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FINDINGS
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BORDER PATROL SYSTEMS-USING ADVANCED WIRELESS SENSOR NETWORKING DEVICES

T. DEEPIGA
RESEARCH SCHOLAR
DEPARTMENT OF COMPUTER SCIENCE
D.K.M COLLEGE FOR WOMEN
VELLORE

A. SIVASANKARI
HEAD
DEPARTMENT OF COMPUTER SCIENCE
D.K.M COLLEGE FOR WOMEN
VELLORE

ABSTRACT

Early days, the conventional border patrol systems suffer from intensive human involvement. Recently, unmanned border patrol systems employ high-tech devices, such as unmanned aerial vehicles, unattended ground sensors, and surveillance towers equipped with camera sensors. However, any single technique encounters inextricable problems, such as high false alarm rate and line-of-sight-constraints. There lacks a coherent system that coordinates various technologies to improve the system accuracy. In this paper, the concept of hybrid wireless sensor network architecture for border patrol systems, is introduced. It utilizes the most advanced sensor network technologies, including the wireless multimedia sensor networks and the wireless underground sensor net-works. The framework to deploy and operate is developed.

KEYWORDS
Border patrol, Wireless sensor networks, Multimedia sensor networks, Underground sensor networks.

1. INTRODUCTION

Border patrol systems have recently gained interest to address the concerns about national security. The major challenge in protecting long stretches of borders is the need for intensive human involvement in patrolling the premises. Conventional border patrol system consists of security checkpoints and border troops. The security checkpoints are set up on the international roads where all vehicle traffic is stopped to detect and apprehend illegal aliens, drugs, and other illegal activity. Each border troop watches and controls a specific section of the border. The troops patrol the border according to predetermined route and time interval. Under the conventional border patrol system, even modest-sized areas require extensive human resources if manual patrolling is considered alone.

To monitor the border in real-time with high accuracy and minimize the need for human support, multiple surveillance technologies, which complement each other, are required. To address the challenges still faced by the existing surveillance techniques, we introduce Border Patrol System, a new border patrol system framework based on hybrid wire-less sensor networks, which can accurately detect and track the border intrusion with minimum human involvements. Border Patrol System utilizes the most advanced sensor network technologies, including wireless multimedia sensor net-works (WMSNs) and wireless underground sensor networks (WUSNs). The hybrid WSN consists of three types of sensor nodes:

1. Multimedia sensor nodes that are equipped with video cameras or night vision scopes and deployed on the surveillance towers,
2. Scalar sensor nodes that are equipped with vibration/seismic sensor and deployed on the ground or buried underground, and
3. Mobile sensor nodes that roam throughout the border on the surface or in air. These three types of sensor nodes While the potential benefits of Border Patrol System are significant, several research challenges need to be addressed be-fore a practical realization. In this paper, a framework to deploy and operate Border Patrol System for border patrol is de-scribed. Based on this framework, research challenges and open research issues are discussed.

2. SYSTEM ARCHITECTURE OF BORDER PATROL SYSTEM

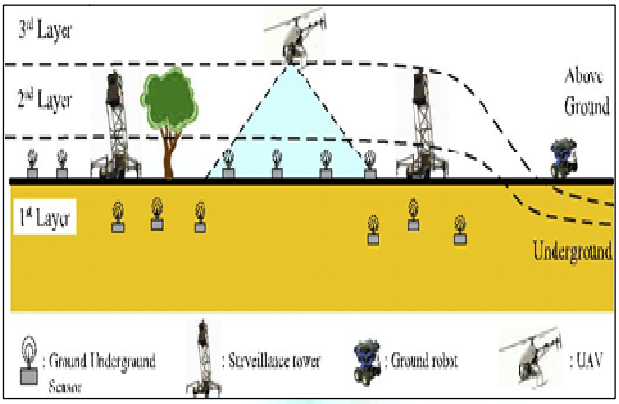
Current WSNs for border patrol are based on a flat, homogeneous architecture in which every sensor has the same physical capabilities and can only interact with neighboring sensors .Such a structure results in several shortcomings in border patrol such as limited cover-age and high false alarm rate that require additional human intervention. Instead, we consider a hierarchical WSN architecture with heterogeneous sensor nodes as shown in Fig. 1. In this architecture, three different types of sensors are used in three different layers of the hierarchy.

As shown in Fig. 1, the system architecture of Border Patrol System has three layers. The unattended ground sensors and the underground sensors constitute the lower layer of the architecture, which provide higher granularity for monitoring. At the second layer, multimedia sensors improve the accuracy of the system through visual information. Finally, mobile ground robots and unmanned aerial vehicles constitute the higher layer that provides additional coverage and flexibility. Advanced WSN Devices are:

2.1. GROUND SENSORS AND UNDERGROUND SENSORS

The ground sensors and the underground sensors in the lower layer are resource-constrained, low-power scalar sensors, which perform simple tasks such as taking seismic/vibration measurements and sending the information to data sink or processing hub. The underground sensors can either communicate with the ground sensors or other underground sensors . Due to the complex underground channel characteristics ,new physical layer propagation techniques are needed to realize the communications, such as underground electromagnetic wave techniques or magnetic induction waveguides Different from the camera sensors in the surveillance towers or UAVs, the ground/underground sensors can detect non-line-of-sight intruders. However, as discussed in the introduction, based on the limited information acquired by ground/underground sensors, it is difficult to distinguish actual intrusion alarms from false positives. Consequently, the false alarm rate of the ground/ underground sensors is considerably high.

FIGURE 1: NETWORK ARCHITECTURE OF THE HYBRID WIRELESS SENSOR NETWORKS FOR BORDER PATROL



2.2. MOBILE/STATIONARY SURVEILLANCE TOWERS

Mobile or stationary surveillance towers can host very powerful and reliable multimedia sensors, i.e., radars ,cameras, and sensors, which constitute the second layer of the hierarchy. The multimedia sensors are resource-rich, high-power devices with higher processing ability and larger communication range. As a result, these components are also used as local processing hubs. The multimedia sensors are responsible for more complex tasks such as collecting the sensing reports from the ground/underground sensors, detecting possible intrusion according to the sensing reports as well as the local image/video information. As a results, the false alarm rate of the ground/underground sensors can be significantly reduced. After the surveillance towers con-firm intrusion detection, they report the detection results to the remote administrator, and inform the mobile sensors the position of the intrusion for target tracking. Furthermore, the measurements and image/ video information are stored for future use. There may also exist cooperation between imaging sensors to detect intrusions collaboratively. In this case, correlation-based camera selection schemes and data compression frameworks are required to reduce the redundancy among correlated cameras.

2.3. UNMANNED AERIAL VEHICLES (UAVs)

In addition to the stationary components, unmanned aerial vehicles (UAVs) and robots provide additional capabilities at the third layer. UAVs have recently been used for several applications including environmental surveillance and infrastructure maintenance Drones and Remotely Piloted Vehicles (RPVs) are two types of UAVs. Drones are configured for autonomous flight with a pre-determined course and schedule. RPVs are remotely controlled by ground operators. In addition to mobility, UAVs can also be equipped with on board sensors and camera systems to provide additional coverage in an on-demand basis. Furthermore, UAVs can track intruders based on information from stationary sensors and help the border patrol agents catch intruders.

3. ADVANTAGES

Compared with the existing border patrol techniques provide the following advantages:

1. The multimedia sensors provide accurate detection as well as large detection range;
2. The ground sensors provide additional information that cannot be detected by the multimedia sensors ,e.g. in cases here the intruder is hidden behind an obstacle that cannot be detected by the imaging sensor;
3. The underground sensors guarantee the proper system functionalities here aboveground visible devices are not preferred for concealment purposes;
4. Mobile sensors provide intrusion tracking capability to track the intruders after they have been detected;
5. It detect the intrusion and report the results to a remote administrator;

4. DEPLOYMENT OF BORDER PATROL SYSTEM

In border patrol applications, the established monitoring network should cover a significantly large monitoring area. However, the sensing radius of a single sensor node is normally limited. Thus, a large number of sensor nodes are expected to fulfill the coverage requirement. Moreover, different types of sensor nodes(e.g., underground, ground, camera and mobile sensors) provide different coverage capabilities. The deployment of border patrol system such as

- Deployment of ground/underground sensors,
- Deployment of surveillance towers,
- Deployment of UAVs.

5. OPERATION FRAMEWORK

The operation framework of border patrol system used to detect the intrusion detection by using detection algorithm. It has consists of three parts

- Cooperative intrusion detection,
- Intrusion tracking,
- Detection-oriented communication.

Example algorithm is shows how to automatically detect and track a face using feature points

```
1)  oldPoints = points;
2)  while ~isDone(videoFileReader)
3)  videoFrame = step(videoFileReader);
[points, isFound] = step(pointTracker, videoFrame);
4)  visiblePoints = points(isFound, :);
5)  oldInliers = oldPoints(isFound, :);
if size(visiblePoints, 1) >= 2
6)  [xform, oldInliers, visiblePoints] = estimateGeometricTransform(...
7)  oldInliers, visiblePoints, 'similarity', 'MaxDistance', 4);
8)  bboxPoints = transformPointsForward(xform, bboxPoints);
9)  bboxPolygon = reshape(bboxPoints', 1, []);
10) videoFrame = insertShape(videoFrame, 'Polygon', bboxPolygon, ...'LineWidth', 2);
11) % Display tracked points
12) videoFrame = insertMarker(videoFrame, visiblePoints, '+', ...
13) 'Color', 'white');
14) % Reset the points
15) oldPoints = visiblePoints;
16) setPoints(pointTracker, oldPoints);
```

```
17) end
18) step(videoPlayer, videoFrame);
19) end
20) % Clean up
21) release(videoFileReader);
22) release(videoPlayer);
23) release(pointTracker);
```

6. CONCLUSION

In this paper, introduce Border Patrol system, a hybrid ireless sensor network architecture for border patrol to reduce the intensive human involvement and to improve the detection accuracy of current border patrol systems.

Border patrol system is coherent system that coordinates various technologies, including unmanned aerial vehicles, unattended ground/underground sensors, and surveillance towers equipped with camera sensors

7. FURTHER ENHANCMENT

The future works involve the simulation evaluations of the purposed deployment and operation framework of border patrol system and also developed many advanced devices are introduced in laterly

8. ACKNOWLEDGEMENT

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