions must be designed to withstand high operating temperatures and temperature variations such as specified by Mil-Std 810f (e.g., -30ºC to +70ºC). Moreover, for above-ground deployment sensors are susceptible to damage by animals or other natural events and sabotage by humans (see Figure 1). Thus, they must be easy to conceal (hardly noticeable) and capable of withstanding animal disturbance and other forces of nature such as high winds, rain and blowing debris.

Figure 1: MicroObserver® seismic sensors emplaced in ground

Modern day terrorists can afford the latest, sophisticated, commercially available electronic equipment capable of RF detection, interception and spoofing, and IR signature detection. Therefore, in addition to visual concealment, these new challenges must be addressed for UGS systems utilization for effective HSCB missions. Finally, power management is necessary for achieving long mission life.

2.2 Power Management and Mission Life

In a typical HSCB monitoring application, long deployment time is required for data collection and analysis; and for unattended systems, this translates into a critical requirement for low power consumption. This can be achieved through clever power management that reduces overall energy consumption, prolongs battery life, reduces or eliminates cooling requirement, electronic noises and operating costs for energy and cooling. Furthermore, lower power consumption also reduces the need for heat dissipation - which affects system stability – decreases IR signature, and leads to less energy usage - which in turn reduces the total cost of ownership and the environmental impact and footprint of the system. –

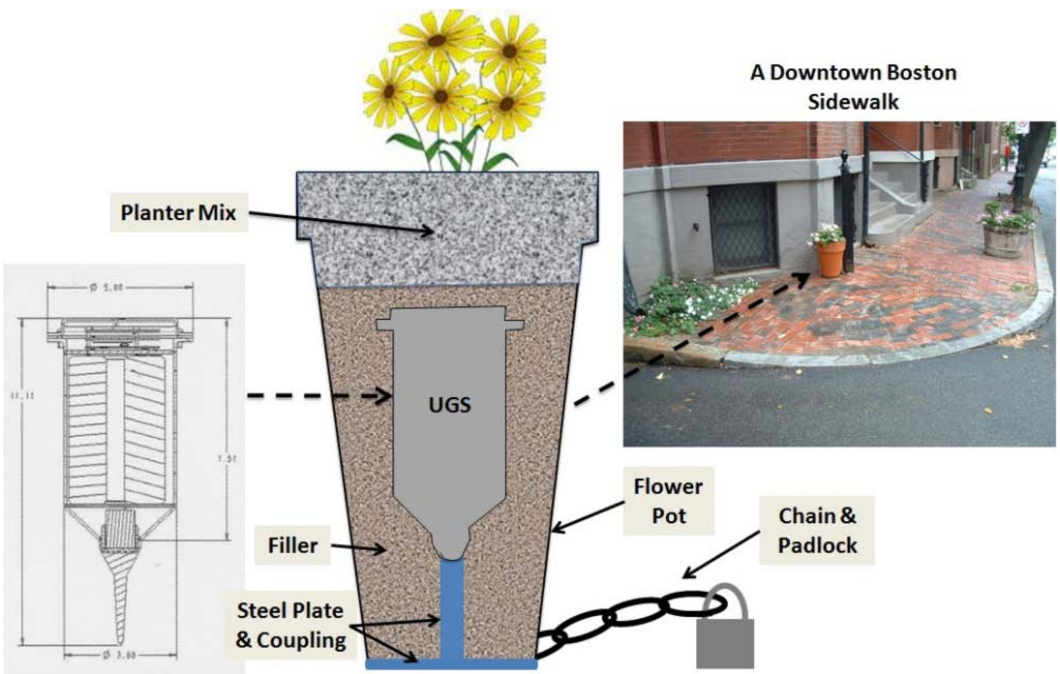

Figure 2[1]: MicroObserver® seismic sensors concealed and emplaced in downtown Boston

2.3 Non-line-of-sight communications

In typical HSCB mission environments (both remote and urban), LOS communications between sensors and between sensors and gateways cannot be guaranteed at all times. Therefore, the UGS system network must be fault-tolerant, capable of NLOS communications and able to recover from temporary or sporadic loss of connectivity. For example, for ground system, this can be achieved through the use of low-profile, conformal antennas optimized for close-the-ground communications (see Figure 1) or the use of special antennas for surface waves NLOS wireless communications.

[1] Courtesy of Bruce Bullock and Mike Farry at Charles River Analytics, Inc. (Cambridge, MA)

2.4 Advanced UGS Analytic & Processing Tools

Automatic Target Recognition (ATR) or the ability to recognize targets or objects based on sensor data is critical to UGS systems. Its application to HSCB mission intends to automate behavior pattern recognition, mitigation and effect measurements. Reading and measurement errors are inherent to typical sensors. Therefore, it is critical that the ATR algorithms understand the nature of sensor errors, well characterize the errors and reject sensor noise [5] so as to prevent misinterpretation of behaviors, bad judgment, and potentially detrimental (tactical or strategic) decisions.

HSCB missions often require or generate large, multidimensional sensor data. Thus, for such applications, the key to a robust sensor-based detection capability is the combined capacity for both continuous collection and rapid processing of large volumes of data. Data reduction is necessary to reduce processing time and speed up meaningful information extraction, threat detection and mitigation.

New signatures, algorithms and analytic methods are required (see for example [5, 6, 7, 8, 10]) to collect, extract, analyze, correlate, and, especially, visualize behavioral patterns and social phenomena out of UGS data. These algorithms must mitigate noise arising from variations in the pertinent socio-cultural signals or from the background environment, as well as filter out irrelevant, duplicative, or deceptive signals, which humans can exhibit intentionally. Ideally, the new analytic tools will leverage the rapidly expanding flow of open source data and support the automation of the preparation, collection, and analysis of that data.

3. THE NEW MODULAR MICROOBSERVER® SEISMIC SENSOR SYSTEM

Textron's new modular MicroObserver® sensor system [2, 3] meets the aforementioned system requirements. With its built-in conformal antenna, it is small in size and easy to conceal (see Figures 1, 2, & 3), preventing intruders or casual observers from noticing the system and avoiding, disturbing, or disrupting it. Thus, there are no components exposed and, therefore, minimal risk of discovery.

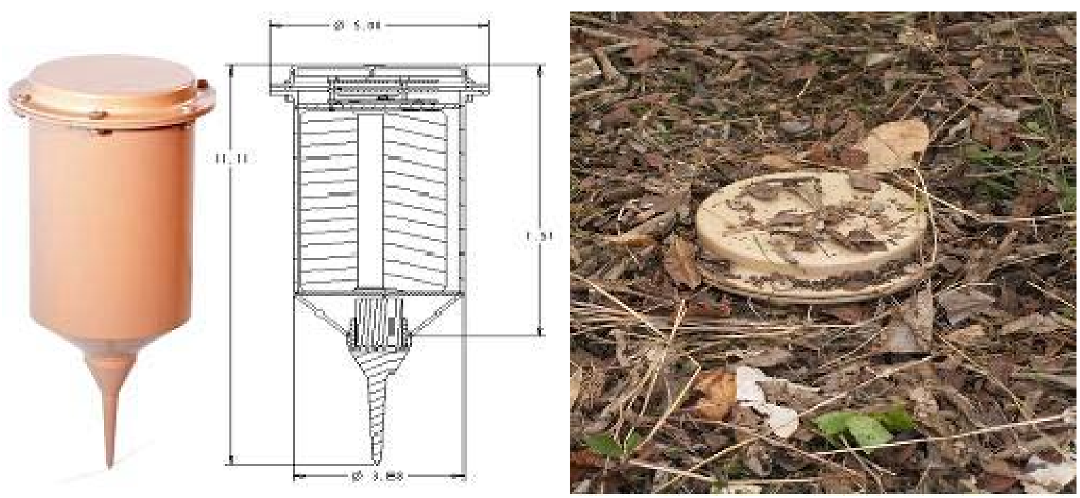

Figure 3: MicroObserver® MO-2730 seismic node, 2.8" X 3.2" X 1.6", conformal antenna, 2 years mission life

All sensors of the MicroObserver® system are passive and this minimizes power usage and maximizes covertness against even an enemy with sophisticated equipment. NLOS communications are optimized for ground-level RF propagation characteristics in varying types of terrain, using:

- an optimally-designed, low-profile antenna,
- self-configuring and fault-tolerant networking to ensure connectivity,
- minimal transmissions to ensure low probability of detection,
- advanced signal processing for maximal communications ranges, including adaptive modulation and data rates and reduced susceptibility to noise and interference, and
- advanced power management scheme using an extremely low power state for the EO/IR imager electronics and camera during the vast majority of most mission scenarios – whenever there is no target activity within or around the sensor field. Upon target detection by any of the seismic or acoustic sensors, the EO/IR is cued and executes the unique Target Activated Frame Capture Algorithm (TAFCA) [4, 9].

The new modular MicroObserver® product line wireless communications are low power (15 mW transmit power for the core system) and operationally secure, incorporating features that provide low-probability of intercept and low-probability of detection. Its EO/IR node can be mounted and camouflaged in trees. Furthermore for sophisticated enemy, the new modular MicroObserver® product line's small size and low power consumption (~10 mW for the core) extend its battery and mission life to 2+ years and make it very difficult to detect by its IR signature.

4. FUTURE UGS SYSTEMS

The DARPA ADAPT program, under the Strategic Technology Office (STO), promises to revolutionize sensor development for DoD applications through the use of generic, re-usable hardware cores whose design, manufacturing and maintenance and evolution are in par with commercial (cell phone technology) approaches. ADAPT is also creating a streamlined OS capable of state-of-the-art power management that will dramatically reduce power usage throughout the system, increase mission life, and lower the total cost of ownership. Furthermore, the ADAPT program is developing generic, reusable processing software tools adaptable to multiple missions. The hardware core is based on cell phone technology (e.g., currently using the Qualcomm MSM 8900 processor family) and allows simultaneous use of multiple sensors (e.g., video/camera, acoustic, seismic, PIR, radar), use of multiple radios, data storage and ample processing power appropriate for in situ data analysis.

5. CONCLUSION

Unattended ground sensors (UGS) can provide the capabilities to discover, distinguish, and locate operationally relevant socio-cultural signatures through the collection, processing, and analysis of socio-cultural behavior data. UGS processing automation is important to scalability, affordability, and accuracy of socio-cultural and behavior phenomena detection capability. The new Textron modular MicroObserver® sensor system offers many functionalities and capabilities that meet current HSCB mission needs. Nevertheless, new technology enablers, such as that envisaged under the DARPA ADAPT program, will soon become available and will usher a new era and generation of highly capable, but still highly cost effective, UGS systems that meet HSCB mission requirements.

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